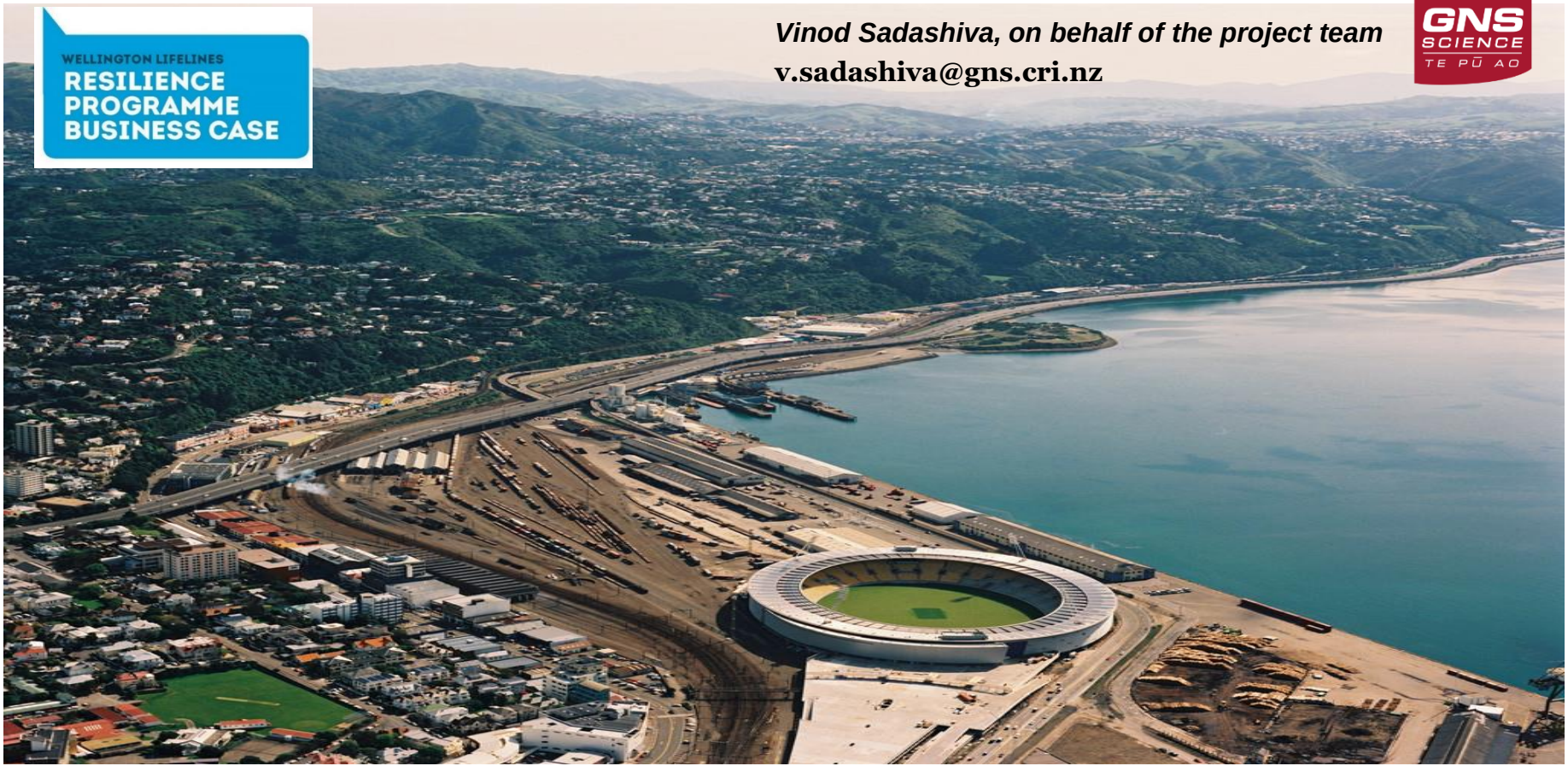
Reducing disaster impact by targeted infrastructure resilience investments

