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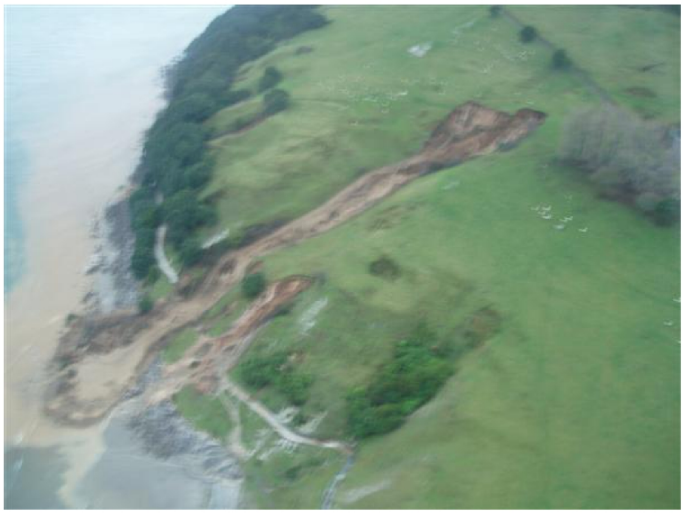
# Report on: Mauao Slopes

# May 2005 Flood damage &

# Slope remedial works



## Client: Tauranga District Council

## August 2005

**Avalon Report No: 0534 B**

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# EXECUTIVE SUMMARY

In May 2005 a 150 year return period extreme rainfall event occurred in Tauranga causing significant regional flood damage.

Mauao's tracks and slopes suffered extensive rockfall, surface scour and over forty individual slips and dropouts.

The largest single mass slip involved an estimated 8,000m$^3$ of material. The next largest was around 250m$^3$.

TDC commissioned Avalon to investigate resulting rockfall and landslip hazards and risks, carry out emergency remedial works and record the damage.

This report provides a factual record of the slopes flood damage and associated remedial works.

Separate reports assess the hazard and risks associated with mass slips and rockfall over the campground and hotpools.

# CONTENTS



# 1 INTRODUCTION

Avalon specialises in Geotechnical Engineering consultancy and contracting services in difficult and high access environments.

Avalon has carried out a number of engineering geological investigation and rockfall hazard/risk assessments on Mauao on behalf of Tauranga District Council (TDC), since February 2003. These included; Post fire upper slopes hazard assessment [1], Numerical rockfall risk assessment [2], earthquake damage report and risk reassessment [3].

On 18th May 2005 Tauranga received 350mm of rainfall in 24 hours and the region experienced extensive flood damage.

Mauao's tracks and slopes suffered extensive rockfall, surface scour and over forty individual slips and dropouts.

The largest single mass slip involved an estimated 8,000m³ of material. The next largest was around 250m³.

Following this extreme rainfall event s 7(2)(f)(ii) of TDC contacted s 7(2)(a) Privacy s 7(2)(a) – Privacy with Avalon and commissioned investigation of flood damage and assessment of associated hazards.

Site works commenced the following week with approval of Tangata Whenua.

Towards the end of the flood damage remediation works, on 22nd June, after a day of heavy rainfall, a 2-3m diameter boulder rolled approximately 25m down slope and came to rest adjacent to the campground boundary fence. This prompted a detailed investigation and report of potential rockfall hazards above the southern campground/hot pool area and is reported separately [4].

The rockfall risk/hazard to the southern campground has been reassessed and reported separately [4].

A preliminary hazard and risk analysis for mass slips from Mauao's lower colluvial slopes is underway and will be reported in due course [6].

This report intended to be read in conjunction with the following reports [1, 2, 3, 4, 6].


1 Avalon Industrial Services Ltd. Mauao Rock Slopes & Rockfall Hazards. Report to TDC, 12 July 2003.

2 Avalon Industrial Services Ltd. Mauao Rockfall Hazards; Risk Assessment & Management. Report to TDC, 26 June 2004.

3 Avalon Industrial Services Ltd. Mauao Slopes Earthquake Damage and Revised Risk Assessment. Report to TDC, 26 July 2004.

4 Avalon Industrial Services Ltd. Mauao Slopes Zone 6 Hazard Assessment. Report to TDC, 28 July 2005.

5 Avalon Industrial Services Ltd. Mauao Slopes 2005 Flood Damage & Slope Remedial Works. Report to TDC, 2 August 2005. This Report.

6 Avalon Industrial Services Ltd. Mauao Slopes 2005 Preliminary colluvial Mass Slip Assessment & Revised Risk Assessments. Report to TDC, Not yet completed.

# 2 THE MAY 2005 RAINFALL EVENTS

Rainfall data was obtained from NIWA for the nearest weather monitoring site, Tauranga Airfield, approximately 5km from Mauao.

On the 18th may the rain gauge recorded the following peak accumulations:

| 1hr | 2hrs | 3hrs | 6hrs | 12hrs | 24hrs |
|---|---|---|---|---|---|
| 58.0mm | 97.8mm | 133.4mm | 191.2mm | 255.0mm | 346.8mm |
| 75yrs | >150yrs | >150yrs | >150yrs | >150yrs | >150yrs |

The lower data row gives NIWA's calculated return periods.

The peak 1hr rainfall was 75yrs return period. The return period for all other accumulations was given as >150 years.

