



Summary of Earthquake and Tsunami Damage Assessment in Port Vila

by

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(The full report can be downloaded from SOPAC website using the hyperlink <http://www.sopac.org.fj/Data/virlib/reportsindex.html?ss=type&vv=LR> or from ITIC website at <http://www.shoa.cl/oceano/itic/pdf-docs/Port-Vila-03-Jan-2002-SOPAC.pdf>)

Summary

On January 3, 2002 (UTC 2002/01/02 17:22:50, 04:22 am local time), a magnitude Mw 7.1 earthquake, the largest recorded so far in the vicinity, struck Port Vila, Efate, Vanuatu (Figure 1). It was located only 50 km west of Port Vila and at the shallow depth of 21 km below the sea floor. Fifteen minutes after the main shock, a tsunami (Figure 2) struck Port Vila Harbour. The event was followed that same night by a large aftershock (Mw 6.4) which also produced a tsunami, though much smaller in size. A SOPAC assessment team was dispatched to Port Vila January 8-24, to survey the damage, under funding provided by the UK Department For International Development (DFID), Suva, Fiji.

Although of large magnitude, the earthquake occurred far enough to the west of Efate to ensure that relatively little damage was caused in Port Vila and surrounding southeast Efate area. The great majority of buildings escaped with little more than apparently superficial damage, although several bridges or their approach embankments were severely damaged and visible cracking in some concrete structural building members was recorded. Buildings that were more seriously damaged (Figure 3) generally either had serious design or construction flaws or were founded on fill or reclaimed land that subsided due to liquefaction or other soil failure phenomena. The bridge and approach embankments failures in the Port Vila area were mainly due to a combination of the high liquefaction potential of saturated, fine-grained alluvium, and the construction of embankments high enough to cope with flood conditions. Slope failure was almost entirely confined to volcanic tuff in high cliff faces, although the overlying limestone was involved in consequent landslides.

A tsunami of appreciable size was generated with the earthquake, but was fortunately small enough, given the extremely low tide at the time, not to cause any significant flooding above Highest Astronomical Tide (HAT) level (Figure 6). Had it struck at high tide, much flooding, damage and perhaps loss of life could have resulted. The potential for Port Vila to experience similar, or even significantly worse, earthquakes and tsunamis in the future can be considered relatively high in the 50-100 year timeframe, as this was not an isolated or unexpected event.

Earthquake Damage

The majority of buildings fared well in the earthquake, and most of the damage appears to be the result of either ground failure or inadequate structural design. Although the full extent of damage is still being assessed, earthquake damage currently falls into several categories: significant structural damage; apparently superficial building damage; foundation failure; and slope failure.

Significant structural damage occurred to the Lycee Bouganville where a 3-storey school classroom building was severely damaged, displaying short-column failure concentrated at the top of the infill walls throughout the entire ground floor level (Figure 4), an adjacent dormitory block suffered similar, significant structural damage, and a 2-storey classroom block reached the stage of incipient failure. The school buildings are built on a cut and filled slope.

A large number of buildings suffered apparently minor structural damage, including shearing of infill walls and window breakage. Movement of the sea wall during the main shock has led to permanent deformation seaward and subsidence of the foreshore in reclaimed areas around the Central Business District (CBD). The worst affected area runs for some 150 m from the open park area north of the main public Market (Figure 5), southward through the seaward end of the Market building and car park and then through the seaward end of the Sea View Restaurant/Bon Marché in a 25 m-wide zone adjacent to the sea wall.

A number of large landslides occurred on the access road to the main wharf at the southern end of Port Vila Harbour. The geology of Port Vila is characterised by a thick series of weak volcanic tuffs capped by a cemented limestone some tens of metres thick. The slope failures in the wharf road were principally in the weaker tuffs although undercutting of the top of the cliff has brought down significant blocks of limestone as well.



Tsunami

A tsunami generated with the earthquake struck Port Vila Harbour some 15 minutes later according to records of the National Tidal Facility (Australia) supplied by Bill Mitchell through the Acting Director of the Vanuatu Meteorological Office. Although the tsunami only registered on the tide gauge as having a crest to trough amplitude of 0.8 m (Figure 3), eyewitness accounts in different parts of the harbour (Figure 6) put the maximum effect at around 3.0 m, nearly four times that of the height recorded on the water level gauge, making it large enough to have the potential to cause significant damage.

Predictive tsunami modelling carried out prior to the actual event by Vasily Titov, NOAA Pacific Marine Environmental Laboratory, USA, in conjunction with Stan Goosby of the Pacific Disaster Center, Hawaii, USA, as part of the SOPAC Port Vila Pacific Cities project, confirms that such amplifications are likely due to resonance and interference effects within the harbour (Figure 7). Final modelling will incorporate actual tide gauge records and eyewitness accounts of the event. A video-animation of the simulated tsunami in Port Vila harbour prepared by Vasily Titov, but based on the scenario of a larger, M 8.2 earthquake occurring in a similar location, is available from SOPAC.

