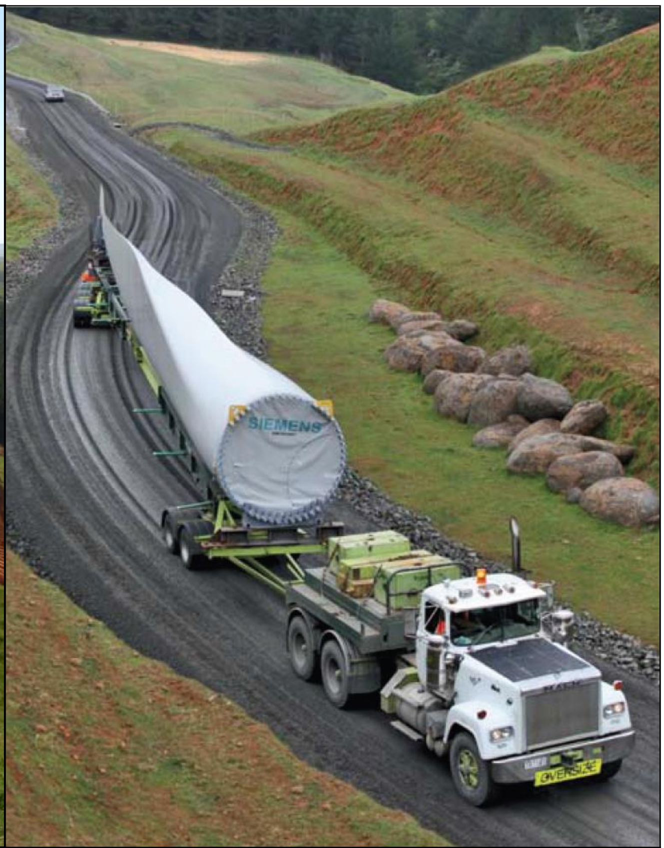
TE UKU WINDFARM ROADING NETWORK

(Meridian Contract No. me-grd9019)

HICK BROS CIVIL CONSTRUCTION &

HIWAY STABILIZERS NZ LTD



June 2011

ENTRY FOR:

RNZ Roading Excellence Awards

New Zealand Roading Solutions Excellence Award for a Medium Road Project

PROJECT DETAILS AND SCOPE

Project: Te Uku Windfarm Civil Works (*Roading Network*)

Client: Meridian Energy Limited
Rob Batters (021) 445 345

Consultant: Bloxam, Burnett & Olliver Ltd
Tony Keyte (07) 838 0144

Contractor (Roading Network): Hick Bros Civil Construction
Rob Fenwick (021) 430 703

Sub Contractor: Hiway Stabilizers NZ Ltd
Allen Browne (021) 719 067

Value: $19.6 Million (earthworks, drainage, pavements, environmental elements relating to roading component)

Details

Scope: The Te Uku Wind Farm Project consisted of the construction of the civil infrastructure for a 64MW wind power site including the road network and turbine foundations. This submission is related to the roading network civil works. Major works included in the construction contract include:

- Construction of 26km of access road network purpose-built for access and the delivery of over-weight and over-dimension wind turbine components.
- Construction of platforms for the 28 turbine sites, site lay-down areas, concrete batching plant & substation platform, transmission tower and switchyard platforms.
- Disposal of excess excavated material at approved sites with controls in accordance with Resource Consent conditions and in the Environmental Management Plan.
- Implementation of the sediment and erosion control systems (with 180 control devices) and dust management. Maintain water quality in surrounding streams.
- Construction of all subsoil and stormwater drainage systems
- Respreading topsoil, hydro-seeding and re-vegetation of fill sites, roads, platforms etc. Permanent and temporary fencing throughout for surrounding dairy farm
- Integration with tandem construction of 28 turbine foundations requiring 1335 tonnes of reinforcing steel and 12,000m3 of concrete, and installation of 70km of high voltage electrical cables between turbine sites and the substation.

