

Landslip Stabilisation - Turei Hill, Kawakawa Bay

*Mark Faulkner, Manager/Partner
and
Greg Saunders, Projects Team Manager, Partner*

*Opus International Consultants, Manukau
Corner of Davies Avenue and Putney Way
PO Box 76 725 Manukau City*

Abstract

Prolonged wet weather in June, July and August 2008 resulted in the mobilisation of a significant landslip above the Clevedon–Kawakawa Road in Manukau City at Turei Hill.

Perched on top of the slope was the adjacent land owners house, plus a further five houses and the important coastal road link below, were within the area encompassed by the active landslip. Accelerated movement of the slope and fears of a sudden catastrophic failure resulted in the closure of the road and evacuation of the six potentially affected properties at the end of August 2008.

Access to the communities of Kawakawa Bay and Orere Point was severed forcing residents to take a 100km long alternative route which resulted in widespread disruption and potentially devastating social impacts. The road closure attracted widespread negative local and national media attention.

This paper details the response by Manukau City Council (Council) to manage the community affects and expectations along with restoring temporary alternative access and the permanent restoration works to stabilise the landslip.

Introduction

Small slips occurred in numerous locations in the rural areas of Manukau City following a sustained period of wet weather during the winter of 2008. This is not an uncommon occurrence in many areas of New Zealand and the majority of those that occurred in Manukau were isolated and harmless. However a seemingly innocuous small slip occurred on the Clevedon–Kawakawa Road at Turei Hill on 28 July 2008. This deposited approximately 300 to 400m³ of material on the road completely blocking it and temporarily severing access to the seaside communities of Kawakawa Bay and Orere Point.

This was removed by the Council's road maintenance contractor but highlighted a concern with respect to the remainder of the slope stability. The road and slope were subjected to a geotechnical assessment on 6 August 2008 to gauge the extent of the problem and Council were advised that a potential major landslip may occur as there were significant cracks appearing in the slip scarp some 40 to 50m above the road.

The adjacent landowner's house was contained within the zone of influence of the landslip and as a consequence the New Zealand Earthquake Commission (EQC) was notified by the landowner of cracks appearing within the dwelling and that continued movement was occurring.

Monitoring of the movement of the house, undertaken by the EQC's consultant Tonkin and Taylor Ltd, began on 13 August 2008.



Figure 1: Road Slip Face August 2008

As Council's Road Network Management Consultant, Opus began similar survey of the slip movement relative to its proximity and impact on the operation of the road. Continued wet weather resulted in further movement of the landslip and on Sunday 24 August 2008 the Clevedon-Kawakawa Road was closed to all through-traffic as a precautionary measure. A further deposition of material occurred later that day which pushed concrete median barriers intended to contain slip material across the "live" lanes of traffic and blocked the road as illustrated in Figure 1. The duration of the road closure and scale of the landslip at this time was not fully understood.

Council established their Emergency Management Office (EMO) to assess the community impacts associated with the road access severance and possible scenarios associated with a prolonged closure. Developing and implementing action plans to communicate and mitigate the consequences of the "temporary" closure was the initial priority, although the EMO anticipated that a longer term closure may be necessary.

Equally important for the EMO was to consider alternative access options in the short term and, if appropriate, realignment of the road or development of remediation measures to stabilise the landslip to restore permanent access in the event that a protracted or extended road closure eventuated. While this was a conservative approach, subsequent events proved this to be an invaluable exercise for the events to come.

Within a few days Saito plots of the landslide movement produced by Tonkin and Taylor Ltd for the EQC indicated acceleration of the landslide movement. These plot the inverse rate of movement versus time (refer to Figure 2) and at this point they concluded:

“If the data and empirical interpretation are correct and the slope continues to accelerate as of yesterday’s readings, then the plot indicates that failure is likely within the next 24 hours to 4 days”.

