Reconnaissance of landslide and flood damage in the Gisborne area caused by the 2005 Labour Weekend Storm

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ABSTRACT

The Labour Weekend storm event was generated by a low pressure system that travelled southeast across the East Cape of the North Island over Friday 21 and Saturday 22 October 2005. Gisborne District was the worst affected area suffering the most damaging flooding since Cyclone Bola in 1988. The highest total rainfall was experienced in the coastal ranges between Tolaga Bay and Te Puia Springs where up to 385 mm of rain fell in 44 hours. Peak rainfall intensities of between 34.5 and 44.5 mm/hour were recorded between Tolaga Bay and Ruatoria. Provisional 48 hour rainfall return periods were estimated at 40 years for Ruatoria and Gisborne city and 85 years for the Hikuwai Valley.

Peak water levels on the Waipaoa and Hikuwai rivers were within 0.6 metres of those recorded during Cyclone Bola. However, the Labour Weekend storm was of shorter duration resulting in shorter flood peaks and causing less damage to surrounding farmland and flood protection works. Floodwaters entered seven houses around Tolaga Bay, along with the Mangatuna Marae, depositing silt and debris. Crop losses due to flooding and silting on the Tolaga Bay and Poverty Bay flats were estimated at $8.4 million. State Highway 35 north of Gisborne, and some local roads, were blocked at several locations by silting and landsliding. Damage to local roads was estimated to be at least $1 million. Flood protection works damage totalled around $500,000.

Aerial and ground reconnaissance of landslide and flood damage between Gisborne and Te Puia Springs was undertaken by a GeoNet response team between 7 and 10 November 2005. The most significant landsliding and erosion occurred in the Hikuwai catchment near the area of heaviest rainfall. This generally took the form of reinitiated gullying of weak Miocene mudstone in the catchment headwaters. Many new, small soil slides and flows were also triggered by the storm in both farm and forest land along the length of the district.

Gullying and shallow soil flows were the largest sources of the Hikuwai River's sediment load which was subsequently deposited on the Tolaga Bay flats. River bank slumping, caused by elevated pore pressures in saturated silty river banks as water levels rapidly receded, was observed between Gisborne and Te Puia. Damage from river bank slumping was minimal.

Many erosion prone areas of farmland were planted in exotic forestry after Cyclone Bola. This has succeeded in stabilising soil and preventing numerous small landslides, particularly soil flows, which occur in many areas of pastoral farming. However, the steep, dissected headwaters of some of the district's rivers, while planted, continue to erode and supply large amounts of sediment to rivers and streams during high intensity rainfall events.

KEYWORDS

2005 Labour Weekend storm, rainfall-triggered landsliding, gullying, soil flows, silting, river bank slumping, Gisborne, Hikuwai River, Tolaga Bay.

1.0 INTRODUCTION

1.1 Background

Labour Weekend 2005 saw the most severe flooding in the East Cape area since Cyclone Bola in 1988. Up to 385 mm of rain fell in parts of Gisborne District over a period of 44 hours on 20-22 October. The greatest rainfall was experienced in the coastal ranges between Tolaga Bay and Te Puia Springs.

The Hikuwai catchment, receiving over 340 mm, was the worst affected with widespread flooding and silt deposition over recently planted cropland, and the inundation of seven houses around Tolaga Bay and the Mangatuna Marae. The Te Arai catchment received around 240 mm and the Waipaoa catchment around 180 mm. Water levels in the Waipaoa and Hikuwai rivers were both within 0.6 m of Cyclone Bola flood peaks.

State Highway 35 north of Gisborne and some local roads were blocked at several locations by flood-deposited silt and debris and, in places, by landslide debris or undermine collapse, isolating some communities.

A state of emergency was not declared, with Gisborne District Council (GDC) and local communities able to manage the response and recovery.

1.2 Field response

The Labour Weekend storm event caused over $1 million of direct damage and around $10 million in economic losses (including damage from flooding and silting). For these reasons the storm was considered a significant event warranting a GeoNet[1] reconnaissance of landslide damage in the affected areas. The event was also of particular research interest as it affected similar locations to Cyclone Bola in 1988 which caused severe flooding and triggered many damaging landslides and widespread soil erosion on high country farmland.
The reconnaissance included ground and aerial reconnaissance of landslide and flood damage between Gisborne and Tokomaru Bay between 7 and10 November 2005 by Dick Beetham (GNS Science) and Helen Grant (Greater Wellington Regional Council) in collaboration with Gisborne District Council (GDC), Landcare Research and P F Olsen and Company Ltd (forest management).

An aerial reconnaissance of the worst affected area was made on Tuesday 8 November using two light planes from Gisborne airport. The flights covered an elongated strip extending about 30 km inland from the east coast and reaching as far as Te Puia Springs 70 km to the north, and Waingake 25 km to the south of Gisborne.

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[1] GeoNet is a collaboration between the Earthquake Commission, GNS Science, and the Foundation for Research, Science and Technology for the monitoring, data collection and rapid response to earthquake, volcano, landslide and tsunami hazards in New Zealand. It is managed by the Geohazard Solutions Section of GNS Science.