Two weeks earlier, on the 4th may, the following peak data was recorded:

| 1hr | 2hrs | 3hrs | 6hrs | 12hrs | 24hrs |
|---|---|---|---|---|---|
| 67.0mm | 83mm | 89.2mm | 108.8mm | 130.2mm | 144mm |
| 140yrs | 105yrs | 80yrs | 45yrs | 30yrs | 10yrs |

The two week period between these two major events was relatively dry, with no rainfall from the 5th to the 15th. However, 29.4mm fell on the 16th May and 5.6mm on the 17th.

Tauranga experienced its wettest month for any time of the year in more than a century, 700% of normal and had its heaviest 1 day rainfall ever on the 18th.

# 3 REGIONAL AFFECTS OF THE MAY 2005 RAINFALL

From the NIWA National Climate Summary:

> "3-4 May Torrential rainfall resulted in serious widespread flooding in Tauranga, especially in Otumoetai, Arataki, and Omanu. Many homes and businesses were flooded, with water a metre deep in areas, and emergency services were stretched to the limit. Rainfall totalling 144 mm was measured at Tauranga Airport in the 24 hours to 8am on the 4th. Heavy rainfall occurred between 3pm and 11pm on the 3rd, during which time there was 1-hour with rainfall totalling 67 mm. High rainfall also affected other sites in Bay of Plenty, as well as Hawke's Bay, on the same day, many locations recording 75-100 mm.
>
> 17-18 May A phenomenal, unprecedented high-rainfall flood-producing event affected Bay of Plenty, particularly from Tauranga to Matata. Heavy rainfall occurred between 11pm on the night of the 17th and 8pm on the night of the 18th, during which time there were 6-hours with rainfall exceeding 30 mm per hour, and one hour with 58 mm. Tauranga Airport recorded a massive 346.8 mm of rainfall in 24-hours. This was well above any other daily rainfall total there in records which commenced in 1910, but comparable with those recorded for shorter durations on 17 April 1948, when 95, 146 and 212 mm was recorded in 1, 2 and 6 hours respectively. Rainfall totalling 94.5 mm in one hour was reported at Awakaponga, inland from Matata. The New Zealand low lying land-station record was 109 mm in an hour recorded at Leigh (north of Auckland) on 30 May 2001.
>
> High rainfall totals in Bay of Plenty for the mid-May rainfall event were:
> Location Rainfall, mm 48 hours to 9am 19 May
> Tauranga Airport 370
> Te Puke 187
> Whakatane Airport 127
>
> Some of the effects of the storm were:
>
> A state of emergency was declared on 18 May in Tauranga and Matata. There were hundreds of calls for emergency services. Police and army personnel assisted evacuations, while fire fighters pumped water from homes. Emergency personnel were also called in from outlying districts. About 450 people were evacuated for Tauranga, Papamoa, and Matata. In Tauranga, several city homes were destroyed by mudslides and floodwaters and rising waters threatened hundreds of others. The airport was closed by flooding.
>
> Landslides threatened several homes and over a hundred residents were evacuated. More than 40 houses in Papamoa were evacuated. Many residents described the scene in Tauranga as a "disaster zone". Several of the Tauranga houses had to be demolished. Flooding was extreme in Matata, where a stream became a torrent of water, mud, huge boulders, and debris.
>
> Approximately 200 of the towns 500 people were evacuated. Houses were pushed off their foundations, nearly 100 being damaged, many motor vehicles were swept into the lagoon, some buried. Children were trapped in schools. One family became trapped in the roof of their home. Two houses and several caravans were swept out to sea. Railway lines were buckled, and about 20 motorists trapped. Parts of roads and two bridges near Matata on SH 2 were washed away. There was no drinking water supply."

In addition to these regional effects the high rainfall had significant effects on Mauao including mass soil slips in the colluvium on the lower slopes and gully scour effects on the upper slops and tracks.

# 4 MAY 2005 RAINFALL; AFFECTS ON MAUAO

## 4.1 General.

Immediately following the 18th May event TDC closed public access for safety reasons.

Numerous soil slips had occurred on the lower slopes, many of which had destroyed areas of track, particularly the Base Track. Remaining slip crests were up to 5m in height, overhanging and prone to further failure. Much of the lower slip debris was highly saturated silty sand; essentially a quicksand.

There was evidence of fresh rockfall from the steep upper slope areas. In some areas fresh rockfall littered the slope surfaces.

Many track surfaces were severely gullied and in need of repair. The majority of the shell surfacing was washed off the base track.

A water main had been cut by one of the slips and access up the 4WD track was lost.

## 4.2 Slips on the lower colluvial slopes & track cuts

Although some slips were entirely in the 'natural' slopes many were immediately above the trackside cuts where stability was reduced by removal of toe support. A total of around forty individual slip sites were noted of which thirty were at least partly influenced by the trackside cuts.

The slipped material was generally sandy but locally contained significant boulders and/or had a significant silt and clay fraction.

The majority of the slips were relatively small, involving only a few cubic metres.

The largest single slip however, between the Base and 4WD tracks in the south west, was much larger than any others (see photograph below) and alone involved around 8,000m3.

The next largest single slip was estimated as 250m3. The total volume of slip debris is estimated as being in the vicinity of 10,000m3.