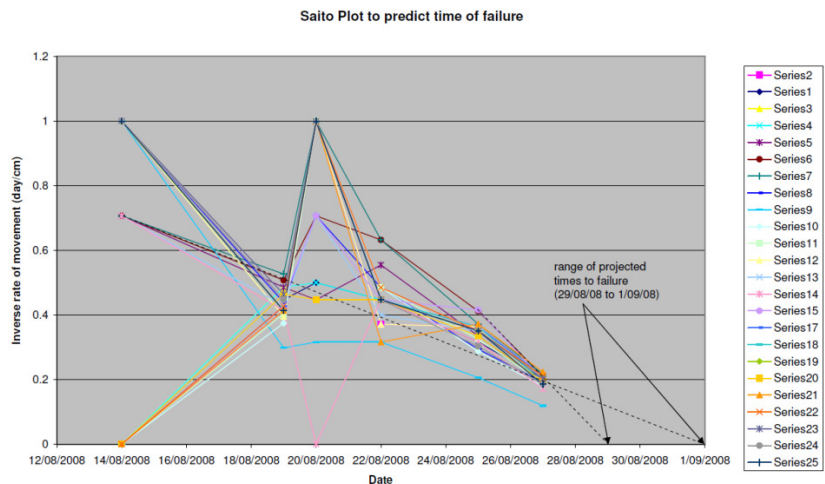


Figure 2: Saito Plot

On 28 August 2008 the five residential properties below the landslide were evacuated, again as a precautionary measure due to concerns that sudden catastrophic failure of the slope represented an imminent threat. The affected residents were relocated within the community where practical.

The decision to close the vital road link and to evacuate the affected properties was not taken lightly or flippantly by Council but in the interest of public safety due to the gravity of the situation and consequences of a sudden slope failure.

Council were fully aware of the distress and economic hardship that the road closure had on the local communities as the landslide had by this time attracted widespread negative local and national media attention.

Access to the communities of Kawakawa Bay and Orere Point had been severed forcing residents to take a 100km long alternative route as detailed in Figure 3 resulting in widespread disruption and potentially devastating social impacts.

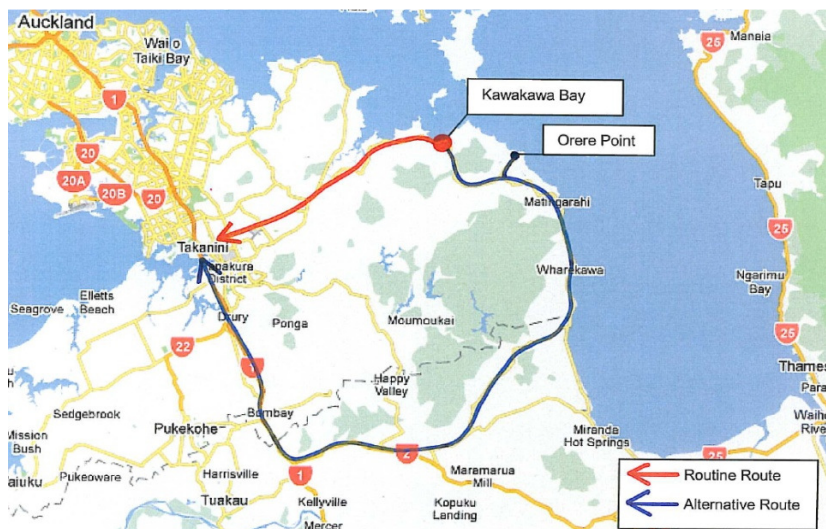


Figure 3: Detour Route

The following details Council’s response to the access severance, the options considered for alternative access provision, the options implemented and those discarded and the final remediation option chosen to stabilise the landslide.

Initial Response

From the outset Council sought to engage and inform the local and wider community to communicate the magnitude of the landslip and the potential impact on their daily lives. Media releases and standardised responses from Council's Call Centre were developed, website information updates initiated and on-road signage to advise all users of the road closure were implemented. Local businesses were also contacted and asked to convey information about the closure.

Signage was erected around the affected properties to prevent access and warn of the danger as well as the provision of security guards 24 hours a day to prevent unwanted attention from vandals and other opportunist elements of society. An email distribution list was established by the EMO to provide regular updates with the members of the community directly affected.

A public meeting was held at Kawakawa Bay on 27 August 2008 to outline the size, nature and scale of the landslip which had subsequently been determined, but from road level was not immediately evident and lead to scepticism about the seriousness of the event. The landslip covered an area greater than two hectares and the head scarp encircled the adjacent landowner's house as depicted in Figure 4, which was gradually moving down slope, severing the utility service connections. The house moved vertically in excess of a metre before it was eventually demolished.