Case study: Wellington Lifelines Resilience Project

Vinod Sadashiva, on behalf of the project team
v.sadashiva@gns.cri.nz



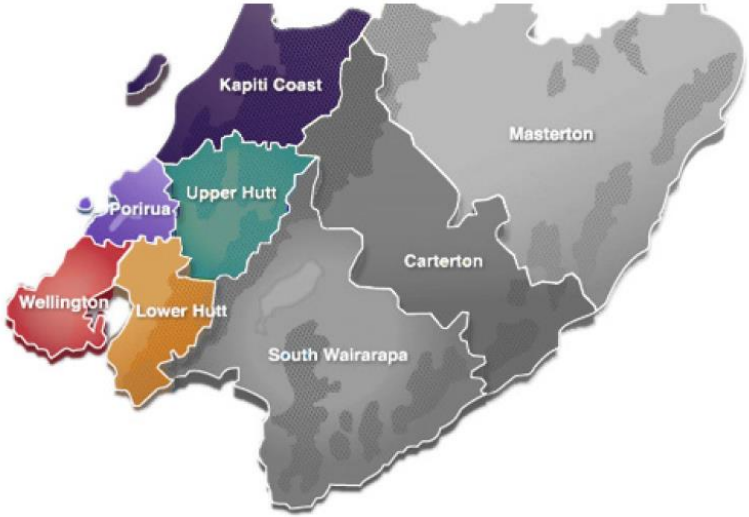
The Need

- We have witnessed several damaging earthquakes in the last decade that have tested the resilience of our built environment and communities
  - E.g. 2016 Kaikōura earthquake severely damaged large sections of State Highway 1 and railway lines, resulting in significant direct and indirect impacts due to disrupted services
- Events such as this provide a compelling case to accelerate building resilient infrastructures in the country so we can reduce impacts from future natural hazard events
- Towards this aim, many lifeline organisations have made (& continue to do so) resilience investments that have been demonstrated to have helped reduce the impacts in recent events (e.g. Orion's experience in Canterbury eqs.)
- However…many investments are often made independently with no-to-limited consideration given to the resilience of interdependent networks that together collectively contribute to a region's resilience

Project Area

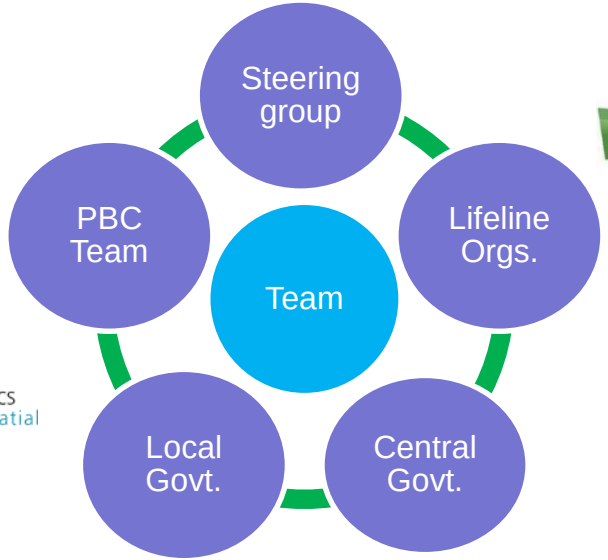
- The PBC covers the western side of the Wellington Region including Wellington, Upper Hutt, Lower Hutt, Porirua, Kapiti Coast District areas (as well as some connections outside this region identified as being critical to the Wellington Region's resilience).

