Petone to Grenada, the Takapu extension, and Resilience in the Wellington Region

Contents

Petone to Grenada has the potential to significantly increase network resilience in the Wellington region, and should be designed to maximize this benefit. The natural hazard resilience of P2G is not great, due to the difficult terrain at the Petone end. The Takapu extension offers very little in the way of additional network resilience, and is also a poor choice for natural hazard resilience. The SH2 end of SH58 should be seismically strengthened as part of the interchange upgrade, to extend a lifeline route to the Hutt via Transmission Gully.

Background

If the stars and the BCR align – and NZTA has been working very hard on the latter, to be sure -- Wellington will be getting a new road, the Petone to Grenada Link road. To recap a bit, here's the situation. The extra blue lines are a rough indication of NZTA proposals for Petone to Grenada. The brownish one shows a rough outline of Transmission Gully.

[Source: Google maps]

As you can see in that red circle, there are currently two routes out of Wellington:

SH1 goes up Ngauraga Gorge, through Johnsonville, Churton Park, Tawa and Porirua to (eventually) Kapiti.

SH2 runs along the edge of the harbour and goes through Petone, Lower and Upper Hutt, and then over the Rimutaka Hill Road to the Wairarapa.

By "cutting the corner" to connect these two routes, P2G is intended to increase resilience for the Wellington Region.

However, there are two different meanings of "resilience", and each has to be looked at separately.

(1) Network Resilience – The ability to route around congestion, crashes, and other events that temporarily block a part of the road.

(2) Natural Hazard Resilience – The ability of any given road to withstand damage from storms, earthquakes, etc., and how quickly a damaged road can be brought back into service.

Network Resilience – Petone to Grenada

Improving network resilience is especially important for areas where there are no alternatives – and this is the big problem with the Ngauranga Triangle region, in the red circle above.

Neither SH1 through the Gorge nor SH2 along the harbour shore have much in the way of alternatives, if there's a blockage. For instance, if a crash closes SH2, the only way to get into Lower Hutt by road is to go up SH1 all the way to SH58 up at the top of the map there, and then come back south.

With P2G, if you need to get to the Hutt and SH2 is blocked, you'll be able to take SH1 up the Gorge and cut across P2G to get to Petone, instead of going all the way up to TG and SH58. But see what they've done:

1-- Option C Tawa end, from Petone to Grenada Project website

The main connection to P2G is all the way up at Tawa. There's access from Churton Park via Mark Avenue, a 5km shorter trip, but only via surface streets and roundabouts (the unmodified Churton Park interchange is just out of the image at the left). If Hutt-bound traffic tries to use P2G to route around a blockage on SH2, the undersized linkage will quickly clog northbound SH1 at the Churton Park interchange.

The same applies if there is a problem in the AM peak – Hutt drivers will try to take the shortest route, and be balked by the Mark Avenue roundabout.

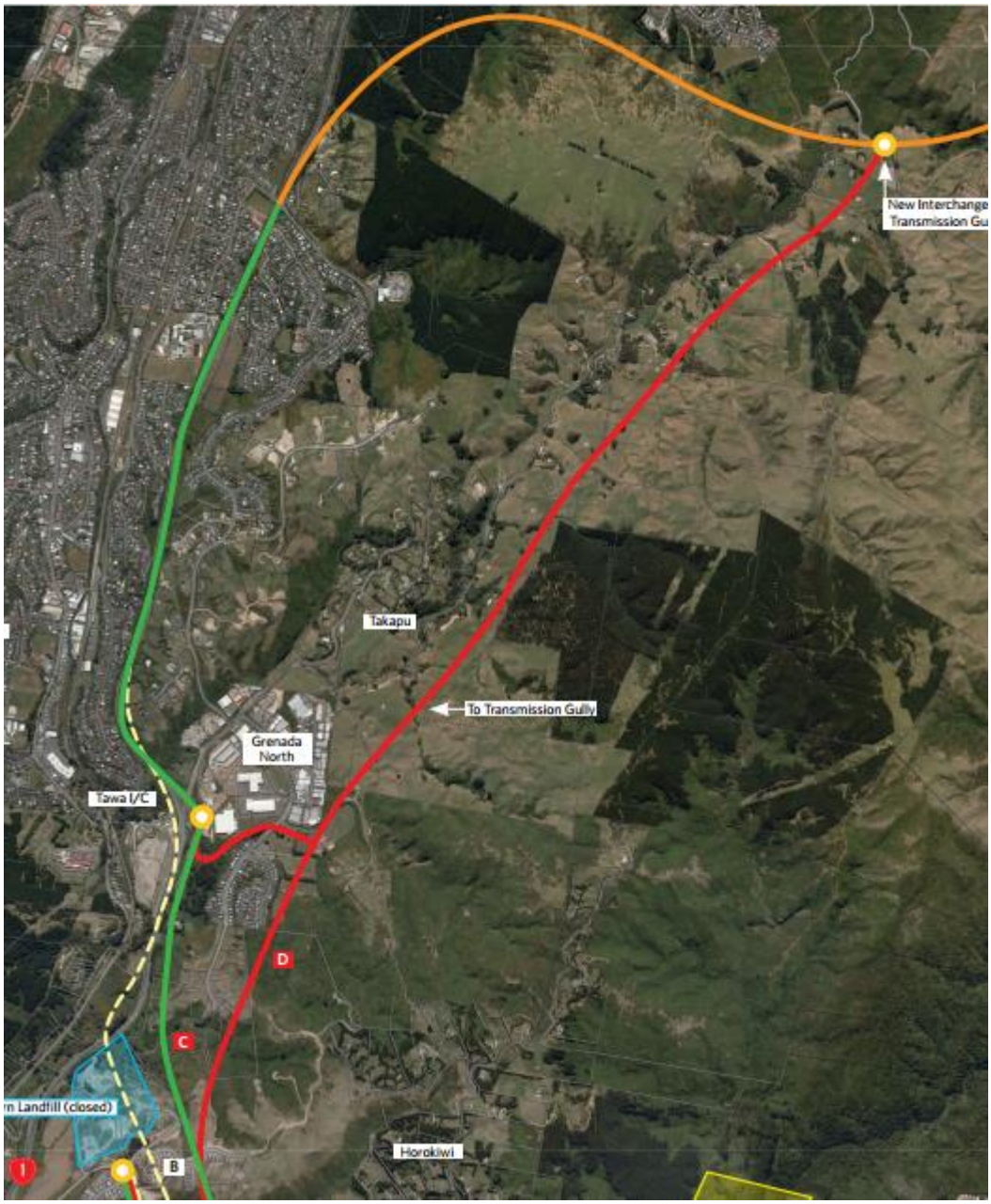
There is less of a problem if the blockage is on SH1 in the Gorge, depending on how far north people are going/coming from, and whether they get the word early enough to get onto P2G at Tawa or get stuck queuing at Churton Park – but SH1 drivers can and do avoid the Gorge via designated roads through Broadmeadows and Khandallah. Hutt drivers have nowhere else to go.