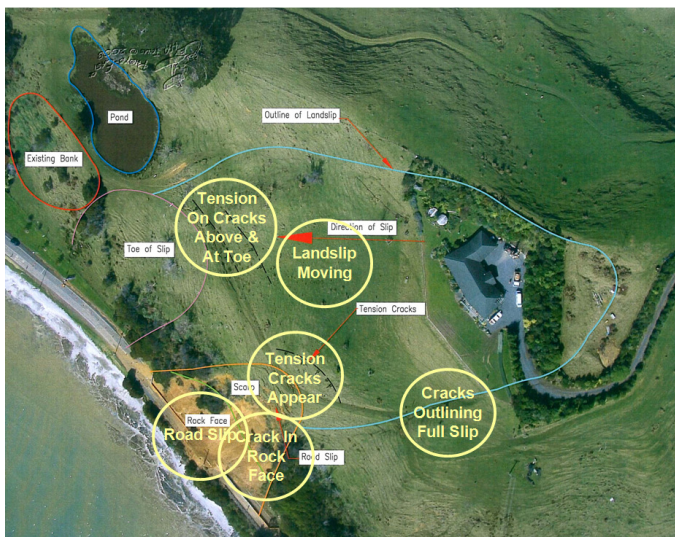


Figure 4: Plan View of Landslip and Features

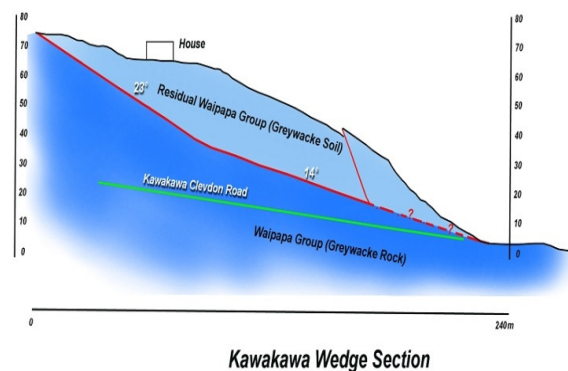


Figure 5: Stylised Cross Section of Landslip

Community views in terms of alternative access options were sought at this first public meeting, with a number of alternatives offered and patronage rates assessed. These included:

- A bypass walking track around the extent of the landslip (which included the creation of car park areas with security lighting at each end).
- Construction of a four wheel drive access track to transport passengers to and from the walking track car parks.
- Implementation of a waterborne ferry service from Kawakawa bay to Pine Harbour with the assistance of the Auckland Regional Council/Auckland Regional Transport Authority.
- A shopping bus service from Kawakawa Bay to Thames and Papakura.

As a consequence all of the above were implemented with varying degrees of use and patronage. The alternative access provisions established are detailed in Figures 6 and 7.

The temporary walking track and four wheel drive access track were constructed and operational on 2 September 2008 and 8 September 2008 respectively.

This was undertaken in conjunction with obtaining approvals from the adjacent landowners and resolving issues of potential risk and liability.

Daytime only usage was permitted due to the tortuous nature of the topography of both tracks.

Alternative power supply and telephone lines were also established along the walking track to secure vital power and communication links as the existing lines followed the road alignment and were at risk from the landslide movement.



Figure 6: Realignment Options, Walking Track and Four Wheel Drive Route

The impact of the road closure was discussed with the New Zealand Fire Service, Police and Ambulance Service which all had contingency plans in place to respond to any emergency event.



Figure 7: Ferry and Shopping Bus Routes

Arrangements were put in place to provide transport to Clevedon School for pupils affected by the road closure.

Council also provided additional equipment to Orere Point School to cater for an increased school role by students unable to attend their regular schools.

Council Welfare representatives were active throughout the community providing advice and assistance where possible. The Ministry of Social Development were engaged in providing advice to displaced residents and businesses severely impacted by the access severance.

A second public meeting was held at Kawakawa Bay on 10 September 2008 to reinforce the public danger posed by the landslide involving the mobilisation of some 300,000 to 500,000m³ of material. Further slip material had been deposited on the Clevedon–Kawakawa Road over the previous two weeks. This had not been able to be removed by the Council’s road maintenance contractor due to safety concerns for their personnel.