  - The five cities together contain bulk of the region's population
  - Are vulnerable to shock events that will cause disruptions to community and economy
  - Are consistent with the network coverage of our key infrastructure providers



The Team

- **Steering Group**
- **Lifeline utility organisations – 17 of them**
- **Central Government**
- **Local Government**
- **PBC team**



WELLINGTON LIFELINES
RESILIENCE PROGRAMME BUSINESS CASE

THE PROCESS

WELLINGTON LIFELINES
RESILIENCE PROGRAMME BUSINESS CASE

INFORMATION GATHERING THROUGH: COLLECTING INFORMATION, WORKSHOPS AND MEETINGS

INVESTMENT LOGIC MAPPING

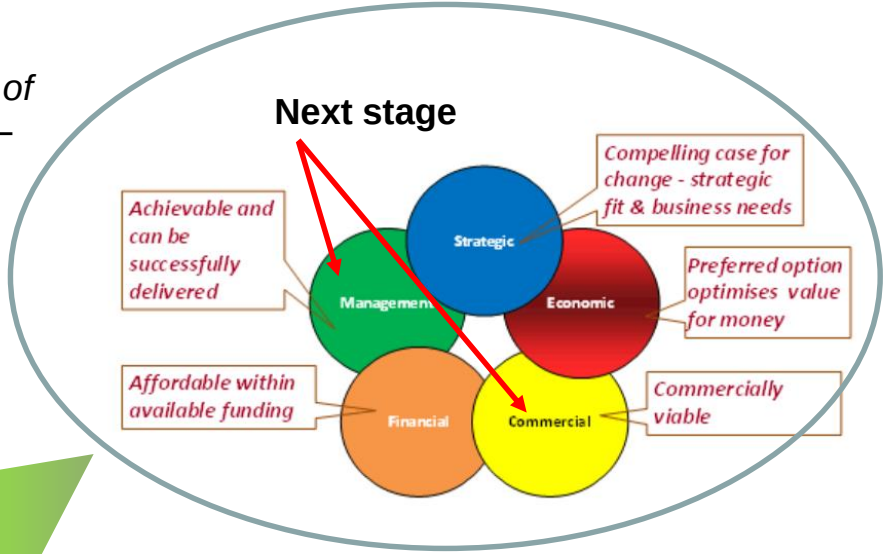
SET INVESTMENT OBJECTIVES AND BUILD MODELS

Damage, outage, economic modelling

DEVELOP INFRASTRUCTURE RESILIENCE PROGRAMME OPTIONS AND MODEL

Stage 1: Demonstration of Benefits of Programme – completed in April 2018
Stage 2: Financing and Timing – completed in Sept. 2019