To sum up: the best option for network resilience would be to make the primary P2G connection

via a robust, preferably high-speed interchange at Churton Park. This is basically what the 2009 Feasibility Study recommended. The 2014 Scoping Report also identified a connection at or near Churton Park as "provid[ing] the best network-wide performance results" – unfortunately, an analysis error resulted in this option being dropped from consideration before it could be developed further.

Network Resilience – Takapu Valley

Not content to stop at Churton Park, or even at Tawa, NZTA has proposed extending Petone to Grenada up Takapu Valley along the rejected Transmission Gully route, to connect with the main TG alignment just east of Linden.



2-- Link Road Options Map from Project Website

This Takapu extension, they say, "provides a complete bypass" for a short (~3km) section of SH1 though Tawa, and an equally short (~2-3km) section of Transmission Gully at Linden. Unfortunately, the resilience specialist who gave the Takapu option such a high rating in the Scoping Report missed the fact that the connection to TG at the top of the valley is via one-way ramps:

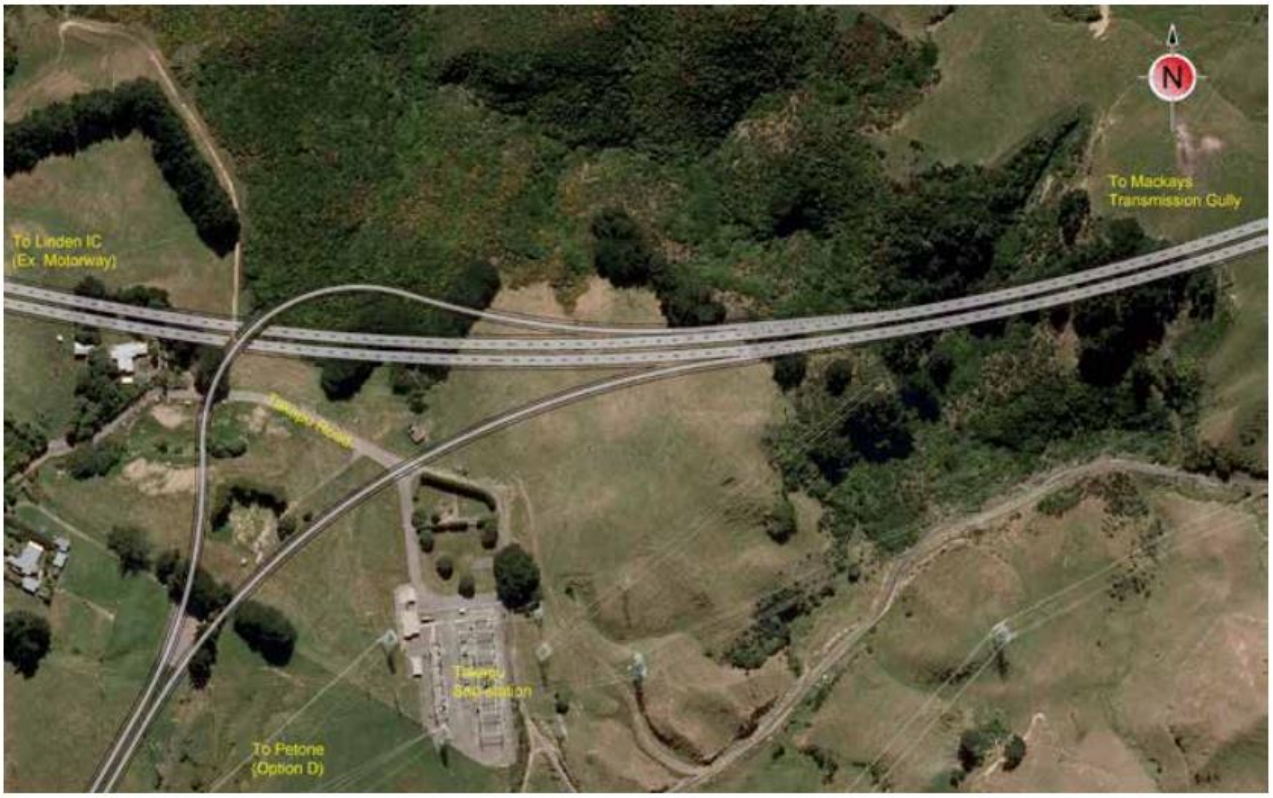