A brief ground reconnaissance along SH 35 between Gisborne and Te Puia was carried out on Monday 7 November. A more in depth reconnaissance of SH 35 between Gisborne and Tokomaru Bay, and of the mostly unsealed inland road between Tokomaru Bay and Waimata (via Tauwhareparae) was made on Wednesday 9 November. A brief reconnaissance was also made up the Waipaoa Valley to Te Karaka to see flooding and silting damage.

1.3 Scope of report

This report reviews the types of landslides generated or reinitiated by the storm and their effects on farmland and infrastructure, particularly roads, and gives only a brief description of the storm event meteorology and hydrology. The report is a compilation of information provided by GDC, Landcare Research and P F Olsen and Company, along with our own observations of the landslide and silting effects.

A comprehensive preliminary internal report on the event, including meteorological conditions, rainfall data and river hydrographs, was produced by GDC in early November 2005. Another report on recovery operations for the flood, outlining damage to farmland, was presented to the Gisborne Civil Defence Emergency Management Group Co-ordinating Executive Group in February 2006 which also provided valuable information.

2.0 LOCATION AND REGIONAL SETTING

The Gisborne area is located on the Raukumara Peninsula at the northeastern end of the North Island's axial ranges (Figure 1). Most of the region is rugged native bush clad ranges or dissected farmed and forested hill country. The region is sparsely populated except for Gisborne city (estimated 2005 population 32,700) and a number of small coastal and inland settlements, most of which are located on the small areas of alluvial plains in the region. (Locations mentioned in the text are shown in Figure 1.)

The geology of the storm-affected area consists predominantly of very weak sandy mudstones of Miocene and Pliocene age (15 to 3 million years old) (Figure 2). These rocks are poorly lithified and tend to slake and crumble into their component materials on exposure to wetting and drying. Since the indigenous forest was cleared for pastoral farming in the early 1900s, the region has become notorious for its high levels of sheet and gully erosion leading to very high suspended sediment loads in the rivers and rapid aggradation of river beds (Mazengarb and Speden, 2000).

Recognition of erosion problems led to large areas being replanted in exotic pine forests from the 1960s. The very widespread and severe loss of pasture through landslides and soil erosion during Cyclone Bola in 1988 led to a further increase in planting of exotic pines over large areas of unstable land. Work by Landcare Research and others shows that the sediment yield in forested catchments with pine trees more than eight years old is dramatically reduced by about ten times (Marden *et al*, 1991).

Along with forestry in the hill country, horticulture has expanded in the fertile low-lying alluvial plains in the Gisborne area over the last ten years. The area now grows about one third of New Zealand's squash, sweet corn and broccoli (GDC recovery newsletter). Beef and sheep farming is also still a major hill country land use.