By this time however the weather had stabilised and the rate of movement of the landslip had slowed considerably. A stock water pond at the toe of the landslip had also been drained to alleviate concerns that this may be lubricating the slip plane.

Opus and Tonkin and Taylor Ltd investigated options for the removal of the loose surface slip material perched above the road and off to the side of the main landslip to allow single lane access to be reinstated if the rate of movement continued to reduce. Aerial sluicing utilising a helicopter and monsoon bucket presented the safest option due to the height and steepness of the adjacent slope.

Sluicing was undertaken on 16 September 2008. The material dislodged was contained within a polythene wrapped concrete median barrier bund to prevent a discharge of the water borne sediments into the adjacent coastal marine area on the down slope side of the road.

Clean up work began using vacuum trucks and took six days to complete and a further geotechnical assessment was undertaken. This assessment confirmed that the slope had gained some degree of stability. Temporary traffic signals were installed to allow restricted one way traffic past the base road slip while the slope stability was monitored with a view to re-opening the road at the earliest opportunity.



Figure 8: Sluicing in Progress

The road was re-opened to one way traffic, controlled by the temporary traffic signals, on 26 September 2008 much to the relief of the local residents for whom the novelty of the interim access arrangements had worn off. The establishment of the temporary access tracks, draining of the stock water pond, sluicing and clean up of the dislodged material were all completed under Section 330 of the Resource Management Act (as emergency works).

Permanent Solution

While all of the above initial response activities were being undertaken Council and Opus were also investigating potential alternative road alignment options to bypass the landslip in the event that the existing road was permanently closed due to a sudden catastrophic movement. Options investigated included several alignments further inland around the back of the active landslip area, but all of these had geotechnical constraints through similar unstable topography and were discarded.

A further option of re-routing the Clevedon–Kawakawa Road through a new road link several kilometres inland utilising partially formed existing forestry roads was also discarded for similar reasons. These options also did not address the threat posed to the properties in the direct path of the landslip at its base, which were being dealt with by Tonkin and Taylor Ltd on behalf of the EQC and separately by Council's Building Consents personnel.

Until the road was re-opened in late September 2008, little investigative work had been able to be undertaken to establish whether or not the entire landslip area could be treated to ensure that an adequate factor of safety could be achieved by remediation, due to safety concerns associated with working within the active landslip area. However pilot horizontal bored drains, vertical boreholes, inclinometers and piezometers were able to be installed in the landslip to establish the extent of ground water trapped and to evaluate the effectiveness of more extensive horizontal drainage in early October 2008. This also revealed multiple shear layers in the base of the landslip.

Concept plans were developed to construct a reinforced earth buttress at the toe of the landslip, utilising material removed from the top, in conjunction with horizontal bored drains to relieve ground pore water pressures. These were later supplemented with ground anchors at various levels to increase the factor of safety of the remediation measures as detailed in Figure 9.

Council were under pressure from the local communities to complete the stabilisation works as soon as practical. They were concerned that further movement of the landslip may result in ongoing road closures the following winter or during any sustained period of wet weather. Movement of the landslip had reduced considerably by mid October 2008, but the community fears were not unfounded or ignored and Council resolved to substantially complete the remediation work over the following summer.

This required a considerable number of issues to be resolved quickly, not the least being finalising the design, funding of the repairs and the completion of the works on private land.