Figure 17-6: North Facing Ramps at Transmission Gully

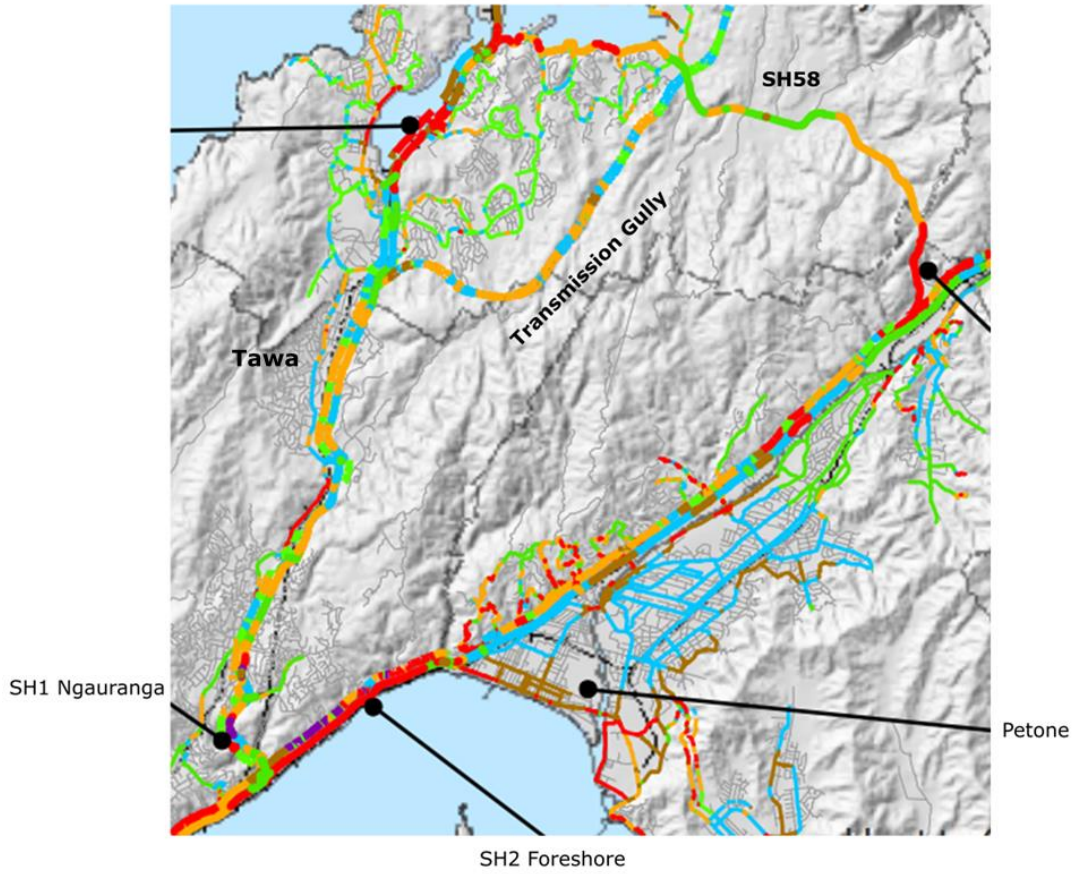
3-- Takapu-Transmission Gully interchange at Cannons Creek viaduct, from the Scoping Report

If you tried to use the Takapu link as a bypass for a crash in Tawa, you'd be stuck on TG all the way to the northeast corner of Whitby, many km out of your way, and have to make your way back via surface streets.

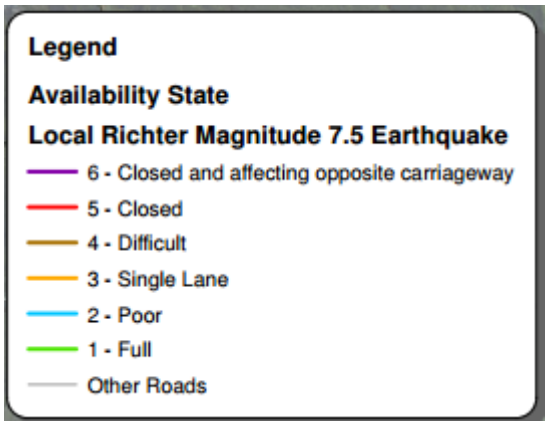
Even if they changed the one-way ramps to a full interchange, there are already alternate routes between Tawa and Linden – Main Road on the west side of SH1 and Woodman Drive on the east side – do we really need to spend $60-140M on another one?

Natural Hazard Resilience – Petone to Grenada

If there's a big earthquake, *both* SH1 in the Gorge and SH2 along the harbour shore are expected to be closed. The map below shows "Availability State" – how bad will a given road be immediately after an event? For example, parts of SH1 through Tawa may be reduced to a single lane each way. Transmission Gully has a couple of short bits that will need a 4WD to get across.



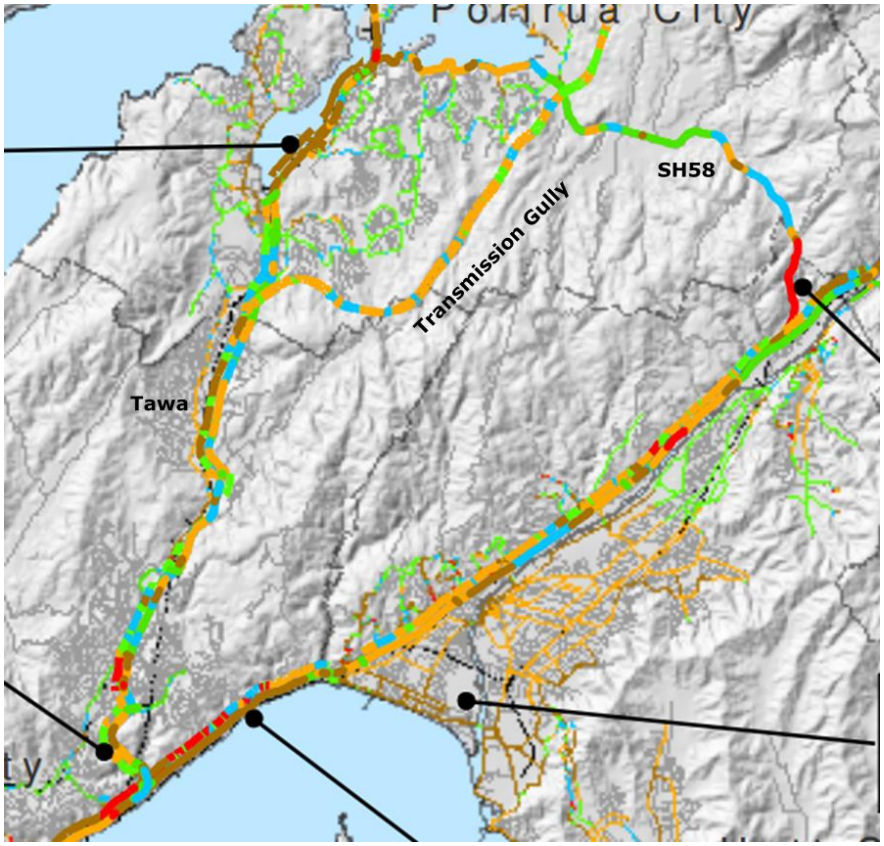
4-- From 2012 Wellington Region EQ Resilience Study, Opus