Note: The entire Civil Works contract was undertaken by a joint venture comprising Hick Bros Civil Construction and Spartan Construction. The component undertaken solely by Spartan comprised on-site batching plant, 28 turbine foundation and transformer bases and substation foundations. These fall outside the elements of the project encompassed by this submission comprising the roading network earthworks, pavement and tower pad construction.

Timeframe: Project Commencement Date: 2 Nov 2009
Original Completion Date: 12 Nov 2010

Achieved Completion Date:
24 Sep 2010

Health & Safety: Serious Harm Accidents – none.
Total Man-hours: 190,000 [roading network component]

Figure 1: Earthworks – Cut & Subgrade

Figure 2: Subgrade Stabilising

A OVERVIEW

Project Te Uku is a 28 Siemens turbine wind farm, substation and electrical lines situated on 56 square kilometres of private land on the Wharauroa Plateau, a remote, coastal, working sheep and dairy farm approximately 30 km west of Hamilton and south-east and inland of Raglan. The installed capacity of 64.4MW is enough to power around 30,000 average homes in the local Waikato distribution network. The Project Te Uku site ranges in 200m elevation at the Kawhia Road site entrance climbing 350m to an elevation of more than 550m on the Wharauroa Plateau [refer to Appendices page 1].

The site is characterised by low lying swampy flats prone to flooding for the first 1km of primary access road to steep sided and well defined to irregular ridgelines and gullies between the 4 – 7 km marks of primary access road. The Wharauroa Plateau topography ranges from gently rolling to steep hilly terrain. In some areas of the plateau, numerous surficial and subsurface basalt and conglomerate boulders are present ranging from 300mm to 3m diameter. The 7 km access “spine road” leading up to the plateau is situated mainly along steep sided ridge tops.

The Pukoka River (and tributaries) situated in the vicinity of the site entrance and the crystal clear Pakahi Stream on the Wharauroa Plateau are the main watercourse features of the project – both of which were crossed or bounded by the construction works. The popular Bridal Veil Falls scenic attraction [refer Appendices page 10] is a short distance downstream making sediment control critical.

The area of construction mainly consisted of well managed farmland with hilly medium quality pastures. Some small areas of bush and scrub required clearance (0.2 Ha) for the construction works. The construction works were carried out on 5 separate properties / 3 farms meaning 4 property boundaries were regularly crossed during construction. Each boundary crossing was controlled to ensure stock from the neighbouring properties did not escape or were not mixed. Approximately 8km of temporary electric fencing was erected to keep stock away from active construction areas.

A 1 Climatic Conditions

The Wharauroa Plateau has no natural shelter and is exposed to high winds from all directions. During winter months, winds from the southerly quarter can be very cold and are often combined with sleet or snow flurries. To combat the high winds and/or wind chill specific procedures were put in place for staff safety including types of work that could not be carried out in strong winds and guidelines for work that was permitted. In the most extreme cases the site was evacuated until wind speed dropped (3 occasions). The average annual rainfall for the site is 1545mm with 100 rain days of 3mm or more per day! These average figures were exceeded for the project period.

A 2 Ground Conditions & Boulders

The general topography along the access road is steep with evidence of soil creep and minor slips. Many basalt and conglomerate boulders of up to 3m in size are present at the ground surface.

Figures 3 and 3A: Okete Volcanic Formation Boulders

The surface geology is primarily made up of the Okete Volcanic Formation, the Glen Massey Formation, and also the Apotu Group. The site access road traverses across similar geology, with the far south-western part crossing alluvial soils of the Tauranga Group associated with the Pakoka River. The typical soils characteristics and management methods were as follows (overleaf):

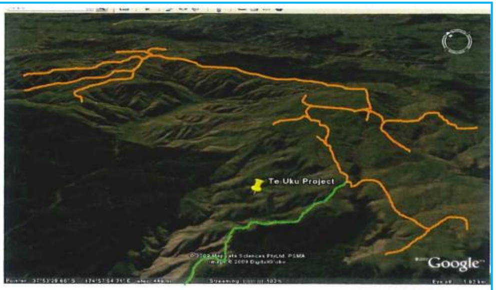


Figure 4: *Re-alignment and widening of existing paper road to form main access Road A (green), and construction of new turbine access roads (orange) (Google Earth 2009)*