Fortunately the tsunami occurred at a time close to one of the very lowest tides of the year (predicted CD+0.15 m), when the tide was close to Chart Datum. If the earthquake had occurred four hours later at high tide (CD+1.35 m), flooding would have reached up to 1 metre over the top of the sea wall in the CBD area. A much smaller tsunami occurred following the major aftershock that night, but passed unnoticed.

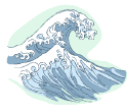
SOPAC and Pacific Cities Program

While SOPAC's role has traditionally been in planning and preparedness, the demand for accurate, informative and timely technical advice has, not for the first time, placed SOPAC into a lead disaster-response role in organizing and carrying out the post-event damage survey – this time for the Port Vila earthquake. Although UK DFID Pacific was able to provide immediate funding for the damage assessment at very short notice., there is a real need for emergency procedures to be in place prior to the natural disaster, and moreover, for emergency resources to be available to carry out such assessments and prepare rapid technical advice. Additionally, it appears advantageous to coordinate all technical response efforts through one agency, for example SOPAC, as this can ensure that all of the reports and data gathered during the efforts are channelled back to the country concerned. Planning and urban development initiatives inherent in the SOPAC Pacific Cities program offer governments opportunities to respond proactively - before the event - as it is obvious that to react later is to react too late.

SOPAC has been accumulating layers of information on population demographics, infrastructure vulnerability and property values and the likely intensity of natural and human-induced hazards on the Port Vila area (as it has for four other major Pacific cities) for the past five years in its Pacific Cities program. The program aims to collate all data relevant to urban planning and risk assessment on a single Risk-GIS database, including hazard information, subsurface data, physical and survey information, building, infrastructure and life-line information, census data, insurance information, and planning and development data in order to perform scenario modelling and risk analysis and, ultimately, appropriate treatment of the risk.

The information base enables modelling and prediction of the effects of tsunamis and storm surges knowing the bathymetry of harbour and the detailed heights of potential flood areas onshore, and the effects of cyclonic winds over the land areas. In this particular case, the effects of the current tsunami were able to be predicted with reasonable accuracy. Furthermore, the actual recorded effects of the tsunami will be incorporated back into the model to ensure better predictions of consequence and likelihood in future. This effort, together with a concerted program in SOPAC to build the capabilities of the National Disaster Managers Office, has resulted in a significant increase in the awareness of the local scientific, disaster response and lay communities of the risk facing the conurbation of Port Vila.

It is critical that backing be given to the Pacific Cities concept both in terms of support for predictive modelling of earthquake, tsunami, storm surge and wind hazard, and in terms of wholehearted support for the program from Government Departments and private organisations through freely providing information for all aspects of urban planning to be incorporated on the Risk-GIS database.



Acknowledgements

SOPAC wishes to express its appreciation to the many people who agreed at short notice to provide information and hold extensive discussions on the event. The author wishes to acknowledge the permission of the Government of Vanuatu to publish this information, and specifically the assistance of the Director General of Lands & Natural Resources and SOPAC National Representative Michael Mangawai, the staff of the Department of Geology, Mines & Water Resources including Director Chris Ioan, Morris Stephen and Eslin for their assistance, Tony Kanas of the Department of Lands & Survey, the Acting Director of the Vanuatu Meteorological Office Jotham Napat for permission to use information from the Port Vila tide gauge and Williams Bae for his assistance, and the cooperation of Job Esau, NDMO. The author also wishes to acknowledge the invaluable assistance of Dr. Marc Regnier and his team from IRD, Noumea in providing information on seismological aspects, and to SOPAC members Monika Swamy and Purnima Naidu for their critical input part into the investigations along with the team performing damage surveys, and the National Tidal Facility in Adelaide, Vasily Titov, and Stan Goosby, PDC Hawaii for tsunami information. Funding for investigation, damage assessment and follow-up work was kindly provided by UK DFID Pacific, Suva.