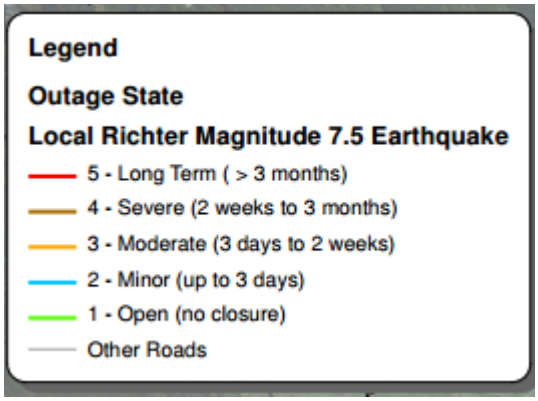
The map below shows "Outage State" – how long will a given stretch of road be in the state shown in the map above? They'll be able to get most of SH1 usable, even through the Gorge – though maybe only via a few lanes – within a few days (though it appears they'll need to divert to surface streets through Johnsonville). The northbound SH1 through Tawa will still be down to a single lane for two weeks to three months, though the southbound lanes should be back to normal much sooner. Transmission Gully likewise should be cleared in that 3 days to 2 weeks timeframe.

The Hutt, though, is expected to be cut off for weeks to months, depending on whether they can

safely clear the slips along the shore there.

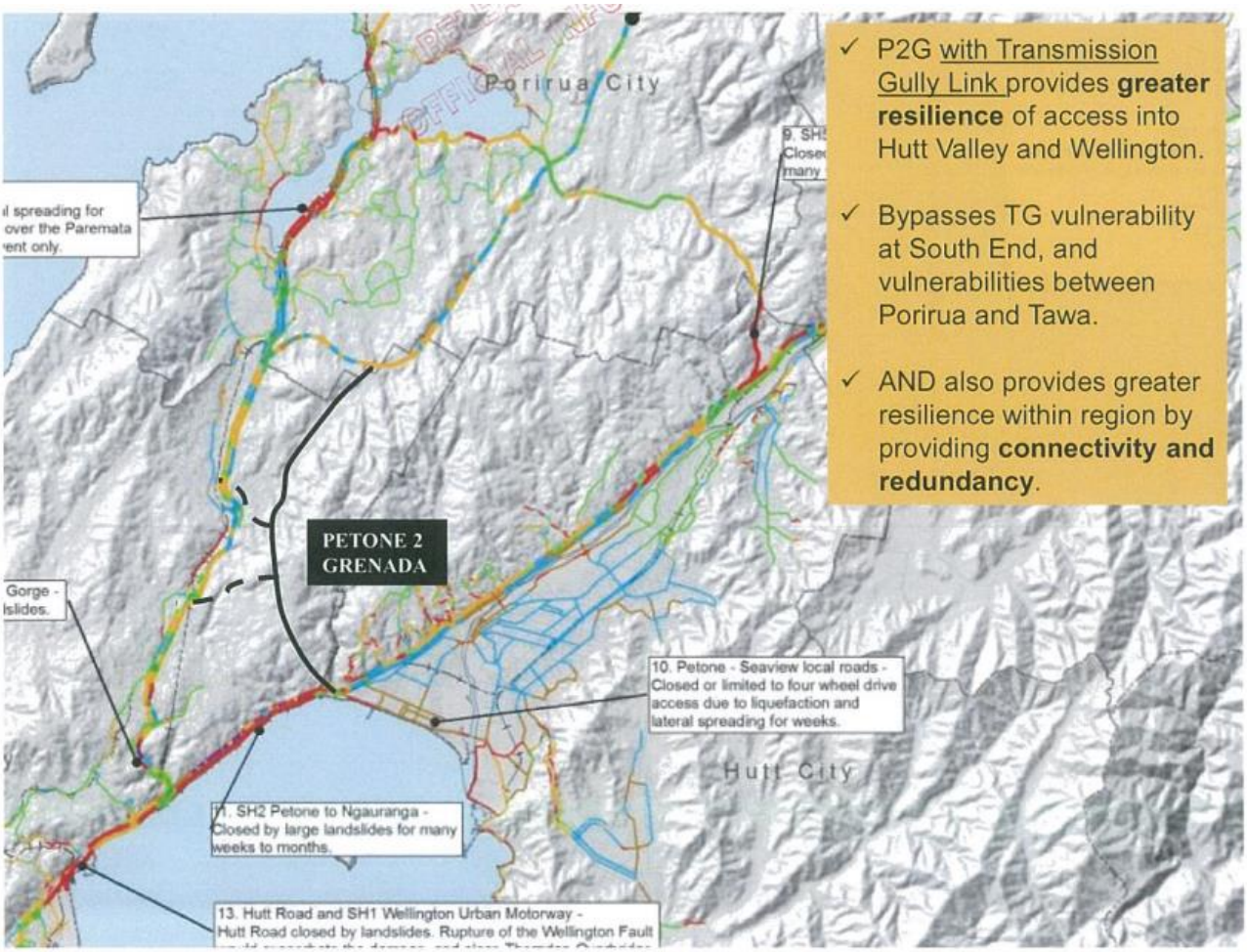


5-- From 2012 Wellington Region EQ Resilience Study, Opus



How will P2G in the event of a Magnitude 7.5 earthquake? What does it do for regional natural hazard resistance?