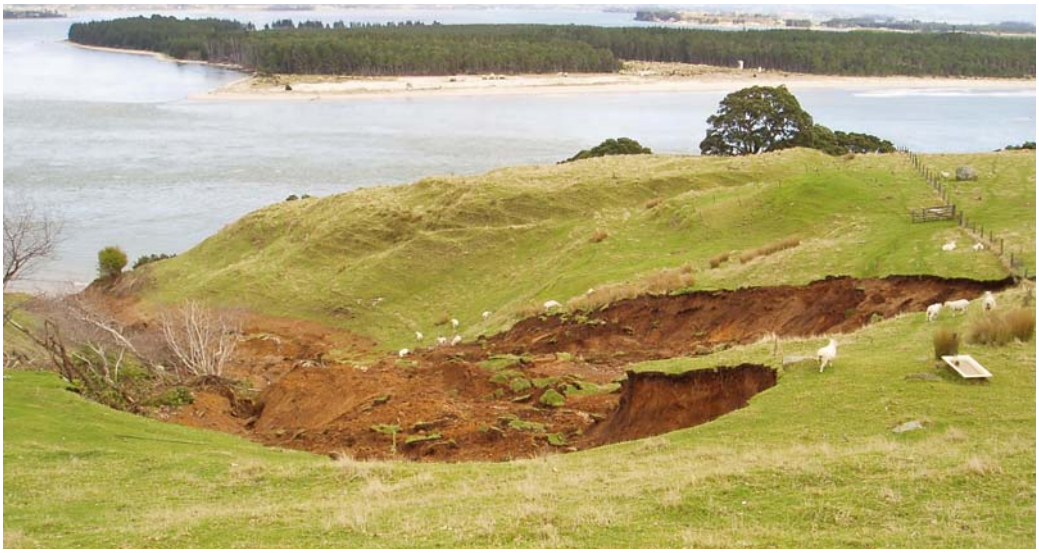
Although some slip debris travelled below the high tide mark much remained on the slopes and of this some material had come to rest in marginally stable positions. In places loose rocks and boulders littered the grass surface, particularly in the grouping of slips on the south eastern slopes.

A slip on the south eastern area above and below the 4WD track cut the council water main running from the concrete tank and temporarily prevented vehicle access to upper areas of Mauao.

Over thirty slips blocked the Base track. 4 slips affected the lower 4WD track. Three slips affected the campground and beach boardwalk.

Many of the affected areas are the sites of historical Maori earthworks & middens and are of archaeological interest.

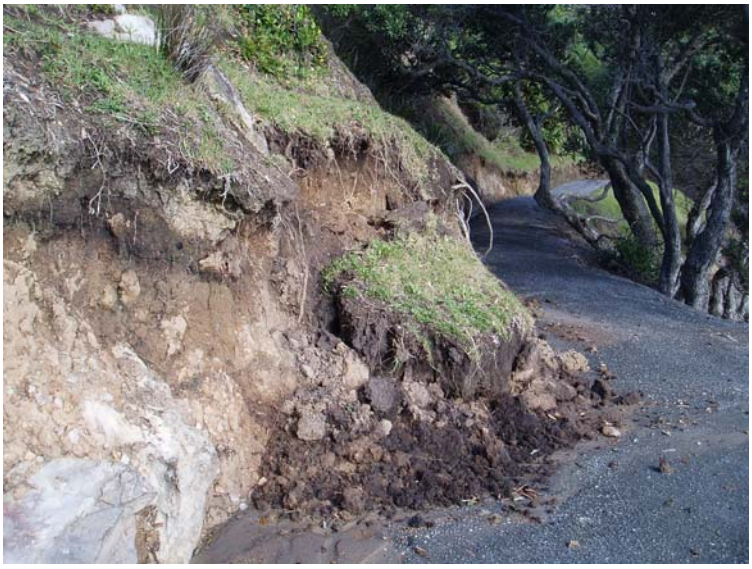


Photograph 1.The largest single slip, est 8,000m3 (Item 34).

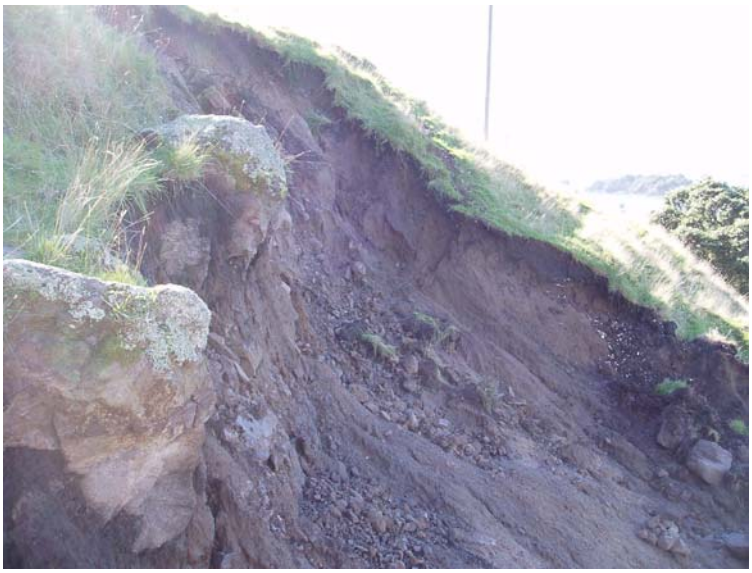
Photograph 2.Debris flow from above (left) and slip 34 (right).