Figure 5: *Re-alignment and widening of existing Plateau Rd (yellow) and existing paper road (green) to form main access Road A. (Google Earth 2009)*

Figure 6: *New access road (green) from Te Mata Quarry entrance to existing Plateau Rd (yellow) to form main Access Rd A. (Google Earth 2009)*

Figures 4, 5 & 6 Showing Terrain

- **Volcanic Ash Derived Soils**: Present for much of the surface, with layer thickness ranging from zero to several metres. The ash soils on site were significantly wetter than optimum especially at depth and very sensitive to overworking and heavy trafficking. The presence of greater than 7% allophanes in the ash also contributed to the soils sensitivity for compaction.
- **Weathered Basalt Derived Soils**: Present in several areas, usually beneath a layer of volcanic ash. Generally wetter then optimum and sensitive to overworking and heavy trafficking.
- **Weathered Conglomerate Soils**: Mainly sub-surface with water contents higher than optimum and the material was sensitive to remoulding. Despite this good quality structural fill could be achieved with drying
- **Weathered Siltstone Soils:** Encountered in some of the road cuts on site and are generally significantly wetter than optimum but structural fill specifications were achieved with minimal drying
- **Other Soils**: Silt and gravel alluvium was encountered between Ch 200 – 1330 and varied from firm to wet and very soft. This material was filled over with an embankment fill sourced from Te Mata Quarry strippings rather than undercut. Geometrics were adjusted to permit this approach.

A 2.1 Groundwater Levels:

Groundwater levels varied throughout the Windfarm site but were generally well below the proposed excavation levels. The exception to this was the Ch 200 to 1300 area near the Pakihi Stream where ground water was just below the ground surface and filled any excavations in these areas. Drainage and pumping was employed in these areas as necessary to control any inflows during construction. In this area the construction of the embankment rather than undercutting the soft alluvium further enhanced constructability of the embankment.

A 3 Summary of Overview:

The ground conditions and soils within the construction area were generally significantly wet of optimum, sensitive to remoulding and water content fluctuation. Despite this the soils were successfully managed by using the most suitable cut materials available in the fill areas and road sub-grades while cutting less suitable materials to waste. Soils on site that were most responsive to lime and cement stabilisation were used as a road sub-grade material (where they were not present naturally) and were then lime/cement stabilised to produce a CBR in excess of 12 in most cases. This provided considerable savings with a significant reduction of pavement aggregate thickness. This meant that the required aggregate volumes could be accommodated by Te Mata Quarry within the contract period.

Figure 7: Rain Affected Days Numbered 130 in 2010

SECTION TWO – AWARD SPECIFIC CONTENT

B1 Client Assessment

The contract works were undertaken with professionalism and completed well within the required time frame and budget. This despite the bulk of the earthworks for the roading network being constructed through a season which records confirmed to be one of the wettest summers experienced since record keeping commenced. The client, Meridian Energy Limited (MEL) is especially pleased with not only the financial and delivery aspects of the project but also the environmental achievements, zero lost time injury health and safety performance, outstanding project team and community relations and good working relationship and outstanding collaborative effort between The Principal (MEL) the Constructor (Hick Spartan JV), Civil Works Consultants (Bloxham Burnett and Olliver) and primary subcontractors such as Hiway Stabilizers, to find innovative solutions and make best for project decisions.

Apart from the attached letter of support from the MEL Project Manager Robert Batters [refer Appendices page 2], a ringing endorsement from MEL was success in the next major Meridian project to market. Recently the Te Uku Windfarm team (the Hick/Spartan JV) were named frontrunners in the recent tender for the Central Wind Waiouru Windfarm contract now having a letter of intent in place between the two parties in readiness for contract award prior to commencement of the project. The Project Central Wind tender was weighted attributes evaluation and the project is approximately double the scope of roading, turbines and price of Te Uku.