The slide NZTA presented to the local chief executives at their closed-door briefing back in November was this:



6 -- from "Petone to Grenada and SH58: Presentation to EAG August 2014", released under OIA

We don't get Availability or Outage information for P2G – instead, it's represented as a black road, apparently constructed of a magical "unbreakium" that won't fail in an earthquake. Note that according to the sales pitch, Transmission Gully, which hasn't even been built yet, is already a write-off and needs to be bypassed, as does the stretch of SH1 through Tawa, which as you can see from all that yellow and blue is likely to be the *least* damaged piece of highway in Wellington.

So how is P2G *actually* likely to fare in the event of a major event?

On the Petone/Korokoro side it has 60-85 meter deep double sided cuts:

7 -- from "Petone to Grenada and SH58: Presentation to EAG August 2014", released under OIA

Cuts of that size – think canyon walls the height of the Intercontinental Hotel in Wellington, or the Quay Tower in Auckland – are capable of generating large landslips. The P2G Scoping Report 2014 notes in regard to the southern end of P2G that "failures in cut slopes can close the road for a few weeks", and "high cut slopes reduce time for recovery." Such slips can be very difficult to clear (think the Manawatu gorge), especially when working at the bottom of a canyon where aftershocks threaten to send more material down onto the diggers below. This means that the slips could *not* be quickly cleared, and the road might well be closed for at least weeks, and possibly even months.

Then there is the fact that the road terminates in Petone, one of the most geologically/geotechnically problematic spots in the Wellington region, subject to subsidence, liquefaction and lateral spreading:

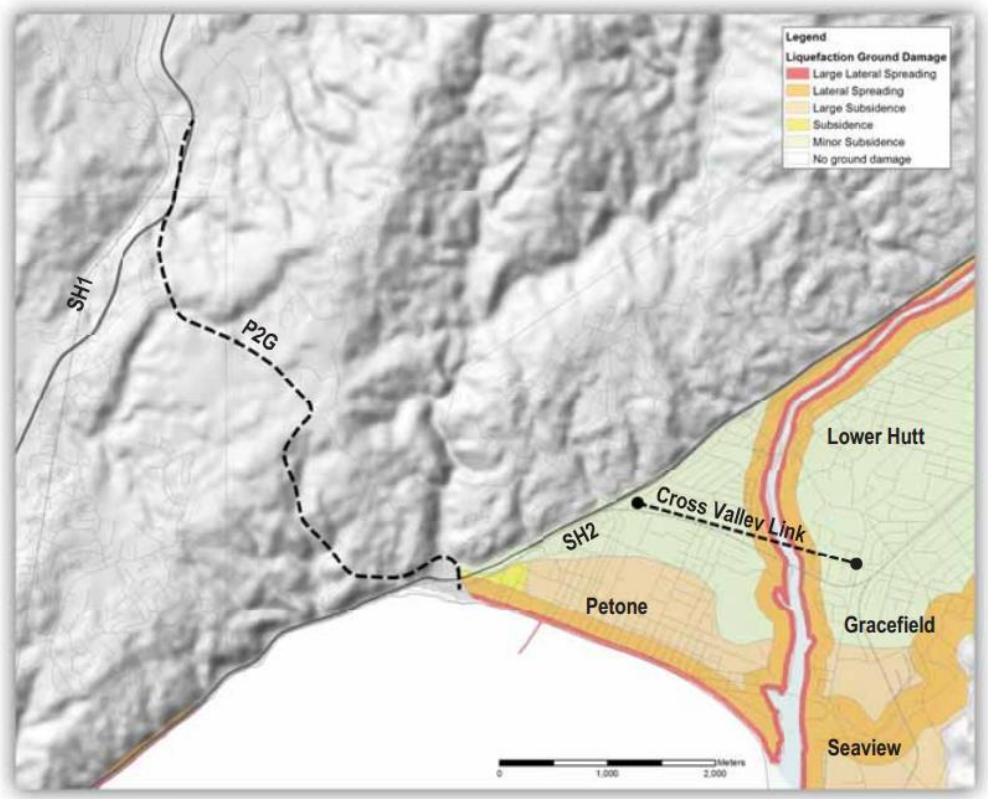
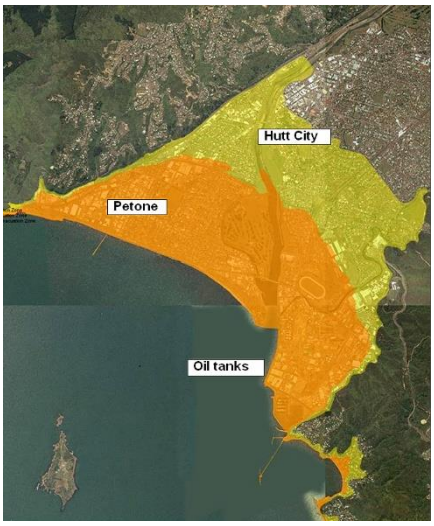


Illustration 10 Liquefaction ground damage hazard map

8 -- from P2G Preliminary Geotech Appraisal, 2013

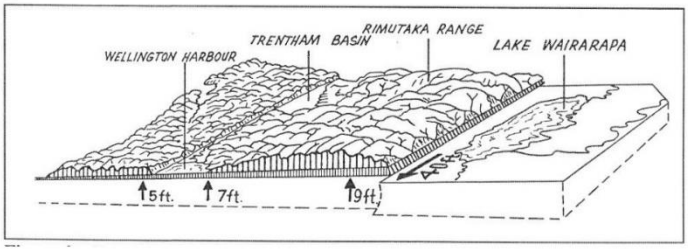
In addition, the area is subject to *Seiches* – a type of harbour tsunami that sloshes back in forth in a periodic oscillation, hammering Petone and the P2G terminus again and again.



9 -- Petone Tsunami risk map from WREMO – the P2G terminus would be in the orange high-risk area at the far left

But it is potentially even worse than that. In the 1855 Wairarapa Earthquake Petone was uplifted about 2 meters.

Fault movement, 1855 earthquake



The Wellington and Wairarapa faults tend to induce movements in opposite directions, so if the next major regional EQ is along the Wellington fault, then all of Petone could be thrust back down ~2 meters over the course of 60 seconds. The end result would be P2G, even if it *was* made of unbreakium (and note the P2G/SH2 interchange at Petone is mere meters from the Wellington Fault), could end up linking to little more than a rubble-strewn lake.