Photograph 3.Slip onto farm track also released boulders to 4WD Track (Item 34).

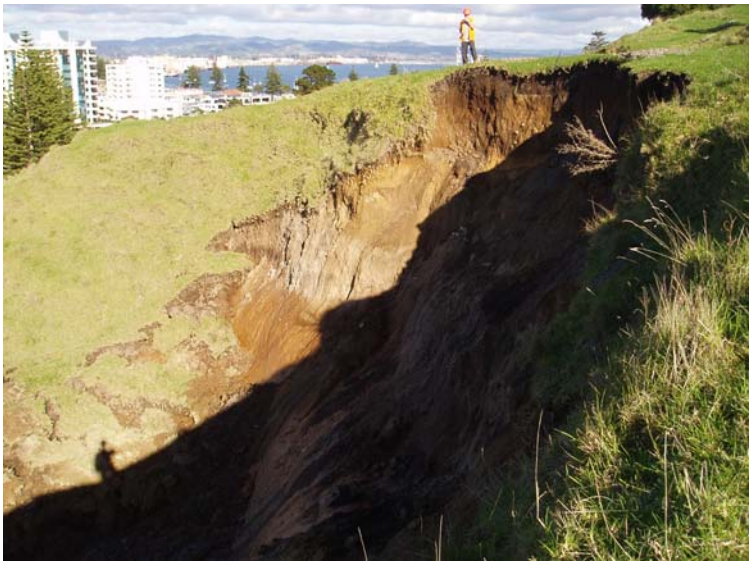
 



Photograph 4.Typical Base Track cut slip (item 31).



Photograph 5.Slip in colluvium with boulders over 4WD Track (item 8).



Photograph 6.Slip in colluvium above campground (item 34).

## 4.3 Effects on the upper slopes & rock bluffs

The soil surface material on many of the upper slopes is a loose sandy (wind blown) matrix containing angular fragments of rock (rockfall & weathering debris) typically 100 to 300mm diameter.

As noted in previous reports this material can be particularly susceptible to erosional scour if it looses the binding effect of plant roots. Sand washes away resulting in gullied areas and accumulations of marginally stable rock fragments build up which become the source of occasional rockfall.

The potential for increased rockfall resulting from scour has been of serious concern since the January 2003 fire. An annual rock scaling programme had been recommended to manage the rockfall hazards. Prior to the May 2005 floods the recommended scaling was only carried out on one occasion, in March 2003.

Since the fire the vegetation has slowly been re-establishing with the help of planting by TDC.

The May 2005 surface runoff was obviously significant and despite the relatively permeable nature of the colluvium the ground in many places became highly saturated. There was a significant amount of scour generated rockfall. Existing gullies were further eroded and new channels formed. After the rainfall the amount of extremely loose surface rock had increased very significantly in many areas.

Since 2003 Avalon has been monitoring 5 locations on the top of selected rock bluffs. Survey benchmarks are installed to reveal any mass movement. These were re-surveyed as part of the post flood inspection and no significant mass movement was detected.

## 4.4 Effects on the upper tracks

The tracks showed some evidence of rockfall; fresh rock sat on the tracks and occasional impact marks, however, most tracks became gullies watercourses during the event and much rock must have been washed away along with the track surfacing.

Exactly how much rockfall occurred is difficult to determine as the runoff will have removed much of the evidence. A few larger rocks were found at rest on the tracks. Hundreds of rocks under 150mm appear likely to have crossed the Oruahine track in the North Western areas.

Eight Slips affected the upper 4WD track. The track was completely blocked by slip debris from slips in the oversteepened cut made in the colluvium to form the track.

The upper 4WD track was severely gullied and again much of the surfacing metal was washed away.

Photograph 7.Typical scour above Oruahine Track.

Photograph 8.Fresh rockfall onto Oruahine track.

Photograph 9.Scour high on bluff above campground.

# 5 SCHEDULE & LOCATIONS OF THE MAY 2005 SLIPS

Descriptions of the individual items and initial remedial action recommendations are contained in the schedule below. Please note that this schedule is essentially site notes taken during the first walkover.

The following photographs, 10 to 13, show a 2003 aerial view with locations of the slip items superimposed.

For more photographs of individual items refer to Avalon photograph set 0534; 24 & 25 May 2005.