While the roading network pavement specimen design for tendering was undertaken by Bloxham Burnett & Olliver Ltd (BBO), [refer Appendices page 3 for letter of support from Tony Keyte, BBO] Hick Bros undertook extensive sampling of representative materials and Hiways undertook reactivity testing to categorise moisture sensitivity and optimum blends of lime / cement for a dependable subgrade improvement layer. This was seen as being critical to mitigate the challenging weather and provide a moisture insensitive substrate for subsequent aggregate construction and plant access. This early testing permitted modelling to be undertaken that represented specific design loading and incorporated preliminary inferred materials properties. On this basis the JV was able to price the earthworks and pavement design with confidence, and also present MEL / BBO with construction/design alternatives that provided both lower construction risk – and significant cost and time savings.

Once the contract was awarded a number of processes were commenced immediately. Additional materials testing and final pavement design was undertaken by Hiways in conjunction with BBO to expand on the preliminary tender design work as the time required to complete these designs would have meant that confidence in supply and the commencement of construction would risk delay – moving even further into autumn/winter. A collaborative effort between Hick Bros Civil, BBO and Hiways expedited the design process, providing for the maximum construction window.

> ***MEL's CEO Tim Lusk commented (Energy News 30/03/11) "We seemed to strike just an absolute sweet spot with Te Uku with some of the partners we had - WEL Networks, Waikato District Council, Environment Waikato, and the people we put on the project. A lot of it just seemed to give us a perfect outcome in that respect. You don't always get it as right as that. That would be an absolute benchmark. We would aspire to repeat that wherever we can really"***

B1.1 VALUE FOR MONEY & TIMELINESS

The Te Uku Windfarm contract programme requirement was to have the work completed by November 2010. The available construction period was tight due to the 54 week contract period and the programme needed to accommodate the very real risk of poor weather. The documented average annual rainfall for the site was 1545mm per annum with 100 rain days (having 3mm or more per day). With earthworks the implications of a rain day are that additional days are often lost after heavy rainfall where drying time is needed for soils to 'recover' from saturation before works can re-commence.

Unfortunately the reported annual rainfall for 2010 when virtually all of construction took place was 1818mm and the rain days numbered 130 – meaning the Windfarm was constructed on a wetter-than-normal year. Often a rain day will delay commencement of work even where the following day is fine to allow sufficient drying. The summer period of 2010 was one of the wettest on record. However, despite this the project was completed 6 weeks early, largely due to construction innovations and mobilisation of additional earthworks construction equipment.

B1.2 Achievement Against the Clients Criteria & Critical Success Factors

A primary key Client success factor is always budget. This project recorded zero claim disputes, zero lost time injuries [refer Appendices page 9] and was under budget by a staggering $2.2M.

One of Project Te Uku's critical success factors as set out in the Te Uku Project plan was to gain outstanding Environmental performance by working to best effect within the environment at Te Uku. MEL's aim was for the project to be positive experience for the local community and which would serve as a reference point for future Meridian wind generation projects. In essence, the key environmental project goal was to leave the Te Uku environment in a better shape than it was found.

MEL's tender documentation was prepared in a way that the bidding Contractors recognised the importance of good environmental practices, and required that contractors involved in the project had suitable company sustainability policy, responsible purchasing policy, awareness of environmental legislation, excellent training for staff and evidence of imaginative community / public relations on sites.

One of MEL's external reference points for environmental success on the project was placed on the relationships with both Environment Waikato and the Waikato District Council, with significant emphasis placed on a collaborative developmental approach. An example of this was the joint site erosion control inspections carried out with Council, contractors / consultant and project team members. This process helped find swift acceptable solutions, and the scale of earthworks meant over 180 erosion and sediment controls during road construction.

In spite of the diabolical weather conditions this has been acknowledged by Environment Waikato awarding Te Uku Windfarm the inaugural Project of the Year in regard to Erosion and Sediment Control which Grant Blackie (Land and Soil Programme Manager for Environment Waikato) referred to as "A great example of best practice and as good as anywhere in the Waikato region or elsewhere in New Zealand that I'm aware of". [Refer to Appendices page 5 for the Award Certificate].