… And speaking of lakes, here's the 1976 Korokoro Flood, caused by a large storm – that flooding is from Korokoro Stream, by the way, not the Hutt River. The photo below is of Ullrich Aluminium and the current Petone overbridge, right where P2G will connect to SH2 in Petone.

December 1976 Flooding from the Korokoro Stream

10 -- from GWRC presentation "Floods and People, a historic perspective of the Hutt River"

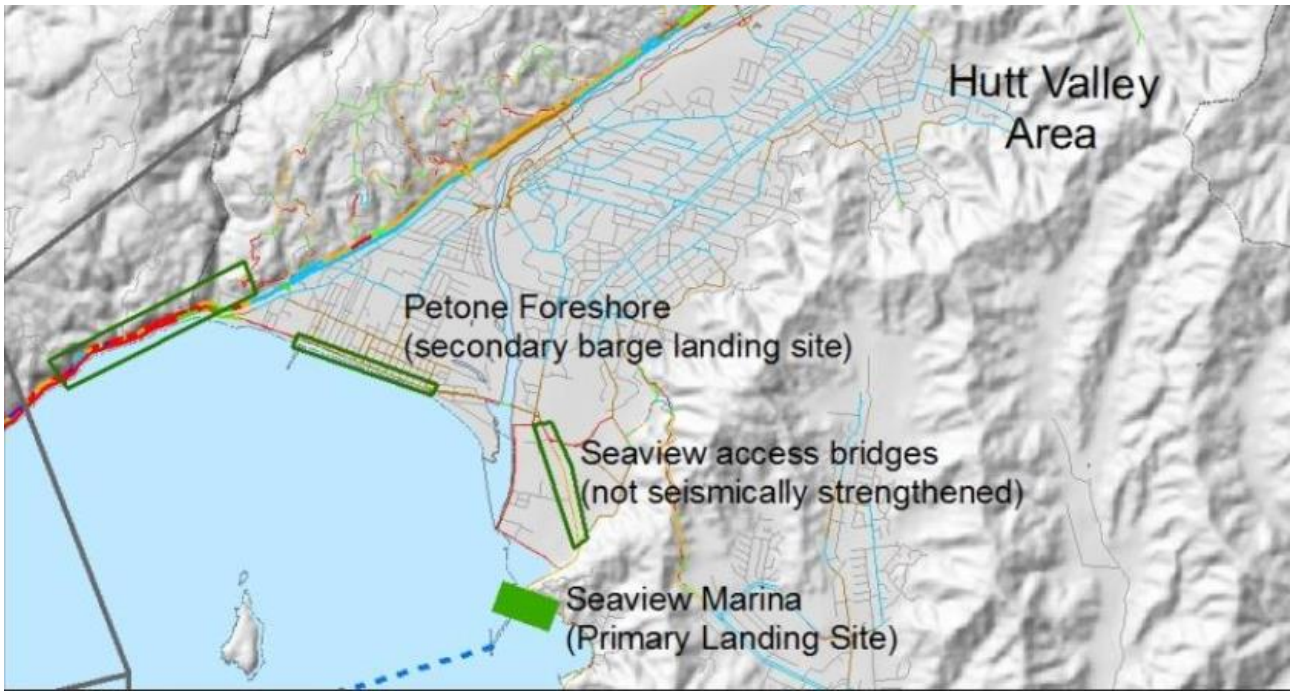
Petone is not the best place to put one end of a road intended to be a natural hazard resilience route, even if that road itself were not so vulnerable.

So how do we rescue the Hutt if the Big One hits?

They're cut off from Wellington by slips where SH2 runs along the harbour, cut off from Wairarapa by slips closing SH2 over the Rimutakas, and cut off from Kapiti by most of the Akatarawa road having fallen down a gully (again).

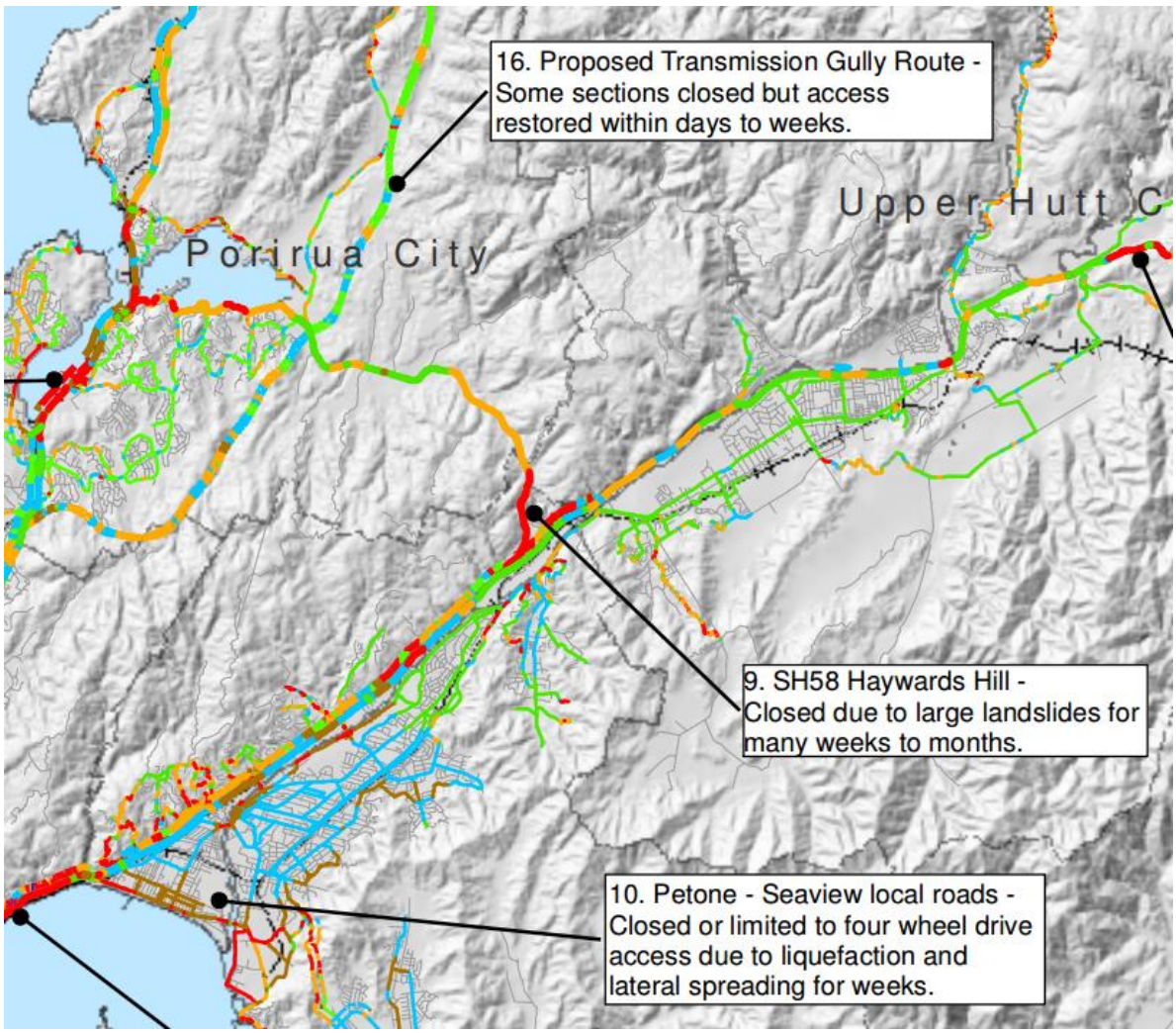
Unlike other parts of Wellington, Porirua and Kapiti, the Hutt Valley is not well-served by water access. The current plans require relief by air to Trentham, or supply boats making beach landings at Petone or Seaview. Petone, as discussed previously, is vulnerable to a variety of quake-related problems: liquefaction, lateral spreading, tsunami, and – in the case of a failure on the Wellington Fault – significant downthrust which may drop that end of the valley by up to two metres.