NZ Treasury's Better Business Case



ASSESS OPTIONS AND RECOMMEND PREFERRED INTEGRATED PROGRAMME OF INFRASTRUCUTRE PROJECTS

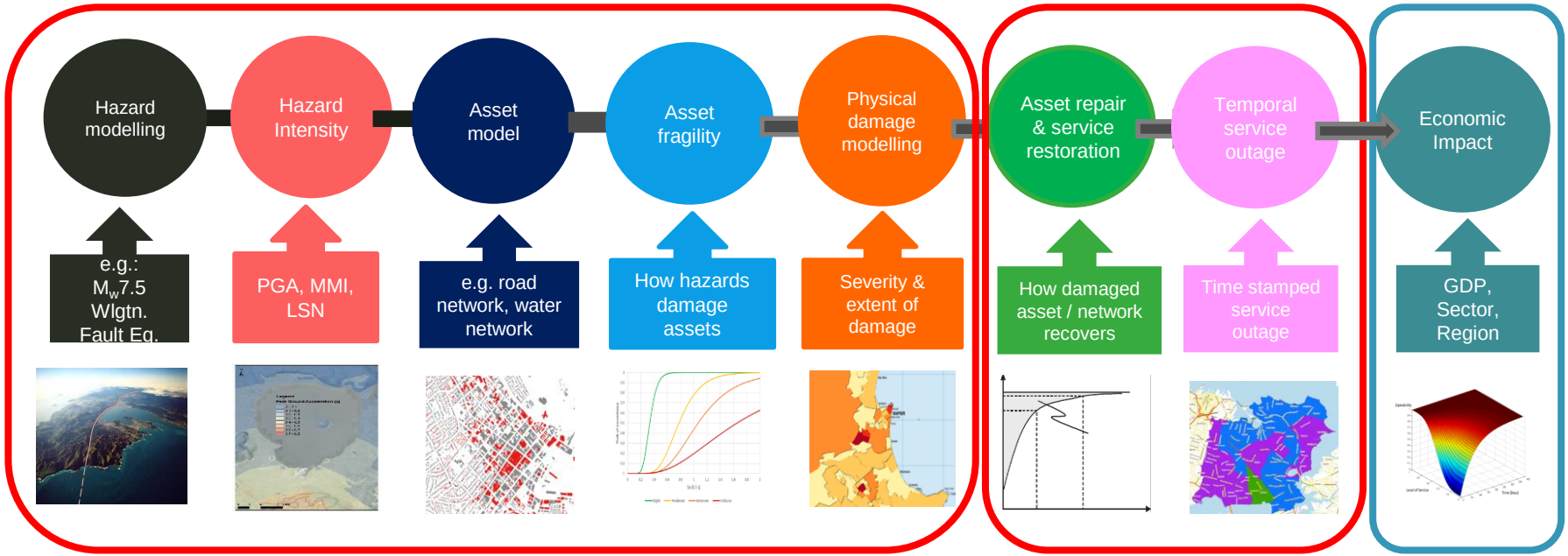
Main objective: Demonstrate potential economic benefit by investing in Wellington's infrastructure resilience

Modelling (with the same earthquake scenario) for:

a) Base case – i.e. considering as-is infrastructures with existing vulnerabilities

b) Improved resilience case – i.e. specific investments made to improve the resilience of the networks

Impact modelling workflow

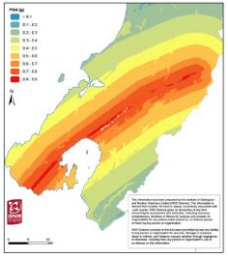


Hazard Scenario: M_w7.5 Earthquake on the Wellington Fault

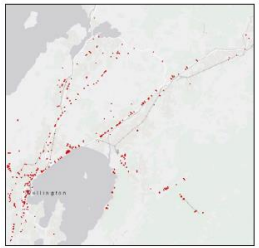
- highly disruptive event
- may tip some people and businesses out of the region either temporarily or permanently
- Likely to take appreciable time for economy to stabilize

Related perils included for modelling:

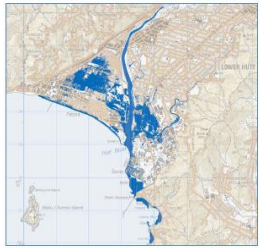
Fault Rupture



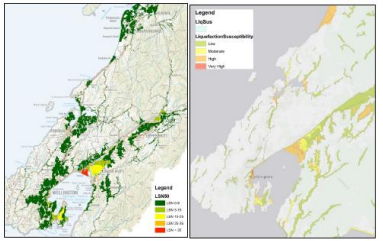
Shaking



Landslide



Co-seismic subsidence

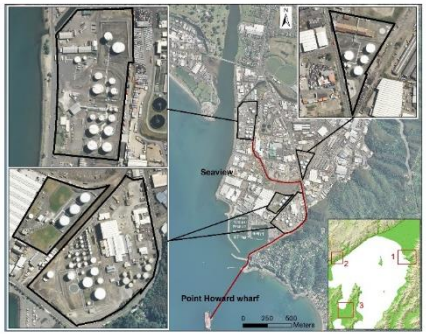


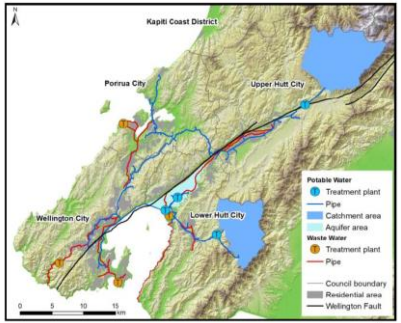
Liquefaction

Lifeline utilities / infrastructure networks included

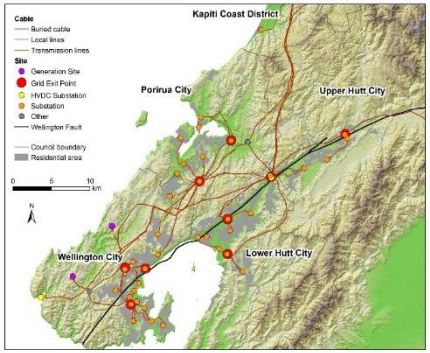
- Roads
- Rail
- Electricity
- Fuel
- Telecommunications
- Water
- Wastewater
- Gas
- Port
- *Airport*

Fuel

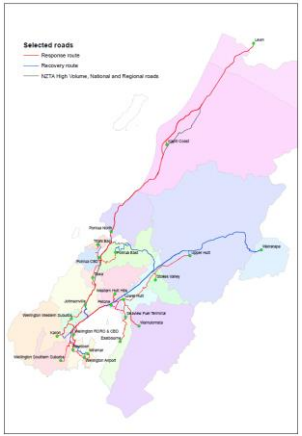




Water & wastewater



Electricity



Roads

Road Network

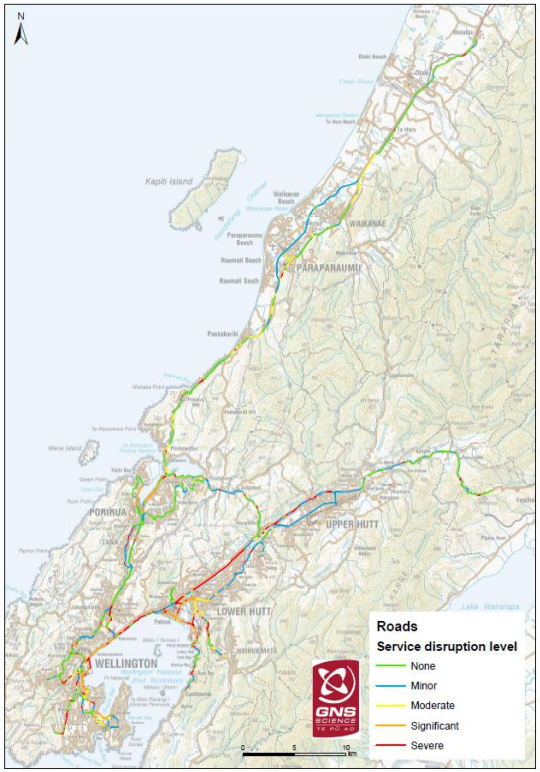
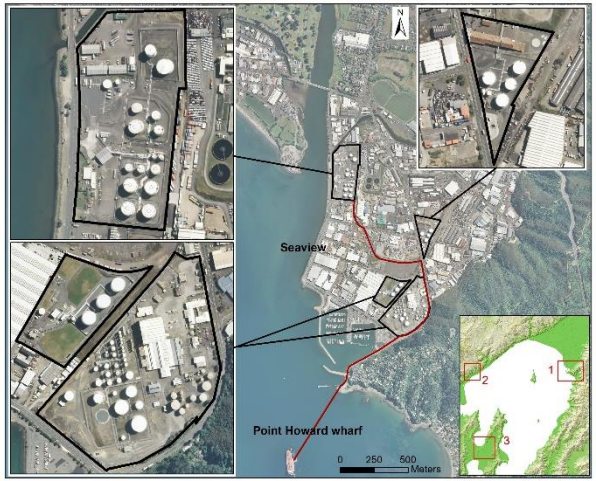


Table 1 – Estimated outage times (in days) for road access between transportation zones (Fig. 3) for Base Case. Values outside and inside the brackets are respectively for response and recovery levels of service