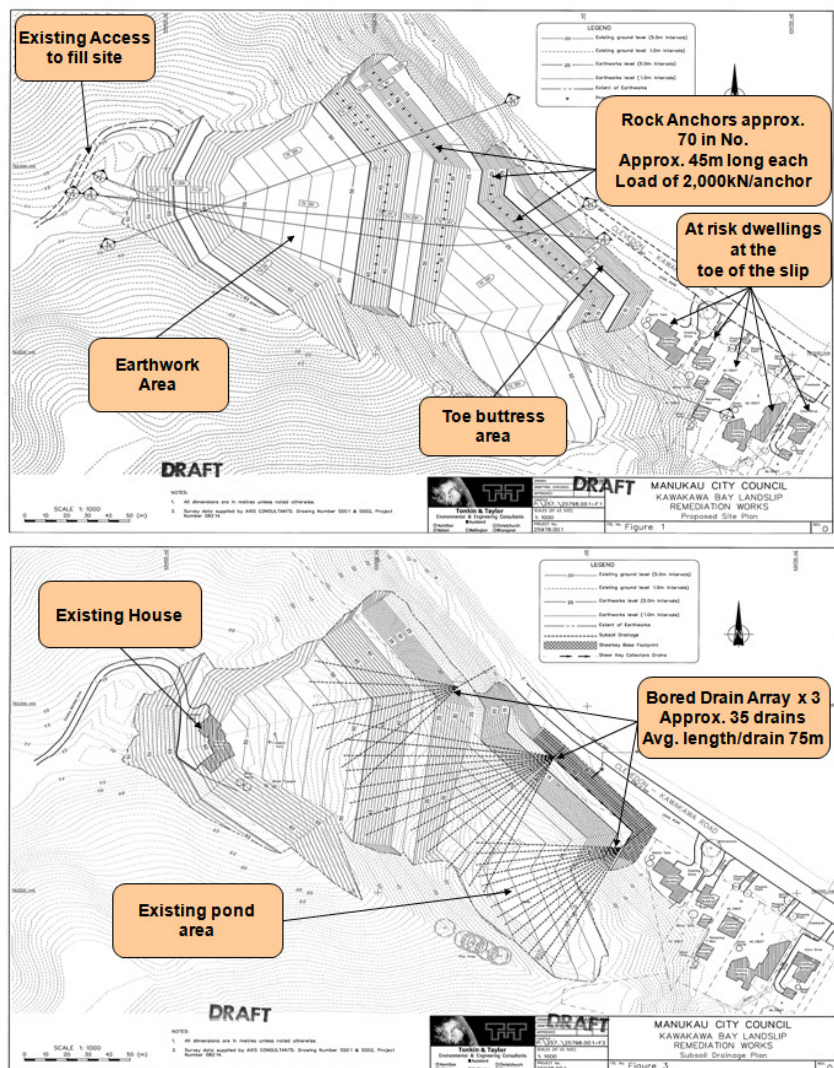


Figure 9: Concept Plans for Remediation Works

This was an extremely fluid situation which altered regularly as updated information became available. The initial estimates for the stabilisation works was \$3.5 million and was to be shared between EQC and Council, with subsidy from the New Zealand Transport Agency (NZTA) as the permanent reinstatement was to be completed as emergency works. Design work was sufficiently advanced by 5 November 2008 to allow a funding request to be lodged in LTP Online to secure NZTA funding. This incorporated:

- The removal of 66,000m³ of material from the top of the landslip.
- Constructing a shear key and reinforced earth buttress embankment 25m high at the toe.
- The installation four kilometres of horizontal bored drain arrays.
- The installation of 70 ground anchors, up to 45 metres in length with 2.4m square, 500mm thick reinforced concrete face plates capable of being stressed up to 280 tonnes.

The landslip remediation design was undertaken by Tonkin and Taylor Ltd on behalf of the EQC, while Opus coordinated the preparation of contract documentation and the funding application to NZTA. Council undertook the affected landowner liaison and community engagement in conjunction with Opus and EQC. This in itself was a complex “organisational” structure but effectively led and managed by the Council EMO.

EQC obtained approval from all five affected property owners below the landslip to allow the works to proceed. At the same time Council obtained approval from the landowner (on whose property the landslip was located) and EQC to demolish the house, re-contour the land to unload the head of the landslip, construct the buttress and utilise a separate area of their property as a disposal site for surplus cut material. In order to expedite the remedial works and ensure that the bulk earthworks were completed by the end of the 2009 earthworks season Council sought internal approval and external NZTA approval to shortlist and invite tenders for the works. A pre-tender meeting was held on 25 November 2008 with invited tenderers and draft tender documents and preliminary design drawings were issued with tenders closing on 12 December 2008. Funding confirmation from NZTA was received on 4 December 2008 which permitted Council to award the construction contract.

Council conducted a further public meeting at Kawakawa Bay on 16 December 2008 to outline the extent and scope of remedial work proposed, to advise that work was to commence in early January 2009 and to warn of the danger posed as the work progressed on the site. This was warmly received by the residents who had observed what was perceived as minimal activity on site while the design and tender process was completed. The perceived lack of activity had exacerbated fears of further potential road closures despite assurances from Council that work would be substantially completed during the 2009 earthworks season. On 19 December 2008 Council awarded the landslip remediation construction contract to Downer EDI Works for a tendered price of \$4.25m.