FIGURES

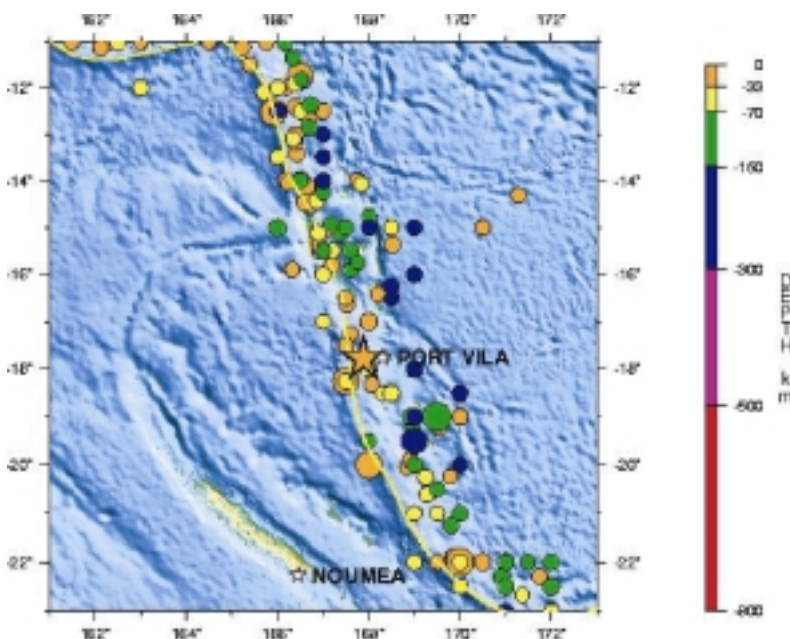
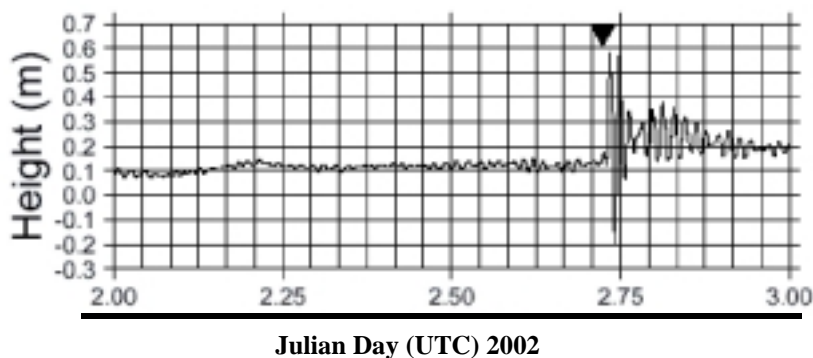


Figure 1:
Historical
seismicity of
Vanuatu; mag.
7 and larger
since 1900
(USGS)

Port Vila, Vanuatu

Figure 2:
Tsunami record,
Port Vila Wharf –
differences
between observed
and predicted sea
level (NTF)