SITE NOTES FORMAT SCHEDULE OF SLIPS:

| *Slip/item No* | *Site Notes Description* | *Possible Remedialtion* |
|---|---|---|
| 1. | Dropout below Pilot Quay sealed road. 15m long. Head wall up to 3m high and over steep at 80˚. 60mm dia plastic pipe exposed. | Fence. Reform with gabion wall. |
| 2. | Dropout. Circular slip below 4WD track at culvert location. Slip surface 6m wide x 10m long x up to 3m deep. Slip in road fill, water main trench fill and underlying colluvium. Culvert was clearly taking very high flow at time of slip (possibly backing up). At time of Avalon site visits flow remained significant. Material released included boulders and swept down to shoreline across pilot quay parking area. A slip in this location above the 4WD track level is evident in an aerial photo but had been excavated by Avalon's 1st site visit (24 May). Springs are present in this vicinity. | Temporary reform 4WD track by cutting back into slope. This work underway 25th May. Fence. Reinstate culvert & drainage. Reinstate water main & associated services. Reinforce slope. Seed. |
| 3. | Slip immediately above 4WD track (lower 2m is in cut slope). 8m wide x 6m long x up to 3m deep. Sandy colluvium (little rock, no boulders). Debris flowed across base track to shoreline. Slip surface appears to be paler brown slightly harder & clayey surface (weathered ash layer) below (wind blown) sand. The clay layers lower permeability directed flow and daylighted at 4WD track level. Tension cracks in surface above up to 2m back from crest. | Clear debris from track. Reprofile back to tension cracks as far as possible. Monitor crest for new tension cracks. Seed. |
| 4. | 10m up 4WD track from 3. Smaller slip with similar characteristics to item 3. 2 x 2 x 1m. | Clear debris from track. Minor reprofiling. Seed. |
| 5. | Slip 40m (up slope distance) above 4WD track. 2 x 2 x 1.5m. Slip in colluvium. Debris including rock swept onto 4WD track. | Scale rock debris & slip surface. Seed. |
| 6. | Slip 75m (up slope distance) above 4WD track. 6m wide x 5m up slope x 2m deep. Slip of colluvium from above paler less permeable & denser clayey surface. Colluvium appears to locally have been 50% rock. Debris including boulders crossed onto 4WD track. One 0.6m3 (800mm) boulder came to rest adjacent to track (photo). At least 3 boulders of 0.15m3 (500mm), 10 rocks of 0.03m3 (300mm) and much smaller debris crossed the 4WD track. | Scale rock debris from slip and debris slope & locally re-profile slip crest. Seed. |
| 7. | Slip 100m (up slope distance) above 4WD track. 2m wide x 2m up slope x 1m deep. Moderate seepage. Debris including rock swept onto 4WD track. One 0.6m3 boulder at rest on slope 6m below slip scar. Other debris spread below. | Scale rock debris from slip and debris slope & locally re-profile slip crest. Seed. |

| | | |
|---|---|---|
| 8. | Slip 120m (up slope distance) above 4WD track. 3m wide x 3m up slope x 1m deep. Debris including rock swept to 4WD track. Some rock & boulders at rest on old farm track mid slope. Boulders in unstable positions on slip scarp. | Scale rock debris from slip and debris slope & locally re-profile slip crest. Seed. |
| 9. | Slip in scrub 180m (up slope distance) above 4WD track. 4m wide x 3m up slope x 1m deep. Slip of colluvium from above paler less permeable & denser clayey surface. Debris including rock swept into paddock below. | Scale rock debris from slip and debris slope & locally re-profile slip crest. Seed. |
| 10. | Slip from crest of cut slope behind water tank. 3 x 4 x 3m. Tank side barrier was effective and trapped debris. | Locally re-profile slip crest. Remove destabilised tree. Clear debris from barrier. Seed. |
| 11. | Slip above Base track. 2m wide x 10m high x 2m deep Debris flowed over base track to shoreline. This slope is steep and is formed on old slip surfaces. Base track cut removed toe support. | Monitor for tension cracks. Clear debris from track. Seed. |
| 12. | Slip above Base track adjacent & similar to 11. 8m wide x 4m high x 1m deep | Locally re-profile slip crest. Clear debris from track. Seed. |
| 13. | Slip above Base track adjacent & similar to 12. Tension crack 10m wide x 5m high. Slipped 20mm then locked. | Install drainage to keep surface runoff out of crack. Seed. |
| 14. | Slip 15m above Base track. 5m wide x5m high x 3m deep. Debris flowed over base track to shoreline. This slope is steep and is formed on old slip surfaces. | Locally re-profile slip crest. Clear debris from track. Seed. |
| 15. | The large slip on the paddock slope between the 4WD track and the Base track west of the water tank. 70m wide x 100m down slope x 4m deep. West side appears to be a planar slide on one of the paler ashy/clay layers. East side appears to be a deeper circular slip mechanism. Water flow of over 1l/s in base on 24 May. Locally cuts through shell middens. A rear tension crack links the two crest sides. The debris flow included a number of trees & root masses. The bulk of the debris swept over the base track and out into a fan on the beach. This failure and debris movement was obviously very rapid. Note: The silty wet debris on the beach is locally over 1m deep and is very easily liquefied; quicksand. Steps should be taken to ensure persons do not access. | Fence well back from rear tension crack. Monitor for new tension cracks. Re-profile slip crest by hand (not safe for machine). Clear debris from lower areas and track as necessary. Seed. |
| 16. | Minor cut slip immediately above 4WD track. 4m wide x 2m high. Approximately 40m above base track. | Clear as necessary & seed. |
| 17. | 12m wide x 20m down slope x up to 4m deep. Slip surface is on one of the paler ashy/clay layers. Approximately 30m above base track. Debris ran out over Base track. West side cuts shell midden. | Reprofile slip crest & clear base track. Seed. Paddock is due to be fenced. |
| 18. | Two adjacent slips. 5m wide x 10m down slope x up to 2m deep and 3m wide x 5m down slope x up to 1.5m deep. Approximately 40m above base track. Rejuvenated slip in over steep slope (as all in this vicinity). Tree and root mass incorporated in debris. | Reprofile slip crest & clear base track. Paddock is due to be fenced. Tree can be left as is. |
| 19. | Rejuvenated slip 6m wide x 2m deep. Approximately 50m above base track. Debris swept onto base track. | Reprofile slip crest & clear base track. Seed. Paddock is due to be fenced. |
| 20. | Shallow slip in steep slope immediately over base track. | Approx 5m3 debris to clear from track. Lightly scale surface. Seed. |
| 21. | Minor slip in steep cut slope immediately over base track. | Approx 2m3 debris to clear from track. Seed. |
| 22. | Minor slip in steep cut slope immediately over base | Approx 1m3 debris to clear |