The turbine tower component specification was amended during the design/tendering period. For example the turbine blades increased in length from 43m to 49m and this required longer trailer units and corresponding adjustments to geometrics. This was accommodated through the tender period. Significant work was also collaboratively undertaken between Hick Bros and BBO to optimise the spine road geometrics including the spine road diversion at Bobs Ridge.

The Environmental excellence as stipulated by MEL has further been acknowledged by the Te Uku Wind Farm Project recently being announced a finalist in the Deloittes Energy Sector Awards for Environmental Excellence category (the winner is still to be determined).

Some other specific key achievements are:

- Zero Lost Time and zero serious harm Incidents in 190,000+ man hours
- Site Leaders in Health & Safety Compliance Audits
- Contract completed 7 weeks ahead of schedule with minimum disruption to farm activities.
- 42% of staff were local with local community involved in supply chain and accommodation

Refer to the Appendices page 5 for the Table for a summary of KPI Measurement and Achievement.

Figure 8: Multiple Simultaneous Construction Elements

Figure 9: Turbine Tower Components

B2 Construction Innovation

The Te Uku Windfarm roading network was completed under budget, under time and to a high standard that quality assurance testing has demonstrated to be in excess of the contract requirements. A variety of innovations were employed through the design and construction of the roading network and these can be summarised as follows:

- ***Pavement design:*** After tender award the specific axle loads and frequencies for the roading, tower bases, tower foundations and tower components were accurately modelled utilising an insitu stabilised subgrade. The specific component / materials evaluation along with extensive materials and subgrade categorisation permitted the design for the different sections of pavement to be optimised [refer to Appendices page 6].
- ***Subgrade Improvement:*** Further to pavement design, the key innovation was the use of a stabilised subgrade significantly reducing the quantities of aggregate required to a level where the Te Mata Quarry could (just) meet supply requirements. The stabilised subgrade provides a robust anvil for aggregate construction that was, most importantly, highly resistant to the effects of water unlike untreated subgrade which experienced strength loss and slow drying. Pre-blending lime oxide fines (-3mm) and cement for single treatment were trialled along with sequencing lime then rehoeing with cement optimised treatment of the variable subgrade soils.
- ***Geometrics:*** The JV undertook extensive changes to the tender geometrics which provided a better cut/fill balance with less cut to waste. The changes to geometrics were tailored to the over-dimension turbine components while also optimising corners versus grade. This was done collaboratively with BBO and Tranzcarr who transported the components with specialised heavy-haul units.
- ***Cable Trenching Offline:*** The cable trenching operation was moved off the road in areas where possible producing less construction congestion and mitigating disturbance and potential for cross contamination of newly constructed pavement layers
- ***Table Drain Changes:*** The typical pavement profile was amended to deepen table drains and reduce the quantity of subsoil drainage.
- **Subsoil Drainage Aggregate:** A locally produced 20mm all-in drainage aggregate was prepared by Te Mata quarry that didn’t require the more expensive filter wrapping.
- ***Boulder Mitigation:*** The presence of boulders up to 3m in diameter introduced risk of damage to earthworks and stabilising equipment. Rock raking was trialled and then introduced to remove cobbles and boulders greater than 150mm diameter - significantly reducing the quantity of subgrade that was unsuitable for stabilising
- ***Road Realignment:*** A realignment of the spine road (Bobs Ridge) was undertaken to avoid a section of road along the side of an adjacent ridge where steep terrain which would have required cut backs of around 50m in height. The road gradient on Bob’s ridge was generally 17 percent which was the maximum allowable but the long straight section and good approaches made it acceptable to all road users.
- ***Testing Regime:*** Changes to the original earthworks and pavement testing specifications use insitu testing rather than sampling and laboratory testing. This was through moving to an air voids and shear strength specification for earthworks. For the subgrade core sampling and laboratory CBR testing were amended to air voids and insitu CBR testing alongside Benkelman Beam testing. This allowed for more extensive testing, yet for a lower cost.
- ***Raise Causeway:*** The Ch 200 to 1330 was through low strength alluvial soil subgrade that was not suited to insitu stabilisation. Rather than undercut the geometrics were raised locally and ‘brown’ rock overburden from the adjacent Te Mata Quarry was used to raise the causeway and provide robust support for the upper pavement. This innovation also corrected near surface drainage problems where greater “freeboard” and increased gradient culvert drainage paths could be implemented [refer to Appendices page 8 for further drainage details].
- ***Aggregate Specification:*** The contract basecourse NZTA M/4 basecourse specification was amended to a high fines AP65/AP40 specification that would suit the unsealed surfacing better, as the M/4 specification is intended for sealed roads and the adjusted grading was more suited to unsealed and would accommodate whether roads cement stabilised or untreated.
- ***Fill Drying:*** Some of the cut to fill earthworks zones – particularly at the top of the plateau, were shaded from trees/bush and wet of optimum, so fill drying was carried out with the use of lime oxide quicklime) where the heat of slaking [$CaO + H_2O = Ca(OH)_2 + Heat$] and pozzolanic reaction made the soils suitable for fill immediately rather than requiring extended spread and drying time or cut to waste.