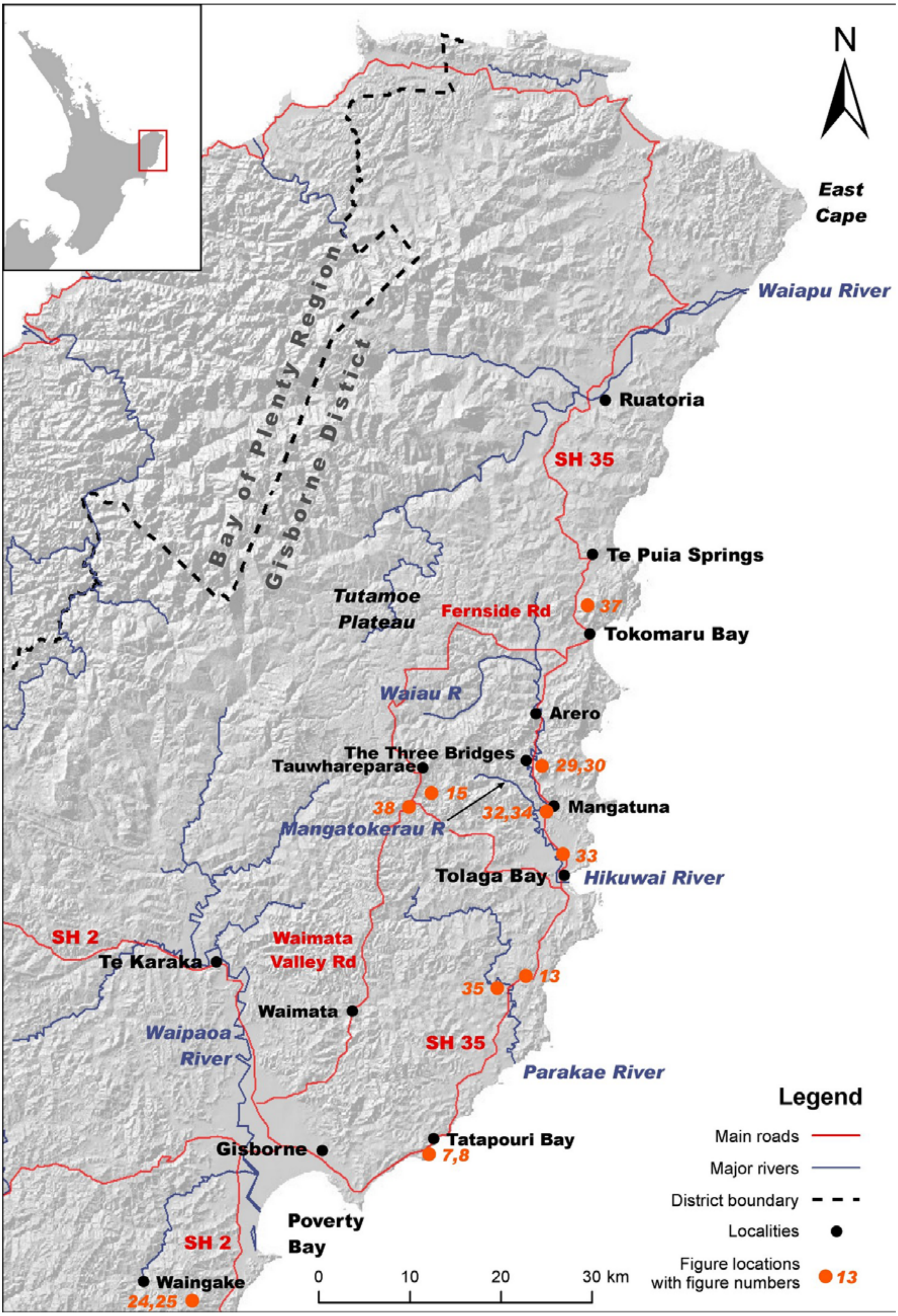


Figure 1 Location map of Gisborne District. Locations are given for some landslide figures within the report (with figure numbers).

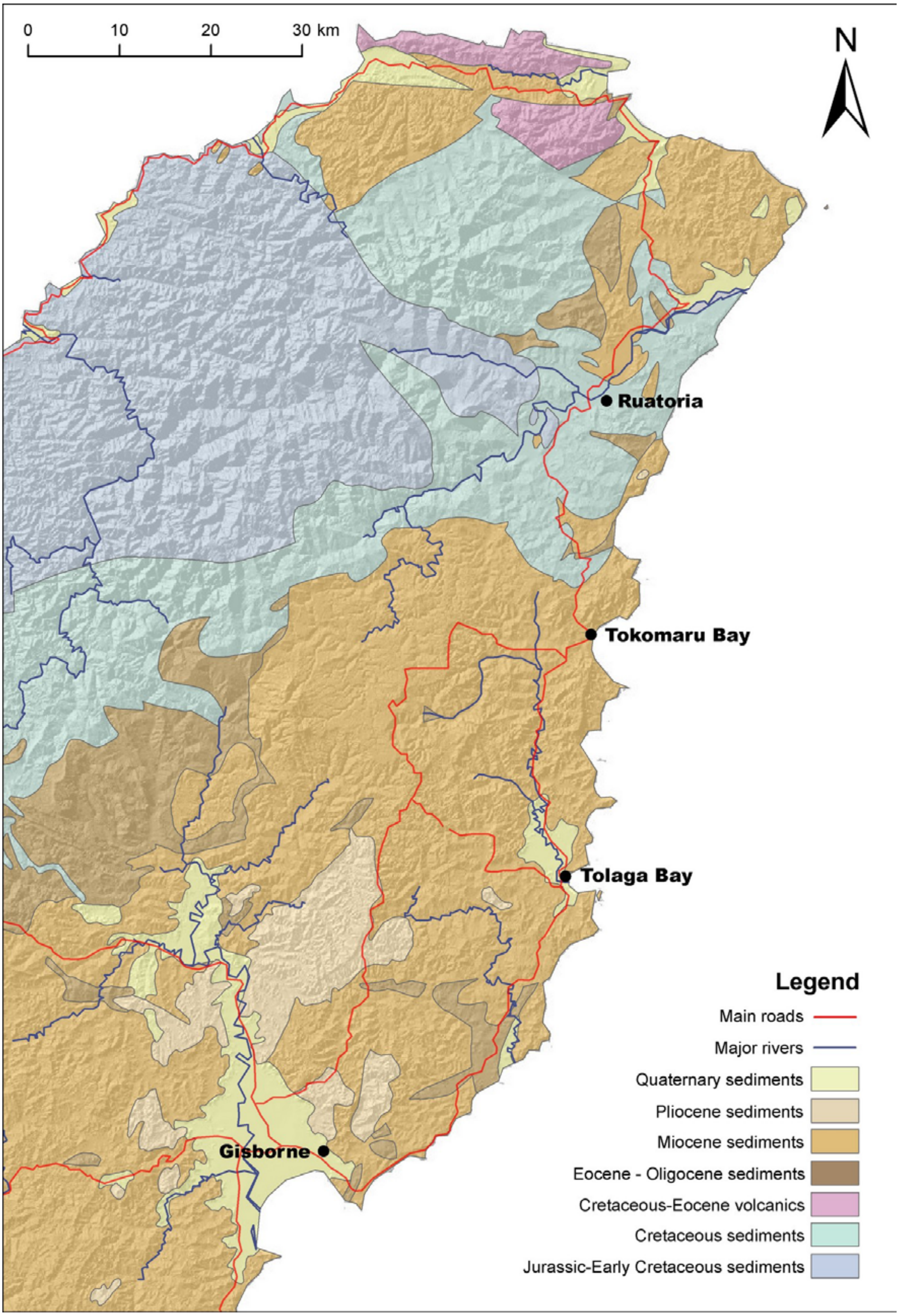
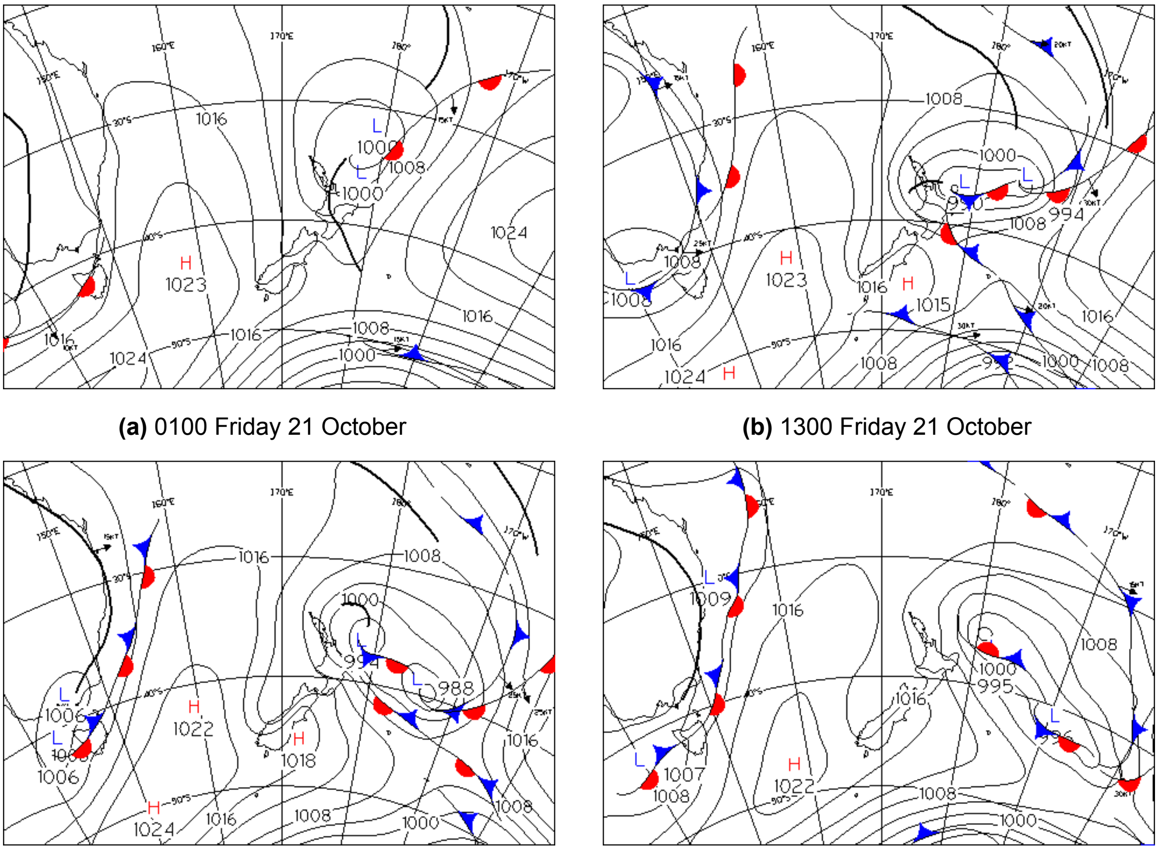