| | | |
|---|---|---|
| | track. | from track. |
| 23. | Minor slip in steep cut slope immediately over base track. | Approx 1m3 debris to clear from track. |
| 24. | Minor slip in steep cut slope immediately over base track. | Approx 1m3 debris to clear from track. |
| 25. | Minor slip in steep cut slope immediately over base track. | Approx 2m3 debris to clear from track. |
| 26. | Tension crack at very low level immediately over base track. 5m wide x 2m high x 1m deep. | Monitor |
| 27. | Minor slip in steep cut slope immediately over base track. | Approx 1m3 debris to clear from track. |
| 28. | Minor slip in steep cut slope immediately over base track. | Approx 1m3 debris to clear from track. |
| 29. | Minor slip in slope immediately over base track.<br>5m wide x 2m high | Debris to clear from track. |
| 30. | Slip 25m above base track.<br>5m wide x 5m high x 2m deep. | Minor crest reprofiling & lightly scale surface. Approx 10m3 debris to clear from track. Seed. |
| 31. | Minor slip in steep cut slope immediately over base track. | Approx 1m3 debris to clear from track. |
| 32. | Slip in slip over base track.<br>5m x 5m x 2m. | Approx 10m3 debris to clear from track. Minor crest reprofiling & lightly scale surface. Seed. |
| 33. | Shallow surface slips immediately above base track. Above old stone retaining wall.<br>10m x 5m. | Minor debris to clear from track. Light reprofiling if necessary. Seed. |
| 34. | Rejuvenated slip 15m wide x 20m down slope x 5m deep. Approximately 25m above base track. Overhanging topsoil above v steep headwall. Evidence of layering in old colluvium. Debris swept onto base track. Crest of slip is encroaching on access track. | Re-route access track approx 4m back from present position. Reprofile slip crest; approx 2m to cut back. Fence. Clear base track. Seed. |
| 35. | Shallow surface slips immediately above base track.<br>6m x 6m x 1m. | Debris to clear from track. Seed. |
| 36. | Minor shallow surface slips & tension cracks on side of gulley above steps track. | Debris to clear from track. Seed. |
| 37. | Slip in steep slope immediately above base track.<br>4m wide x 8m down slope x 3m deep.<br>Slip of old colluvium from above paler less permeable & denser clayey surface. | Reprofile to remove overhanging crest.<br>Debris to clear from track.<br>Seed. |
| 38. | Slip in slope immediately above Waikorere/Oruahine track junction & lighthouse. 15m wide x 20m down slope x 2m deep. Debris has mostly locked up after a few metres slip. Slip of old colluvium. | Debris to clear from track. Seed. |
| 39. | Minor slip in trackside cut slope immediately above upper 4WD track. 4m wide x 1.5m high. | 2m3 debris to clear from track. Seed. |
| 40. | Upper section of 4WD track (to hairpin) has deep rain scour channels requiring filling and surface rocks to clear. | Add metal and reform track surface. |
| 41. | Slip in trackside cut slope immediately above upper 4WD track.<br>6m wide x 4m high. | 20m3 debris to clear from track. Tree to clear & minor reprofiling of slip crest plus scale occasional boulder. Seed. |
| 42. | Minor slips in trackside cut slope immediately above upper 4WD track. | 10m3 debris to clear from track. Minor reprofiling of slip crest plus scale occasional boulder. Seed. |
| 43. | Slip in trackside cut slope immediately above upper 4WD track. | 10m3 debris to clear from track.<br>Minor reprofiling of slip crest. |