- A major risk identified at an early stage was the ability of the nominated aggregate supplier (Te Mata Quarry) to produce and supply sufficient aggregate for the scope of works. It is recognised that it was unlikely the Te Mata Quarry could have supplied the original contract design aggregate quantities within the project construction period.

B3 Consultation and Partnering in Collaboration

The Te Uku Windfarm Project contract was based on the NZS 3910 form of contract which does not in itself have specific processes to support collaborative working. It was necessary therefore for the parties to establish a collaborative relationship structure which was inclusive of all parties associated with the project and as far as possible drew the parties into the project decision making structure. The short construction period meant that a close relationship between client, consultant, main contractor, subcontractors and local stakeholders was always going to be a key factor in successful completion of the project

B3.1 Key Principles

To ensure a successful collaborative culture was maintained the following behaviours and processes were adopted:

- Identification of high level Key Result Areas of importance to MEL and all parties.
- Well constructed KPI's to monitor the health of the project relationship which could be reviewed on a monthly basis – the "Health Check". This encompasses Health and Safety, Environment, Programme and Delivery, Customer Interface, Commercial Management and Project Management. A copy of the initial KPI's is attached in the Appendices.
- A hierarchy which captured problem issues for resolution as early as possible and at the team level where the issues were best resolved. Problems which could not be resolved at a certain level were elevated to the next level for resolution.
- Leadership from the top was provided to support the importance of collaboration and to empower.

B3.2 Information Sharing

For the information to be effective all parties needed to share information in an open and timely manner – in particular issues which relate to project time frames and any constraints such as access that might affect the performance of others. It was important also to share information about all interfaces with community and stakeholders and communicate issues and considerations freely and in a timely manner. The process was undertaken during each of the weekly site meetings and monthly progress meetings. This allowed many uncertainties to be resolved, and also resulted in a number of refinements to construction methodology and pavement design.

B3.3 Continuity and Refinement of Process

To avoid partnering becoming a feast of time consuming (and sometimes) ineffective meetings, the parties reviewed the key elements of the collaboration (including the KPI's) as to what was essential / important – thus delegating the minor issues to different project tiers so that focus and efficiency on key issues was retained. Senior staff remained engaged and led by example The presence of project directors at most meetings together with the commitment from MEL maintained the initial momentum and collaborative culture throughout the project. Note: a full risk/opportunity workshop was carried out prior to commencement [refer to Appendices page 7 for Risk and Opportunity Register details].

B3.4 Landowner Relationships

The project team together with MEL developed and established a Stakeholder relationship plan. The critical element was to engage all affected parties, establish their specific concerns and requirements and then keep them appraised of project elements that influenced them sufficiently early to permit consultation. Key elements of the relationship plan were:

- Development of the plan with MEL to address landowners and local community interests including mitigation of effects of construction where practical. Temporary fencing was used to permit full grazing of paddocks and/or areas of construction.
- Development of a communication plan for key stages of the project which updated landowners about intended construction activities prior to works commencement in their areas and also provided general information about the project construction.