Seaview has the same tsunami and seiche risk as Petone, and will require bailey bridges to reach, as the current bridges are not expected to be usable after a major event. Supplies and personnel landed at Petone or Seaview then have the entire length of the valley to traverse.



12- from Restoring Wellington's Transport Links after a Major Earthquake, Wellington Lifelines Group and WREMO, March 2013

The best candidate for a resilience road for the Hutt is SH58, which in conjunction with Transmission Gully actually looks pretty fantastic:



13 -- From 2012 Wellington Region EQ Resilience Study, Opus

…except for that pesky red bit right at the end where the road sidles along a hillside and then swings down to join SH2. This is a far shorter section of road than either SH2 over the Rimutakas or SH2 along the harbour shore, and unlike the proposed Petone to Grenada link, the road is not at the bottom of a 20 storey canyon.

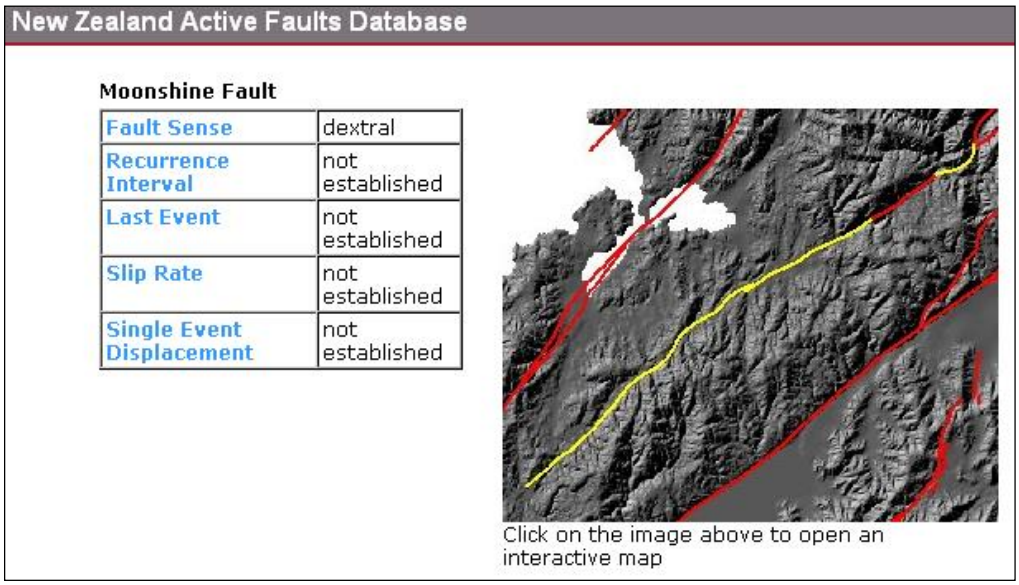
Towards the Porirua end, SH58 connects directly to Transmission Gully, which, supposedly built to the highest seismic standards, is being touted as the EQ saviour of the (rest of the) region. At the eastern end, SH58 connects at the boundary between Upper and Lower Hutt, providing good access to both ends of the valley. It's a short, straight shot on good roads to Trentham, where the Army Camp and racecourse form a natural logistics centre. SH58 would be the lifeline for the 150,000 people of the Hutt.

At the 9th March meeting of the Regional Transport Committee, a vote was taken to (finally) upgrade the interchange between SH58 and SH2. With that work already approved, and funding freed up by the Transmission Gully PPP burning a hole in NZTA's pocket, now is the ideal time to bring that dodgy last couple of km up to scratch and give Hutt Valley a real resilience solution.

Natural Hazard Resilience – Takapu Valley

We've already addressed how the Takapu link does not offer very much in terms of network resilience, how about natural hazard resilience? The resilience specialist consulted for the P2G Scoping Report rated the Takapu Alignment highly.