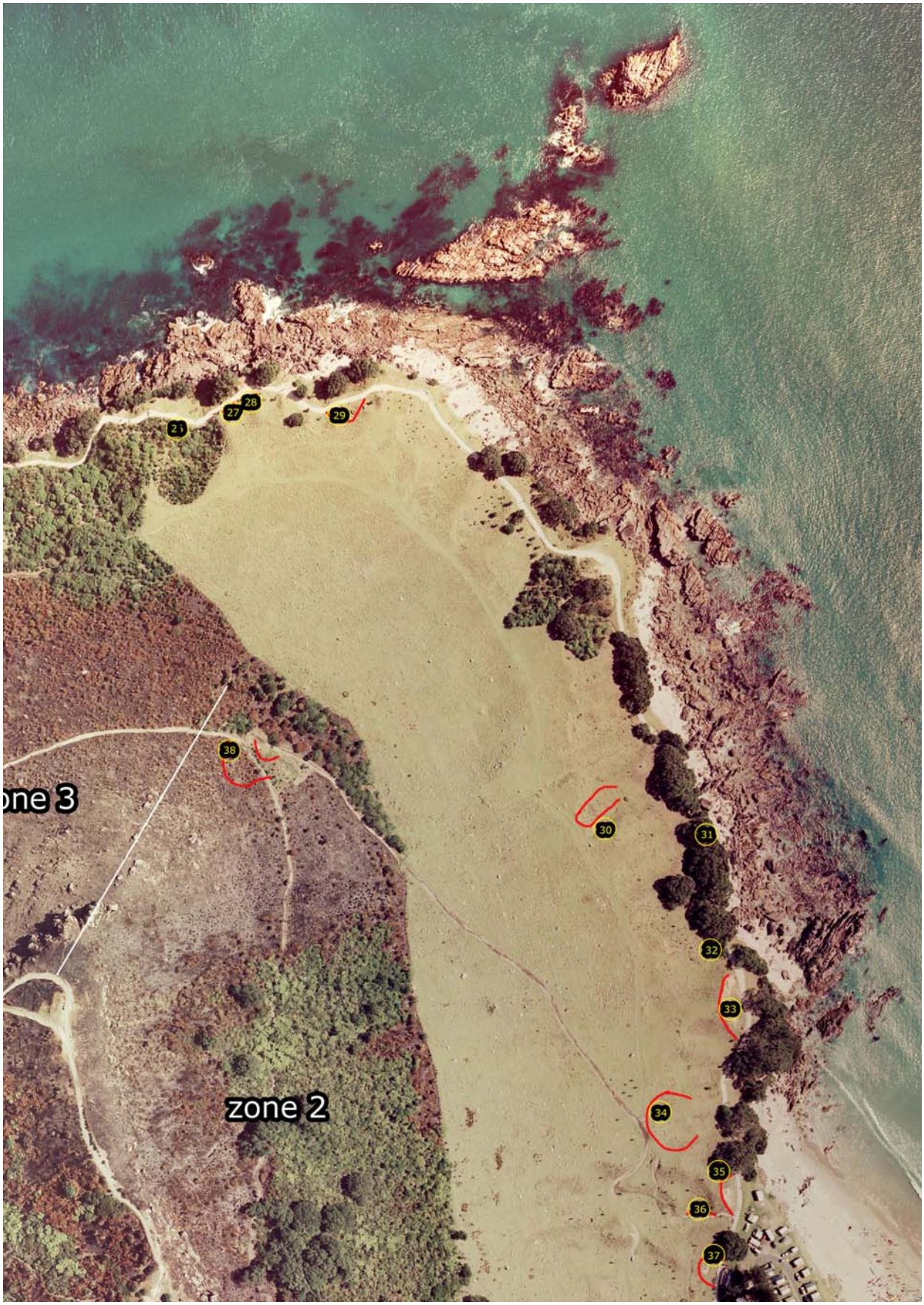
 

| | | |
|---|---|---|
| | | Seed. |
| 44. | Slip in trackside cut slope immediately above upper 4WD track.<br>6m wide x 4m high. | 15m3 debris to clear from track.<br>Minor reprofiling of slip crest.<br>Seed. |
| 45. | Slip in trackside cut slope immediately above upper 4WD track.<br>10m wide x 4m high. | 15m3 debris to clear from track. Minor reprofiling of slip crest plus scale occasional boulder. Seed. |
| 46. | Slip in trackside cut slope inside hairpin bend on 4WD track.<br>6m wide x 4m high.<br>Further slippage could encroach on road. | Fence to keep traffic away from potentially unstable edge.<br>5m3 debris to clear from track.<br>Consider remedial slope reinforcement options to prevent further slips. |
| 47. | Slip in trackside cut slope immediately above upper 4WD track. 4m wide x 3m high. | 5m3 debris to clear from track.<br>Perhaps very minor reprofiling of slip crest. Seed. |
| 48. | Slip onto base track<br>10m3 | Debris to clear from track.<br>Seed. |
| 49. | Slip onto base track<br>10m3 | Debris to clear from track.<br>Seed. |
| 50. | Slip onto base track<br>20m3 | Debris to clear from track.<br>Seed. |
| 51. | Slip onto base track<br>2m3 | Debris to clear from track.<br>Seed. |
| 52. | Slip onto base track<br>2m3 | Debris to clear from track.<br>Seed. |