Figure 2 Simplified geology of the Gisborne area (source: QMap).

3.0 THE STORM EVENT

The storm event was generated by a low pressure system that originated in the northern Tasman Sea and travelled southeast, crossing over East Cape on Friday 21 October (Figure 3). The system caused strong northeasterly winds in the northern catchments (Waiapu and Hikuwai) and southeasterly winds in the southern catchments (Waipaoa) as the low passed through. Two peaks in rainfall intensity were recorded in the northern catchments at around 1200 and 2200 on Friday 21 October, whereas southern catchments experienced one, more prolonged peak between 1000 and 1600 on Friday 21 October. (Times are in New Zealand Daylight Saving Time.)



(a) 0100 Friday 21 October

(b) 1300 Friday 21 October

(c) 0100 Saturday 22 October

(d) 1300 Saturday 22 October

Figure 3 Situation from 0100 Friday 21 October to 1300 Saturday 22 October showing the path of the low pressure system across East Cape (time in New Zealand Daylight Saving Time) (source: MetService).

Isohyets for the storm event are given in Figure 4. The highest total rainfall was experienced in the coastal ranges between Tolaga Bay and Te Puia Springs where up to 385 mm of rain fell in the 44 hours between 1600 Thursday 20 October and 1200 Saturday 22 October. Provisional 48 hour rainfall return period estimates ranged from 40 years at Ruatoria (324 mm) and Gisborne city (183.5 mm) to 85 years in the Hikuwai Valley between Tolaga and Tokomaru bays (384.5 mm).