The increase in cost from the original estimate was primarily due to the design refinements which took place from the time that the initial concept was prepared to when tenders closed as changes were made throughout the tender process. A pre-commencement meeting was held with the contractor also on 19 December 2008 with construction set to commence on 8 January 2009.

By this time the necessity for the continued involvement of the Council's EMO was re-assessed. A conventional contractual relationship had been established between Council and Downer EDI Works with Opus providing contract management and Tonkin and Taylor Ltd providing expert advice as work was to be progressed. The EMO ceased their involvement immediately prior to Christmas 2008.

The first activity undertaken was the demolition of the adjacent landowner's house and installation of sediment and erosion control measures. Earthworks, by sub-contractor Hopper Construction Ltd began in earnest on 19 January 2009 (refer to Figure 10) in parallel with discussions with the Auckland Regional Council (ARC) regarding the preparation of a resource consent application for the works. This was to be sought retrospectively as the works were being undertaken under the emergency provisions of the Resource Management Act.

However heavy rainfall on site on 20 February 2009 caused a breach of one of the decanting bunds on the upper layer of the land being re-contoured on what was a difficult and very steep site.

This overtopped the silt fence at the base of the proposed buttress and resulted in an unintentional discharge of sediment in the Coastal Marine Area, which was reported to the ARC by the contractor. A meeting was held with the ARC on 25 February 2009 where they voiced concern with respect to the work being undertaken at Turei Hill without consent and the discharge that had occurred.

The contractor had previously prepared and implemented an Erosion and Sediment Control Plan (ESCP) and had established this in accordance with the ARC TP 90 requirements.



Figure 10: Earthworks Commencement January 2009

However the rainfall event that occurred was in excess of the TP 90 guidelines. As a consequence the contractor immediately stopped work while the sediment discharge was cleaned up, the ESCP was revised and super silt fences installed (over 1.5m in height) to allow the work to continue.

Despite this the ARC were undecided as to whether or not the work being completed fell within the emergency provisions of the Resource Management Act, while Council considered that it did and that a consent application was not required to be submitted until the physical works were completed, which were not scheduled until October 2009.

However the resource consent application was prepared in parallel with the works and lodged in June 2009, no further breaches occurred and the resource consent was obtained on 18 September 2009. A building consent was also required from the Manukau City Council for the engineered buttress fill and tensioned ground anchors. The building consent was obtained on 23 April 2009.

A further complication involved an Urupa (burial site) of significant importance to local Iwi and the Historic Places Trust. The Urupa had been identified near the toe of the landslide and the final design took this into consideration. The area was avoided and remained unmodified by the works and a blessing of the site was undertaken by local Iwi before the major earthworks commenced.

During construction the contractor encountered a number of other difficulties on site which had to be resolved as the work progressed, including:

- Poor ground conditions at the base of the buttress fill which required the re-design of the shear key and construction of a permanent pump station to dewater the toe of the fill.
- Fractured rock that made drilling the horizontal bored drains and ground anchors a slow and laborious operation.
- Constructability issues around the installation of the ground anchors that resulted in the re-design of the final contoured shape of the landslip. This increased the volume of earthworks removed to 105,000m³ but decreased the quantity of anchors required to 45, resulting in an overall cost reduction.
- Changes to the face plate design for the ground anchors with the inclusion of a greater concentration of shear reinforcement around the central area of the concrete face plate to counter the high punching shear loads transferred through the steel bearing plates for the anchor heads.
- Supply issues relating to the ground anchors which were sourced from Korea.
- Clashes between the ground anchors and the horizontal bored drains.
- Permeability of the ground strata that required the pre-grouting of the anchor holes.

Given the timeframe for the investigation and design work prior to tendering the construction contract (early October 2008 until the end of November 2008) it is not surprising that the above issues were encountered and had to be addressed. The compressed timeline resulted in compromises being made to expedite the remedial works.