- Provided a clear process for landowners to follow in contacting the construction team (where the first point of contact was the land liaison representative – Steve Hick, but with back-up personnel also nominated). This process ensured a rapid and reliable response to farmers concerns – with a 24hr/7day direct contact link with the contractor.
- The land liaison representative and project manager made regular visits to key landowners to develop a strong relationship from the beginning of, and throughout the project term.
- All employees were made aware through the project induction process of the importance of landowners and local community to the project and MEL/WEL ongoing relationships.
- Landowners were invited to key construction milestone celebrations.
- A good example of collaboration with the Client was the managing of the property boundaries – of which there were four boundaries along the spine road. Two of these boundaries were heavily trafficked – with hundreds of truck movements daily. Designated staff were stationed at these gates where stock was in those pastures to open and close gates so that the vehicle movements could be maintained without stopping.

B3.5 Collaboration with the Community

There were many instances of collaboration and consideration for the Te Mata community [refer to Appendices page 4 for specific Community feedback]. Some of the key examples are as follows:

- The speed limit through the Township is 70km/hr. The project team "self imposed" a 50km/hr speed limit on all vehicles and heavy traffic movements were constrained to well before or well after school hours as much a possible.
- The Te Mata school house was rented by Hick Brothers for use as a project office and a relationship was developed with the school where school ladies/mothers were employed to cook for the project for events such as the project wide monthly health and safety meetings, items were made available to the school (i.e. moxy dump truck tyres for recreation).
- Meetings with local emergency services and also the Raglan Fire Department.
- Local service providers were canvassed and used for a myriad of support roles.
- The project team worked closely with the Te Mata Quarry to provide programming schedules (weekly and monthly and to arrive at achievable materials specifications and look to use overburden / rotten rock where possible for non structural fill materials.
- An open day was held where more than 2,000 visitors were ferried to the Wharauroa Plateau to visit the wind turbines, and a gala was held at the Te Uku School organised by MEL to thank the community for their support during the construction of the wind farm. MEL chartered buses and donated the proceeds of tickets to the school.
- Team building activities included project wide monthly Health & Safety BBQ's, joint tree planting & social events, which cultivated a positive work environment and built on open communication.

Finally, there have been several glowing references to the excellent relationships between the Windfarm workers and community from independent local bloggers. For an example please visit;
http://gorgeouswithattitude.blogspot.com/2011/04/up-close-at-te-uku-wind-farm.html




Figures 10: Te Mata School Delivery of Playground Truck Tyres and Sand

B4 LONG TERM STRATEGIC FIT

Typical roading projects employ a pavement design where the road is built to accommodate typical design loadings for a period of time after construction where loading will remain steady or increase for a period of 20 to 30 years. Windfarm projects are vastly different in that the design loading is fundamentally composed of the construction traffic and vertical and horizontal geometry limitations are imposed by the over-weight and over-dimension traffic When the roading network, turbine towers and power substation are completed the only traffic is likely to comprise light maintenance traffic alongside any local landowner utilisation.

So in a similar manner to forestry roading networks the road needs to accommodate an extreme amount of loading over a short period of time where serviceability requirements are paramount, and then maintain a functional capability for future use. It is also important that the roading network maintains durability and serviceability so that should future expansion or upgrade be implemented the asset value is not diminished as a datum for building on the existing structure.

The Te Uku roading geometry comprised a "spine road" with temporary concrete batching plant at the 7 km mark and a permanent power substation at the 11 km mark. The spine road was the only permitted construction access to site, and as such the road network comprised the haul road(s) meaning that development of the roads needed a methodology that protected the integrity of the developing pavement structure components from bulk fill/cut through to finished basecourse while sequencing all project elements in a manner that rework was minimised. Cable trenching through the spine and finger roads also needed to be accommodated for the entire roading system.

The construction materials for roading, tower platforms / bases and finally the tower components themselves were calculated based on detailed methodology and contract schedule / programme. The precise axle loads, tyre configurations and relative frequencies of loadings were calculated and these were modelled to reflect cumulative strains using mechanistic design software for each representative pavement sub-section [refer to Appendices page 6 for development of design loading].