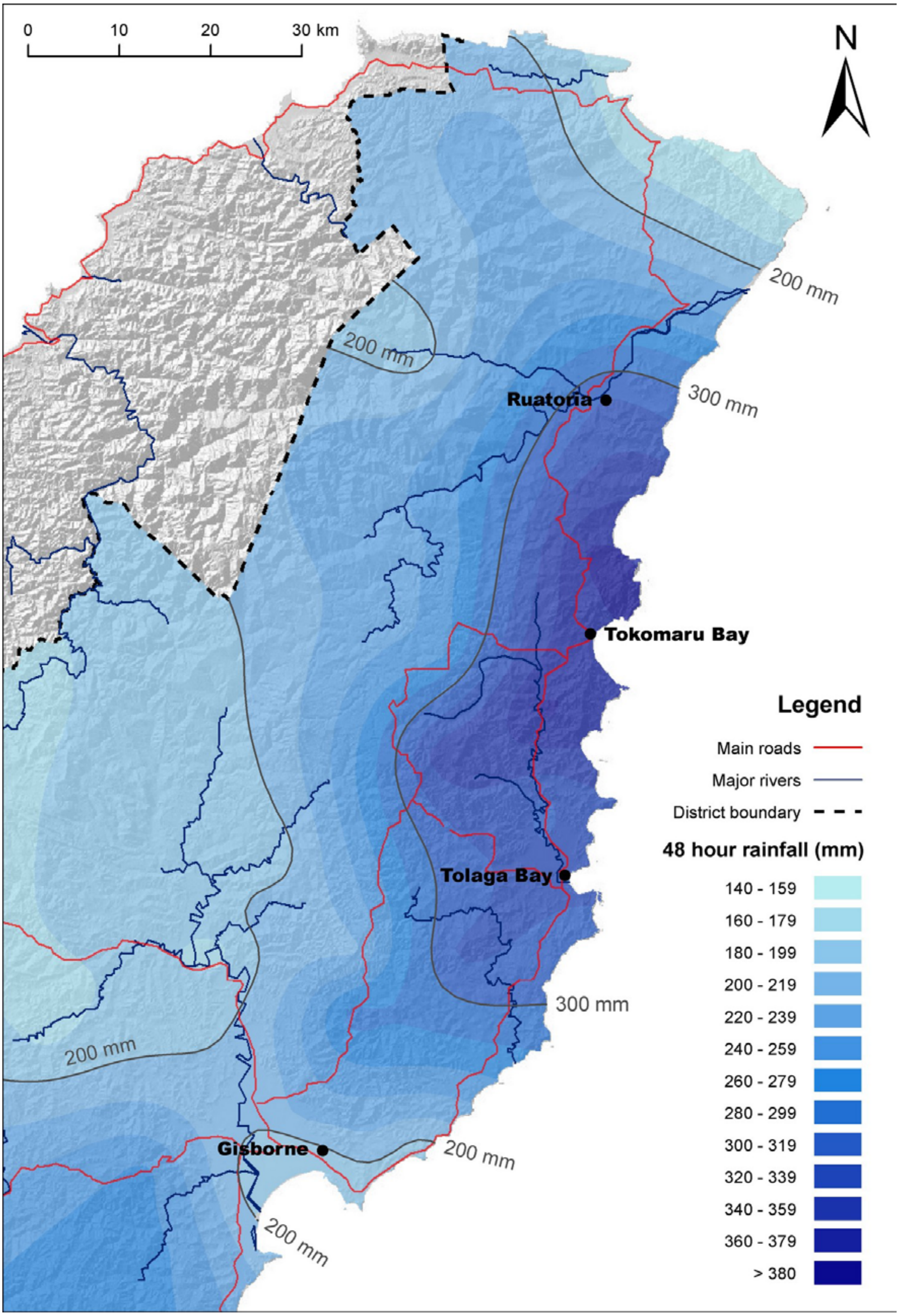


Figure 4 48 hour rainfall total isohyets (source: Gisborne District Council).