Unfortunately, the specialist made another mistake and *also* missed the fact that the proposed alignment runs directly along and atop an active uncharacterized fault:

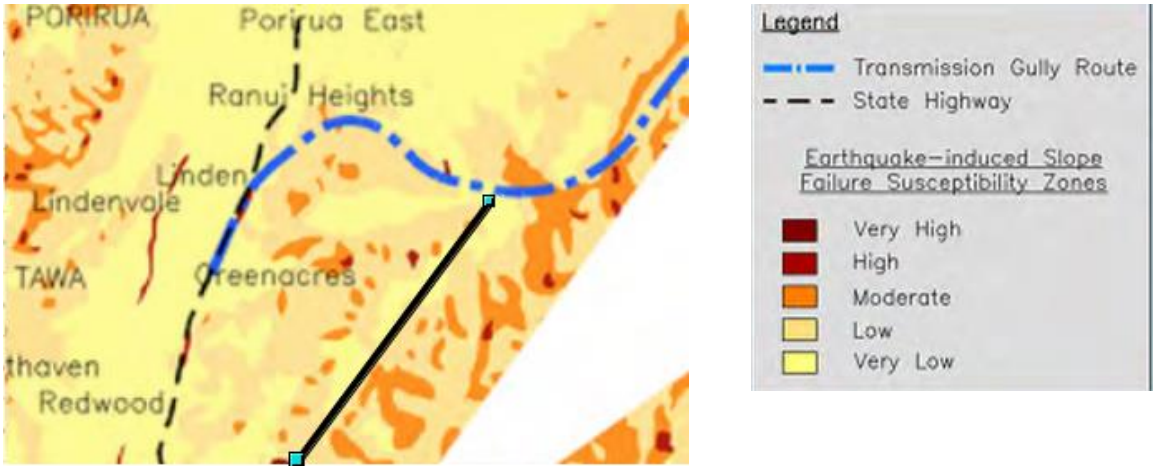


14 -- from GNS Active Faults Database, accessed 29 March 2015

GNS has listed the Takapu Fault as a spur of the Moonshine Fault. The Moonshine Fault has a nice long failure interval – NZTA sources quote a figure of 11,000 years. Unfortunately, geotechnical sources we've consulted tell us that it's not correct to assume that the Takapu spur operates at the same displacement or interval that the Moonshine Fault does. That's why GNS has all those "not established"s in the database.

The fault itself is not necessarily the problem – you can't throw a stone in Wellington without throwing it across a fault line, after all. The problem is that Takapu Valley is narrow and in places quite steep, and the best land has long been occupied by power pylons. Lots of them.

Even with the best alignment they could pick, the Takapu link road features "moderate height cuts that may fail, closing the route for up to two weeks". (The section of SH1 it is supposed to "bypass", by contrast, is expected to remain usable immediately after a quake.) The proposed narrow, two-lane Takapu extension runs through terrain with a moderate to high risk of slope failures, particularly at the southern end, which has an overall greater extent of at-risk slope than the Duck Creek and Linden sections of TG.



14 -- Images from Appendix A, Statement of evidence of Pathmanathan Brabhaharan (Brabha) (Geology and geotechnical engineering) for the NZ Transport Agency and Porirua City Council. 18 November 2011

This is the other shoe dropped by the fault line: even if you give the fault itself minimal clearance (and first they'd need to pay GNS to figure out where it actually *is*, because that bit you can see – where you can see it at all – is only where it happened to break the surface the last time it ruptured), the rock all through there has been fractured and crushed by the movement of the fault over millions of years.

When describing the resilience aspects of the southern end of P2G, the specialist repeats multiple times: "Away from poor rock conditions and faults [the cuttings] can be engineered to reduce failures in earthquakes", "Likely to have better rock conditions being further away from the Wellington Fault Zone", "Rock conditions are likely to be better being away from the Wellington Fault zone, and a short crossing of the inactive Korokoro Fault scarp." If the fault isn't the problem, the rotten rock near the fault is. It's difficult to build on – as the Transmission Gully team has discovered attempting to site the foundations for the Cannons Creek viaduct, which nips off the top of the valley – and it's far more likely to fail than even the usual Wellington "wheatbix" greywacke.

In a series of answers to questions raised by Hutt City Councillors, the P2G project team identified as key risks for Option D specifically:

- Geotechnical, relating to the stability of the large cuts and differential settlement within road embankment fills required to form a link road in complex terrain
- Geometric constraints, particularly with respect to horizontal curvature and gradient, as a result of difficult terrain

An alignment which gives a safe clearance to the fault line may not be possible, with the pylons to the west and the steep hill faces to the east – there's also the Wellington water main and the gas main to avoid, particularly at the north end of the valley. They could be forced into an alignment requiring still higher, more vulnerable cuts into multiply-fractured, slip-prone hillslopes – though if they go too high, they're into more power lines.

Speaking of which:

15 -- Photo taken at the north end of Takapu Valley, looking south along proposed road alignment.

The Wellington Region Road Network Earthquake Resilience Study released by Opus in August 2012 pays special attention to sections of the network – particularly in Upper Hutt – that are at risk from fallen power lines.

The alignment of the proposed Takapu extension weaves under and through the 33, 66, 110 kV lines and under the 220 kV lines and the HVDC link – right up through the spot where more than a dozen sets converge on the Takapu Substation. Even when well-sited, the pylons themselves may fail in an earthquake or severe weather event. One of the sets of pylons running alongside the proposed road alignment was built in 1924.

In conclusion

The Petone to Grenada road has the potential to provide significant improvements to regional network resiliency, especially if the interchange at Churton Park is improved so it can efficiently handle high speed, high load traffic flow between SH1 and P2G. P2G does not provide very good regional natural hazard resilience, due to the vulnerabilities of the deep cuts on the Petone end, and the simple fact that it connects to Petone, one of the most geotechnically problematic areas in the region.

The proposed Takapu extension to Transmission Gully does not contribute significantly to network resiliency, and has mediocre to poor natural hazard resilience. What it does do is add extra lane-kilometres of road that will need to be cleared (or abandoned) after a disaster – likely to be low priority compared to the adjacent Wellington RoNS corridor.

Where Petone to Grenada proposes an improvement in an area of poor network resilience, SH58 must become a priority for regional disaster resilience.