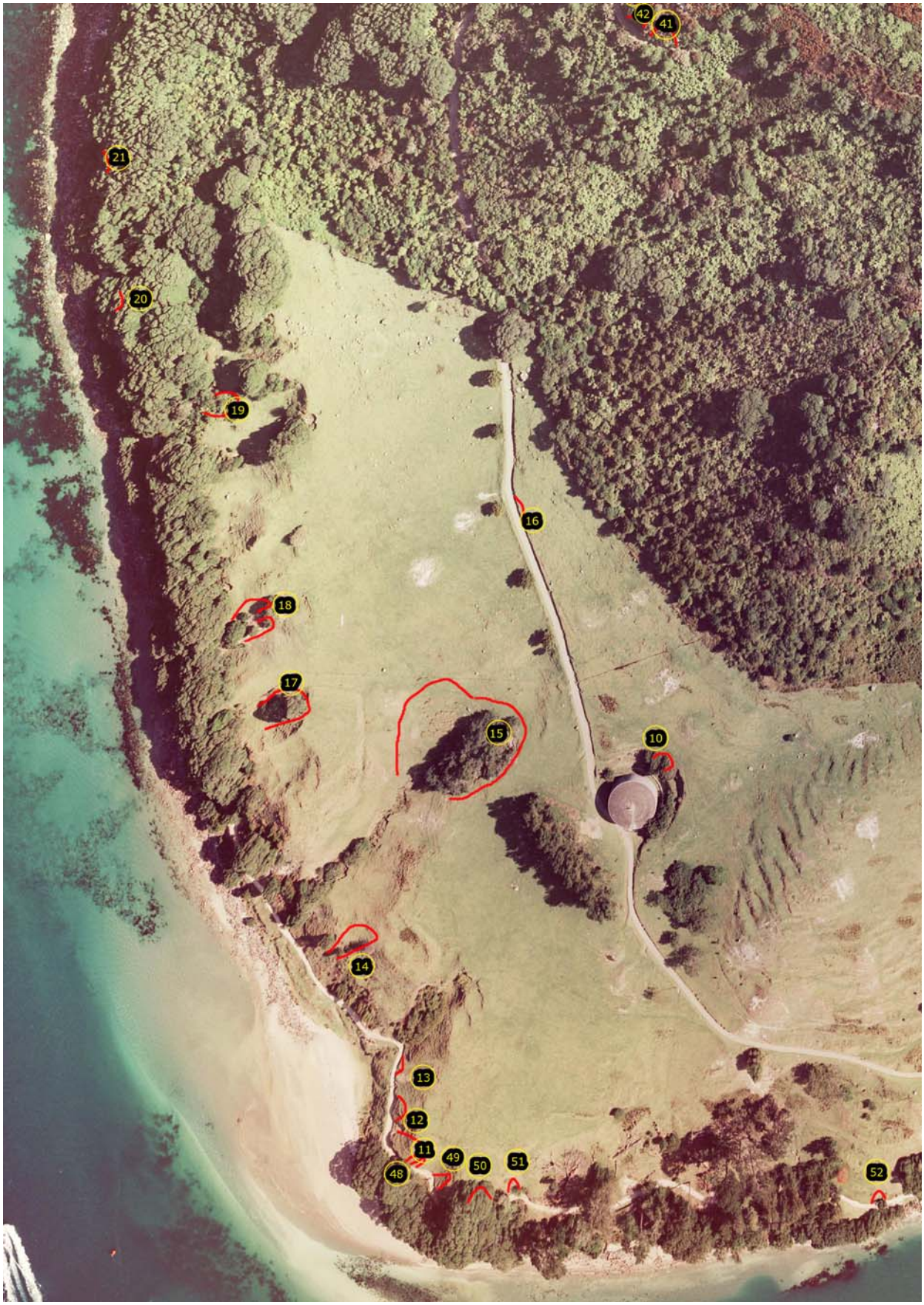

Photograph 10. North West Mauao Slip locations.




Photograph 11. North East Mauao Slip locations.




Photograph 12. South West Mauao Slip locations.


Photograph 13. South East Mauao Slip locations.

# 6 MAY & JUNE 2005 EMERGENCY SLOPE REMEDIAL WORKS

Within the few days following the slips TDC's contractors had commenced the clearing and minor realignment of the lower 4WD track in the vicinity of slip items 2, 3 & 4.

Hand scaling of loose surface rock from the steep areas above the tracks was clearly going to be highly advisable before the tracks could be reopened to the public.

Scaling was required immediately to clear hazards presented by marginally stable slip debris immediately above the area of the 4WD track where the water main was lost. Contractors needed to safely work here to re-establish the town's water supply as soon as possible.

Scaling was agreed in consultation with tangata whenua and this work was commenced by Avalon in the week following the floods.

The scope included safely accessing (using industrial roped access techniques) all areas affected by slips and scour and removing as much marginally stable and loose surface rock as practicable by hand without using tools. The rock to be removed was that which would easily be disturbed and could create hazardous rockfall due to a person walking over the slope.

Occasional larger hazards were encountered which required the use of crowbars although scaling of these was kept to a minimum.

The crests of the larger soil slips on the lower slopes were reprofiled to eliminate the hazards presented by overhanging topsoil, the main danger being to persons who might out of interest walk to the edge to look into the slip.

This was achieved manually using spades and was kept to a minimum (topsoil only, overhangs removed by no more than 500mm of cut at 45˚, generally nearer half this). This work was coordinated with TDC's archaeological consultant.

The clearing of the bulk slip debris from the lower slopes, base track and 4WD track was commenced by machine by the council's contractors in the week following the slips.

All slip debris cleared from the slopes remained on site and fill placement areas were established in the southern area of the camp ground in coordination with Environment Bay of Plenty.

Minor stabilisation work was undertaken to Slip item 46 (approximately 50m2 in area), on the hairpin corner of the 4WD track. The aim of this work was to reduce the possibility of further slippage which could block access to the summit and which would be inconvenient and more expensive to rectify in future. The area is to be reinforced with soil nails, erosion control matting and rockfall mesh reinforcement prior to replanting.