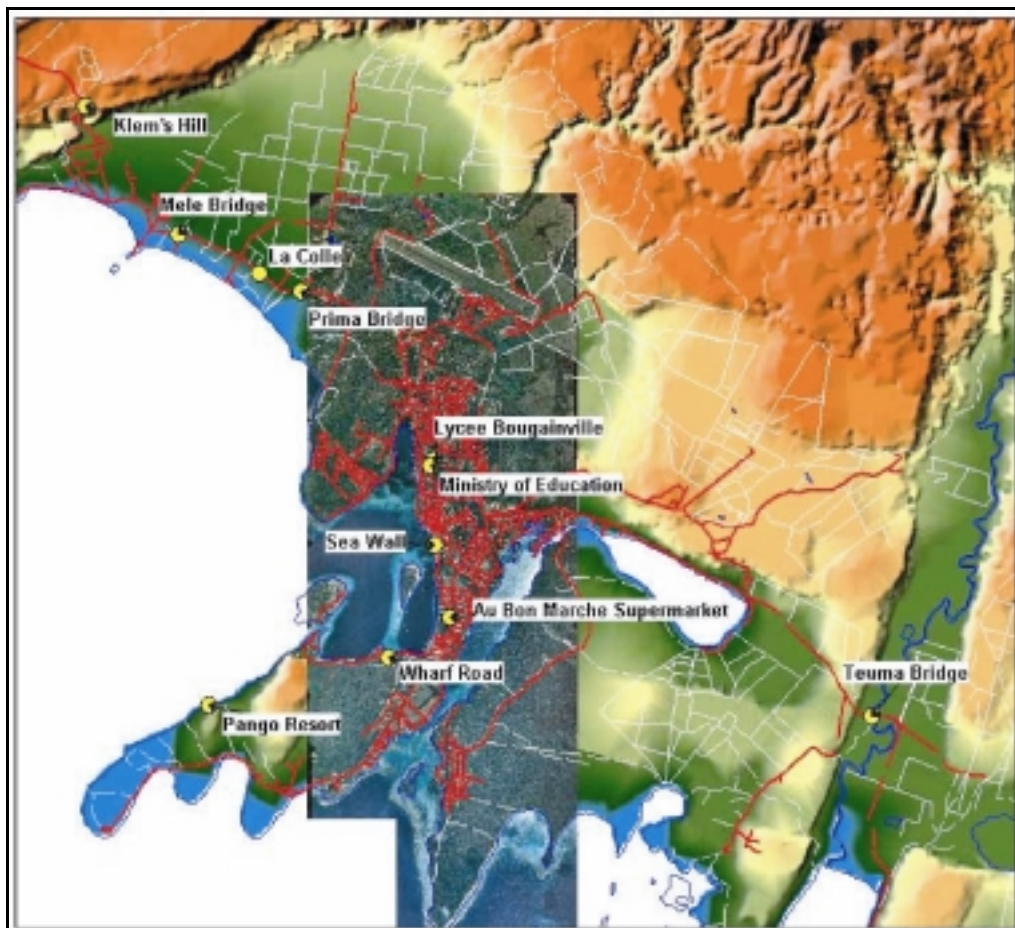


Figure 3: Locality map of Port Vila area showing areas of major damage



Figure 4: Short columns spalled and failed, ground floor, Lycee Bougainville



Figure 5: Fissuring in back-fill behind sea wall, north of Market

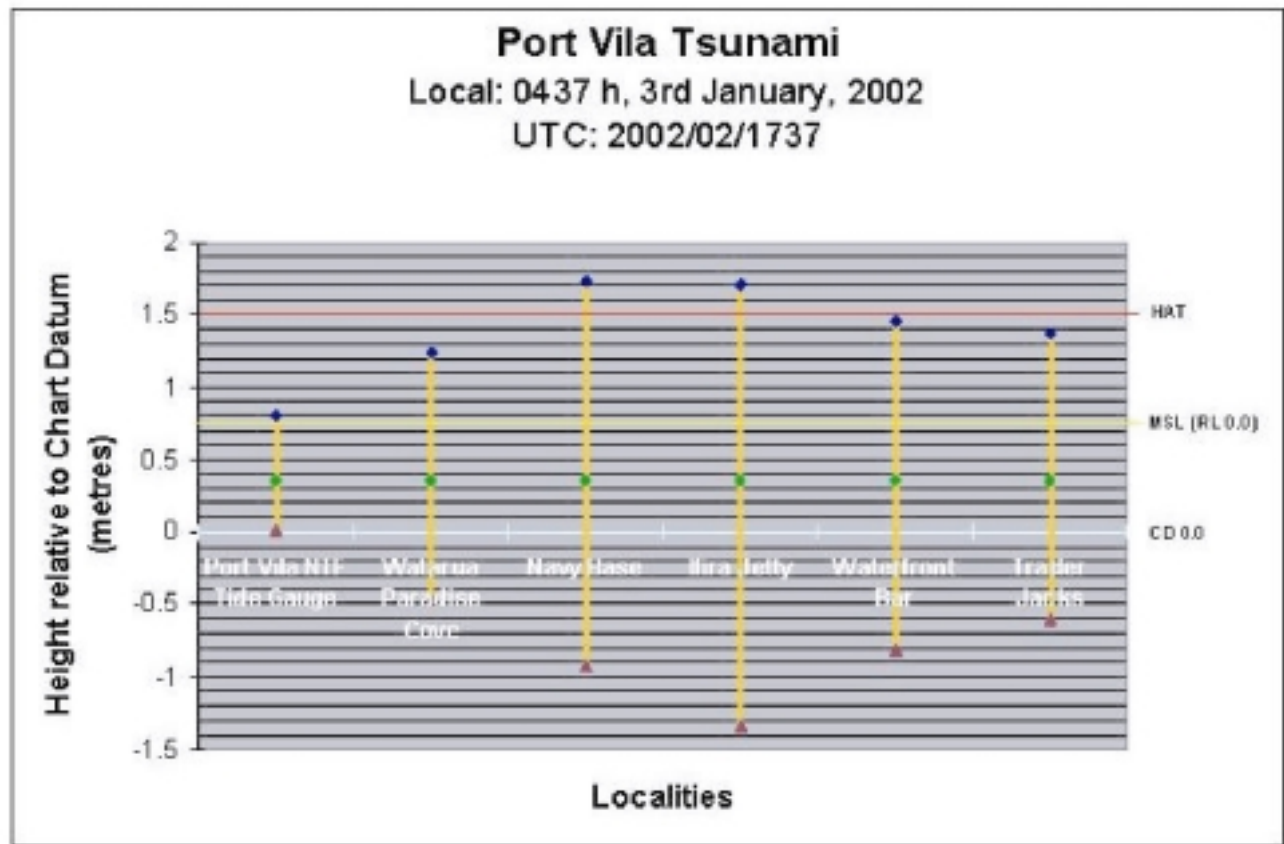


Figure 6: Eyewitness accounts of tsunami amplitudes around Port Vila Harbour (event tide is CD+0.35 m)

Figure 7: Model of tsunami heights in Port Vila Harbour based on tide gauge record (V. Titov)