The road subsections featured vastly different construction and component loading [refer to Appendices page 2 for turbine roading layout], along with variable subgrade conditions. Some of the finger roads supported only one wind turbine, but a functional pavement structure was still required to ensure serviceability and then continued access throughout construction.

There is certainly significant value-added for the landowners who now have a quality road through their properties where previously a weather-sensitive sinuous track was the only access through a portion of the project area.

Finally, as a recreation benefit to the community walking and cycling tracks were constructed between some of the finger roads to provide an extensive recreation network. These commence at the end of the public road section of the Spine Road where parking is available to then access on bicycle or foot.

Figure 11: Open Day Bus Tours


Figure 12: Regrassed pasture around towers

B5 UNIQUE CHARACTERISTICS

This was certainly a project with many unique characteristics (and challenges). An example of some key unique elements are as follows:

Weather / Climate: The recorded 2010 site rainfall of 1818 mm with 130 rain days is challenging, and the drop in temperature and ferocious wind (as necessary for the project purpose) particularly atop the Wharauroa plateau made an extremely challenging environment for project delivery.

Sheer Scale: The scale of the bulk earthworks was immense, being the largest roading project in the Waikato region during the 2009/10 period, this included 700,000m3 cut to fill and waste, culverts ranging from 225mm to 2300mm, 320,000 m2 of sub-grade and basecourse stabilising and over 220,000 tonnes of metal aggregate being produced and utilised on site.

Overdimension / Overload Vehicles: In addition to the heavy loading for construction and materials, the wind turbine components were at top end of what New Zealand roads can accommodate. Weighing more than 300-tonnes for each turbine (with heaviest load being the 84 tonne nacelle) and the length of up to 50 m for the components required purpose-built heavy haulage units. The turbine assembly crane loadings could not be precisely determined until late in the contract due to counterweight logistics between tower platforms and this was a challenge for pavement design.

Working Through 5 Separate Properties: Typically, a project designation is separated from adjoining properties and managed as a continuous entity. However, this extended through five separate properties – four of them working farms. Maintaining productivity on a tight programme required an extraordinary amount of planning and collaboration with the landowners to protect their interest while not adversely influencing the construction programme.

Critics of the Project: There were numerous critics of the project during the consenting process that had dire concerns about the potential detrimental effect on the environment. Many of the critics, including Fred Litchwark from "Whaingaroa Harbour Care" have become powerful advocates encouraging other developers to adopt the same high standards as those applied during the construction of the Te Uku Windfarm. This type of endorsement is only achieved through strong leadership and a commitment from everyone that worked on the project being committed to protecting the environment.

Proximity to Waireinga / Bridal Veil Falls: Adjoining the Windfarm site is the Department of Conservation track where the Pokaka River flows from the Windfarm to the Bridal Veil Falls. To quote Meridian's Te Uku Project Manager Robert Batters "It was vital sediment did not find its way into the nearby rivers and streams – particularly the Pokaka River which feeds into Bridal Veil Falls [refer to Appendices page 10 for picture] – a major tourist attraction in the area. " This was achieved, and don't forget that the project won the Environment Waikato's inaugural earthworks 'Site of the Year' award.

Highly Heterogeneous Materials: The geological units were highly variable and typically wet of optimum as outlined in the introduction. An additional challenge was the presence of numerous weathered basalt boulders up to 3m diameter [refer facing page of Appendices]. These had to be worked out / root raked making earthworks / pavement subgrade works significantly more challenging.

Single Point of Entry: Every element of the project came in through the single entrance and along the spine road. While total loading / stress reduced with distance along the spine road, the first 6km in particular experienced very heavy loading and overlapping project tasks.

Several Overlapping Project Elements: The very short project duration required many tasks to be simultaneously undertaken such as concrete batch plant materials including cement and aggregates, reinforcing steel, subgrade improvement, drainage improvements, environmental measures, cable trenching, concrete foundation construction and farm traffic/stock movements etc. Sharing the narrow corridor, in places at a 17 percent gradient, required intensive project planning and management.