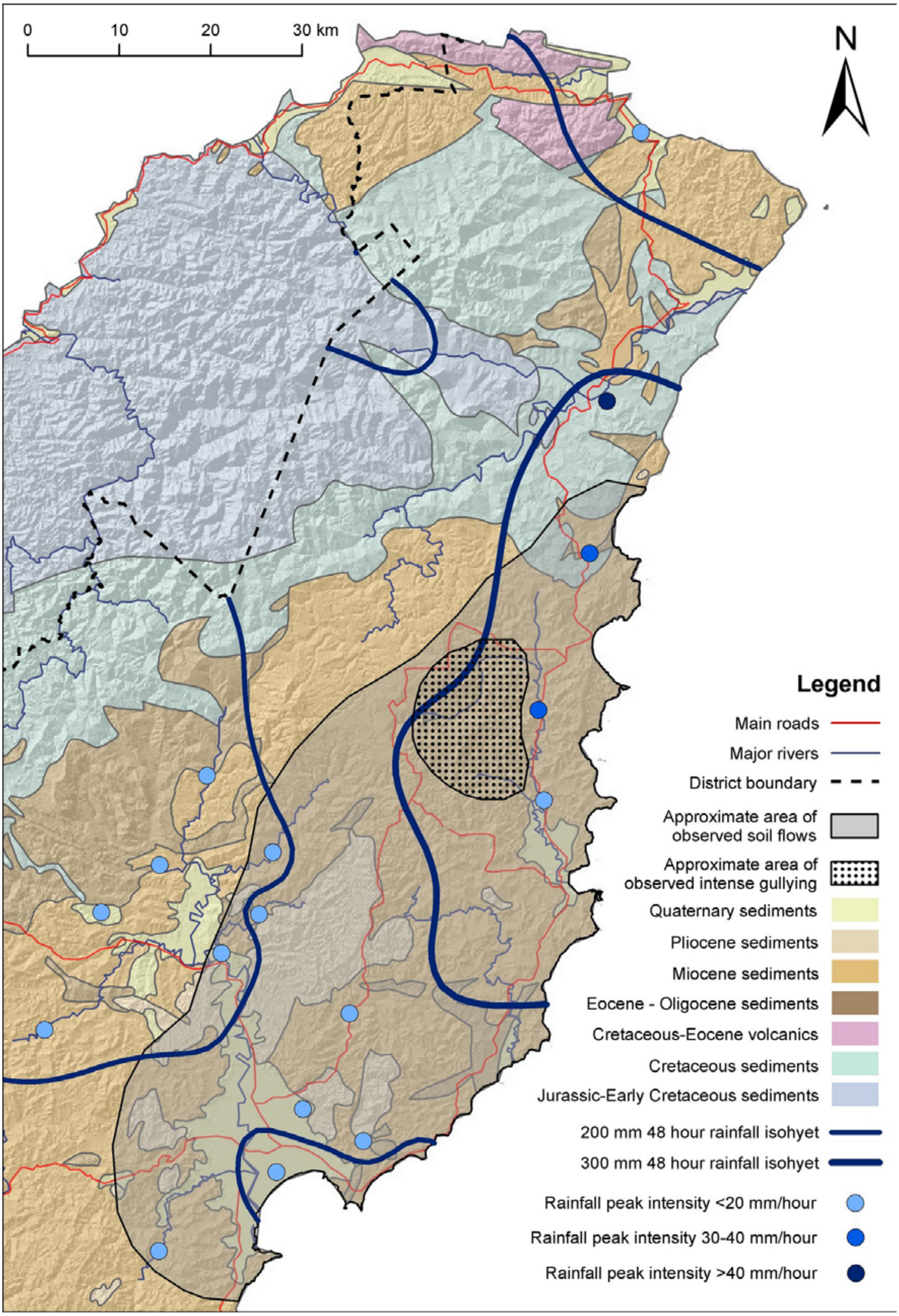


Figure 5 Simplified geology, rainfall isohyets and peak intensities, and areas of observed landsliding.

Peak rainfall intensities in the Hikuwai catchment were up to 34.5 mm/hour (Hikuwai #4 recorder), and were up to 35.5 mm/hour and 44.5 mm/hour in Te Puia and Ruatoria. Peak rainfall intensities were around 12-14 mm/hour in the Waipaoa catchment.

Peak water levels on the Waipaoa and Hikuwai rivers were within 0.6 m of those measured in Cyclone Bola. However, the Labour Weekend storm was of shorter duration than Cyclone Bola producing shorter flood peaks and causing less damage to surrounding farmland and flood protection works. The flood damage curve generated for the Waipaoa River Flood Control Scheme (WRFCS) in 2003 estimated $1-1.4 million worth of flood damages in a Labour Weekend sized event. However, after the Labour Weekend storm flood damages to WRFCS assets were estimated at less than $500,000. This was thought to be due to improved bank protection, short flood peak duration and rapid flood attenuation.

A second heavy rainfall event occurred in the area in late November and, once again, crops that had been replanted after the Labour Weekend event were lost. This event was not as large as the Labour weekend event.

4.0 LANDSLIDE DAMAGE

4.1 Landsliding

Landsliding generated or reinitiated by the Labour Weekend storm was observed by both aerial and ground reconnaissance between 7 and 9 November 2005.

The greatest amount of observed landsliding, in particular gullying, occurred in dissected Miocene mudstone hill country near the area of greatest rainfall - the upper Hikuwai catchment (including the Mangatokerau and Waiau rivers) (Figure 5). This was confirmed in landslide damage investigations undertaken by P F Olsen and Company for insurance purposes (G. Swain, pers comm). While peak rainfall intensity was high in this area (around 35 mm/hour), it was not as high as that recorded in the Ruatoria area (up to 44.5 mm/hour) (Figure 5). However, landslide damage in the catchments around Ruatoria appeared to be minor, which is attributable to the differing geology: Cretaceous as opposed to Miocene sediments.

A number of discrete large (~10,000 m^3) landslides were observed between Gisborne and Tolaga Bay (Figures 6-8). It is likely that these were pre-existing active or dormant landslides which were further activated by the Labour Weekend storm.

The storm generated many new small soil slides and flows in both farmland and young forestry between the hills to the south of the Poverty Bay flats and Ruatoria where peak rainfall intensities of >12 mm/hour were recorded (Figures 9-16). While generally small (10s to 100s of m^3) cumulatively these flows probably contributed a large amount of sediment load to rivers, which was then deposited on low lying farmland.