The complexities of the site and time required for extensive investigation were overridden by the urgency and imperative to secure access to the communities prior to the onset of the 2009 winter season. In addition the five affected properties below the landslip would again have to be evacuated if an adequate factor of safety could not be achieved in time.



Figure 11: Earthworks and Bored Drainage March 2009



Figure 12: Toe Buttress Under Construction April 2009

Despite the above challenges the bulk earthworks to construct the buttress fill embankment, and the disposal of the excess material to the landfill site contained within the adjacent landowner's property were completed by the end of June 2009, (including the 39,000m³ of additional material removed from the top of the landslip as a result of the re-design associated with constructability of the ground anchors).

The surface of the re-contoured slope was stabilised with straw mulch and hydro-seeded to prevent sediment runoff over the 2009 winter. Site progress is illustrated in Figures 11, 12 and 13. The majority of the horizontal bored drains were also installed by the end of June 2009 and this, in conjunction with the completion of the earthworks and the toe buttress fill, restored the factor of safety and minimised the risk of further movement occurring and hence the residents in the properties below the landslip were permitted to remain in residence. Installation of the reduced number of ground anchors commenced in July 2009 (refer to Figure 14) and were substantially completed by December 2009, two months later than anticipated due to the anchor supply delay experienced by the contractor.



Figure 13: Toe Buttress Completion May 2009



Figure 14: Rock Anchors Being Installed August 2009

Overall the completion of the landslip remediation work, managing the earthworks and drilling of the horizontal drainage and ground anchors on a very steep and confined site, while maintaining the safety of the workers and public alike was a daunting task for the contractor.

Conclusions

The success of the landslip remediation works at Turei Hill was not driven by the engineering, which in itself was technically demanding on a very difficult site. And it was not driven by the navigation of the complex funding stream through the tripartite organisations involved and similar complex land ownership and liability issues. The real success came from the way the community concerns and effects were managed by Council in the early phase of the emergency.

Establishment of the Council's EMO to coordinate and lead the activities of the participants at this time was a major influence on the outcome achieved and should be considered by other Council's when faced with similar situations. Community concerns with respect to potential ongoing road closures, or complete severance and the economic impact that this would have, was of paramount importance to all involved with the EMO operation. This provided the impetus to expedite the design and construction process for the remediation measures in parallel with the investigation of various alternative options and saved valuable time. It also reinforced for all involved what can be achieved by a motivated group of people working towards a common goal.

This is not without pitfalls and in normal circumstances there is a greater lead time to develop a more robust solution which leads to greater certainty of final costs, a factor that was considered by Council but overridden by the imperative to restore community access and security for the affected landowners. Again the balance needs to be considered by other Councils when confronted with similar circumstances.

Also the seriousness and urgency of the initial road closure was recognised by Council at the outset and action plans were developed as a matter of priority to address these concerns. These included establishing effective communication through a variety of media from the beginning and putting in place alternative transport arrangements rapidly, which assisted in maintaining Councils credibility within the communities affected.

Regional Councils also need to be involved as early as possible in emergency events as they struggle to comprehend how these fit within the normal Resource Management Act consent processes. This was particularly relevant in this instance where the emergency extended well beyond the initial incident that closed the Clevedon–Kawakawa Road. The landslip was likely to cause loss of life, injury or serious damage to property, was very real and needed to be conveyed at an early stage and this needs to be reinforced to all Councils that find themselves in similar predicaments where there is an “ongoing emergency”.

Council's response to the emergency at Turei Hill, which had the potential to result in disastrous consequences for the communities affected if they had chosen to respond differently, was well managed and appropriate for the circumstances.

Acknowledgements

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Author Biographies

Mark Faulkner is a Chartered Professional Engineer and Project Manager with 30 years experience working throughout New Zealand primarily in the road network and asset management arena for local authorities and the New Zealand Transport Agency. He has also worked on a variety of other projects, including water and waste water schemes, parks developments, wharves and sea walls and tunnelling projects in both New Zealand and the United Kingdom. Mark has been a Member of Ingenium since 1999.

Greg Saunders is also a Professional Engineer and Project Manager with 20 years experience working in New Zealand for local authorities and the New Zealand Transport Agency delivering a range of road maintenance and capital development projects. Greg has been a Member of Ingenium since 2003 and is Engineer to Contract for the Turei Hill Landslip Stabilisation works.