Gullying, in some places severe, was observed in the headwaters of the Hikuwai catchment (including the Waiau and Mangatokerau catchments) (Figures 17-22). This gullying is ongoing but the Labour Weekend storm most likely caused a significant amount of erosion on the exposed surfaces, feeding sediment to the streams. Most gullying was observed in deeply dissected late Miocene mudstone and probably contributed a great deal to the sediment load in the Hikuwai River that was deposited on the river flats around Tolaga Bay. Gullying was generally within areas planted in pine forest. It is evident that vegetation has difficulty becoming established on these bare slopes and planting has not prevented this type of landsliding and erosion.

Little landsliding was observed in the relatively stable farmed “tableland” of the Tutamoe Plateau north of Tauwhareparae (Figure 23).

A large earthflow near Waingake was also included in the reconnaissance (Figures 24 and 25). This earthflow has been active for a number of years and is too large to be stabilised with exotic forest. The earthflow continues to move and enlarge and it is not known how responsive it is to large events such as the Labour Weekend storm.

Figure 6 Large landslide on farmland north of Gisborne.

Figure 7 “Old” landslide on slope behind Tatapouri Bay (approx Y18:576717).

Figure 8 Very large old coastal landslide on east side of Tatapouri Point headland (approx Y18:577708).

Figure 9 Shallow soil slides/flows in the hills southeast of Poverty Bay.

Figure 10 Small landslides on farmland between Gisborne and Tolaga Bay.

Figure 11 Soil slides/flows in steep farm country between Gisborne and Tolaga Bay.

Figure 12 Small landslides on farmland between Gisborne and Tolaga Bay.

Figure 13 Example of a saturated soil flow in farmland approximately 11 km south of Tolaga Bay (approx Y17:687905). Note the "healed" landslide scars.

Figure 14 Typical farmland and forest terrain between Tolaga and Tokomaru bays.

Figure 15 Numerous landslides in a north facing late Miocene mudstone slope planted in young pine forest, upper Ramanui Stream catchment, 2.5 km south of Tauwhareparae (approx Y16:562103).

Figure 16 Landslides in steep forest land in the Mangatokerau River headwaters.

Figure 17 Farmland gully erosion in mid to late Miocene mudstone in the upper Hikuwai (Waiau) catchment inland of Tokomaru Bay. Note the many healed landslide scars, particularly in the right foreground, from Cyclone Bola.

Figure 18 Gully erosion in late Miocene mudstone in the Hikuwai catchment inland from Tolaga Bay.

Figure 19 Severe gully erosion in late Miocene mudstone in the upper Mangatokerau catchment. These landslides date from Cyclone Bola and were reactivated to some degree in the Labour Weekend storm.

Figure 20 Severe gully erosion in mid to late Miocene mudstone in the upper Hikuwai (Waiau) catchment inland of Tokomaru Bay. Note the block slide in the mid foreground. These landslides date from Cyclone Bola and were reactivated to some degree in the Labour Weekend storm.

Figure 21 Detail of severe gully erosion in late Miocene mudstone in the upper Hikuwai (Waiau) catchment.

Figure 22 Gullying between Tolaga and Tokomaru bays.

Figure 23 Relatively stable farmed “tableland” in early Miocene mudstone on Fernside Road on the Tutamoe Plateau, approximately 20km inland from Tokomaru Bay. Photo is facing north looking towards Mt Hikurangi in the distance (taken from approx Y16:548214).

Figure 24 A very large earth flow near Waingake, southeast of the Poverty Bay flats (approx Y18:308564). This earth flow predated the Labour Weekend storm but may have been enlarged by it.

Figure 25 Another view of the earthflow at Waingake. Forestry planting has not prevented further movement on this slide.

4.2 Silt deposition and stream bank slumping

Landsliding in the Hikuwai and, to a lesser extent, the Waipaoa catchments supplied large quantities of silt to the rivers which was deposited over approximately 1000 hectares of low lying land around Tolaga Bay (Figures 26-32) and 2000 hectares of land on the Poverty Bay flats. Much of this land had recently been planted with squash, sweet corn, maize and broccoli and most crops (around 2100 hectares in total) were totally destroyed. The total farm gate value of crops lost was estimated at $8.4 million with total losses over $10 million when including lost wages (GDC recovery report). Floodwaters also entered seven houses around Tolaga Bay depositing silt and debris. The Mangatuna Marae near Tolaga Bay was inundated damaging the kitchen and meeting house floors and mattresses (GDC recovery newsletter).

River levels receded quickly in the 24 hours following the flood peak in the early hours of Saturday 22 October. This rapid recession generated elevated pore water pressures in saturated silty stream banks causing widespread slumping. Stream bank slumping of in situ alluvial silts was observed along most of the length of the Hikuwai River (Figures 30, 33 and 34), as well as on many smaller watercourses between Gisborne and Te Puia, such as the Parakae River (Figure 35). Damage from this slumping was generally confined to localised fence damage and, in one observed instance, subsidence of a power pole.

Figure 26 Looking southeast over the lower Hikuwai (Uawa) River flats towards Tolaga Bay.

Figure 27 Looking southwest over the Hikuwai River flats at Mangatuna, north of Tolaga Bay. The Mangatuna Marae is located at the intersection of SH 35 and Mangatuna Road in the centre foreground.

Figure 28 Looking south down the Hikuwai River towards Tolaga Bay from the Mangatokerau catchment. Note the large areas of silt deposition in the Hikuwai valley floor.

Figure 29 Waitoroko Stream, having carried silt and logs, meets the Hikuwai River at The Three Bridges. Logs have backed up at the confluence in the right centre of the photo (approx Y16:694149).

Figure 30 Silt deposits being prepared for resowing on the Hikuwai River at The Three Bridges. Note the river bank slumping along the river (approx Y16:697148).

Figure 31 Looking east over the Hikuwai valley near Arero, between Tolaga and Tokomaru bays. Note the silt deposition from overland flow.

Figure 32 Thick silt deposits from the Hikuwai River, intersection of SH 35 and Paroa Road, approximately 9 km north of Tolaga Bay. River channel indicated by arrows (approx Z17:707099).

Figure 33 River bank slumping on the lower Hikuwai (Uawa) River adjacent to SH 35 approximately 4 km north of Tolaga Bay (approx Z17:717052). This slumping was common along the Hikuwai River.

Figure 34 River bank slumping in the Hikuwai River at the intersection of SH 35 and Paroa Road, approximately 9 km north of Tolaga Bay (Z17:708098).

Figure 35 Looking north along the Pakarae River near Puriri homestead between Gisborne and Tolaga Bay. Note silt deposition and river bank slumping (approx Y17:645905).

4.3 Damage to roads

State Highway 35 north of Gisborne, and some local roads, were blocked at several locations by flood-deposited silt and debris and, in places, by landslide debris (Figure 36) or undermine collapse (Figures 37 and 38). Batter failure was common in cuts in Miocene mudstone (Figure 39), particularly on the inland road between Tokomaru Bay and Waimata (Figures 40-42).

Communities along the coast were isolated while the clean up took place and damage to local roads alone was estimated at over $1 million. Most flood-deposited silt and debris, and batter failure debris, had been cleared from SH 35 and local roads by the time of the reconnaissance.

Of interest was the check dam constructed in the Mangahauini River between Tokomaru Bay and Te Puia Springs (Figure 43), part of works to help prevent scour of the river channel and subsequent damage to the road such as that in Figure 37.

Figure 36 Typical landslide in early Miocene mudstone on the unsealed Fernside Road, inland from Tokomaru Bay.

Figure 37 Road washout on SH 35 beside the Mangahauini River between Tokomaru Bay and Te Puia Springs, closing one lane (approx Z16:744325).

Figure 38 Landslide in late Miocene mudstone on a new section of Tauwhareparae Road south of Tauwhareparae (approx Y17:567120 ± 1km north or south).

Figure 39 Batter failure on SH 35 south of Tolaga Bay. This had occurred prior to the Labour Weekend storm but had been exacerbated by it.

Figure 40 Typical fretting of slaked early Miocene mudstone on the unsealed Fernside Road, inland from Tokomaru Bay.

Figure 41 Detail of Figure 40.

Figure 42 Road cut failure on Waimata Valley Road, approximately 7 km north of Waimata.

Figure 43 Check dam in the Mangahauini River between Tokomaru Bay and Te Puia Springs to help stabilise river channel.

5.0 CONCLUSIONS

(1) The most significant landsliding and erosion occurred near the area of heaviest rainfall - in the Hikuwai catchment between Tolaga and Tokomaru bays where over 280 mm of rain fell in 44 hours and peak intensities of up to 35 mm/hour were recorded. This generally took the form of reinitiated gullying in the catchment headwaters. The gullying predated the Labour Weekend storm but the exposed weak Miocene mudstone slopes provided a large source of easily erodable silt that was readily mobilised during the storm. This gullying, together with numerous soil flows, were probably the largest sources of the Hikuwai River's sediment load which was subsequently deposited on the Tolaga Bay flats.

(2) Many new, small soil slides and flows were triggered by the storm in both farm and forest land along the length of the district. Rainfall in these areas exceeded 200 mm over 44 hours, and peak intensities of >12 mm/hour and up to 44.5 mm/hour were recorded.

(3) The Labour Weekend storm was the largest rainfall event since Cyclone Bola in 1988, with river levels peaking within 0.6 metres of Bola levels. However, the flood and erosion damage sustained was much less than Cyclone Bola. This can be attributed to the fact that:

- The duration of the Labour Weekend storm was much shorter than that of Cyclone Bola thus while river levels were high, the peak flows were shorter and river levels receded quickly.

- Many houses were raised after Cyclone Bola and infrastructure made more resilient. For example road bridges washed out in Cyclone Bola were replaced by higher, stronger bridges.
- Many erosion prone areas of farmland were planted in exotic forestry after Cyclone Bola to prevent a similar erosion occurring in future. That planting has succeeded in stabilising soil and preventing landslides, particularly soil flows, in many areas reducing the sediment load in the rivers of the district during large storm events.

(4) While forestry has reduced soil erosion and landsliding in many areas, some areas such as the steep, dissected headwaters of the district's rivers continue to erode.

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