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																								
2	7 (28)																							
3	7 (28)	5 (21)																						
4	7 (28)	3 (21)	5 (21)																					
5	7 (28)	3 (21)	5 (21)	2 (14)																				
6	7 (28)	3 (21)	5 (21)	2 (21)	2 (21)																			
7	7 (28)	3 (21)	5 (21)	2 (14)	1 (7)	2 (21)																		
8	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)																	
9	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)	7 (97)	3 (93)																
10	13 (103)	13 (103)	13 (103)	13 (103)	13 (103)	13 (103)	13 (103)	13 (103)	13 (103)															
11	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)	13 (103)														
12	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)													
13	10 (104)	10 (104)	10 (104)	10 (104)	10 (104)	10 (104)	10 (104)	10 (104)	10 (104)	13 (104)	14 (104)	14 (104)												
14	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	12 (102)	14 (104)											
15	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)	14 (104)										
16	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)									
17	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	7 (21)								
18	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	90 (180)	50 (180)	90 (180)	90 (180)	90 (180)	90 (180)	40 (180)	40 (180)							
19	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	50 (120)	90 (120)	90 (120)	90 (120)	90 (120)	7 (21)	3 (14)	40 (180)						
20	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	50 (120)	90 (120)	90 (120)	90 (120)	90 (120)	21 (30)	21 (30)	40 (180)	21 (30)					
21	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	50 (120)	90 (120)	90 (120)	90 (120)	90 (120)	10 (49)	10 (49)	40 (180)	10 (49)	21 (49)				
22	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	90 (120)	50 (120)	90 (120)	90 (120)	90 (120)	90 (120)	10 (42)	10 (42)	40 (180)	10 (42)	21 (42)	10 (49)			
23	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	90 (138)	50 (138)	90 (138)	90 (138)	90 (138)	90 (138)	30 (138)	30 (138)	40 (180)	30 (138)	30 (138)	30 (138)	30 (138)		
24	21 (28)	21 (28)	21 (28)	21 (28)	21 (28)	21 (28)	21 (28)	21 (97)	21 (97)	21 (103)	21 (100)	21 (104)	21 (104)	21 (104)	21 (104)	90 (120)	90 (120)	90 (180)	90 (120)	90 (120)	90 (120)	90 (120)	90 (138)	

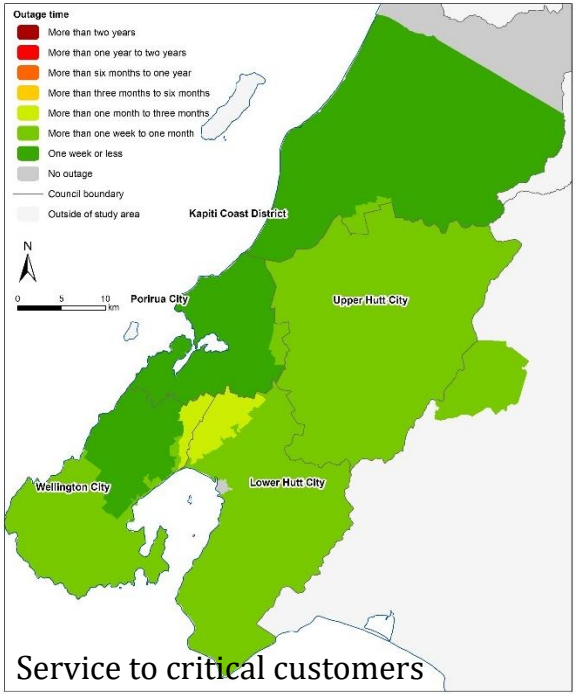
Sadashiva VK, , Mowll R, Heron DW, Lukovic B (2020): Reducing Infrastructure Outages Through Integrated Infrastructure Resilience Investment Programme. Paper No. C002636. 17WCEE, 17th World Conference on Earthquake Engineering, Sendai, Japan.

Fuel

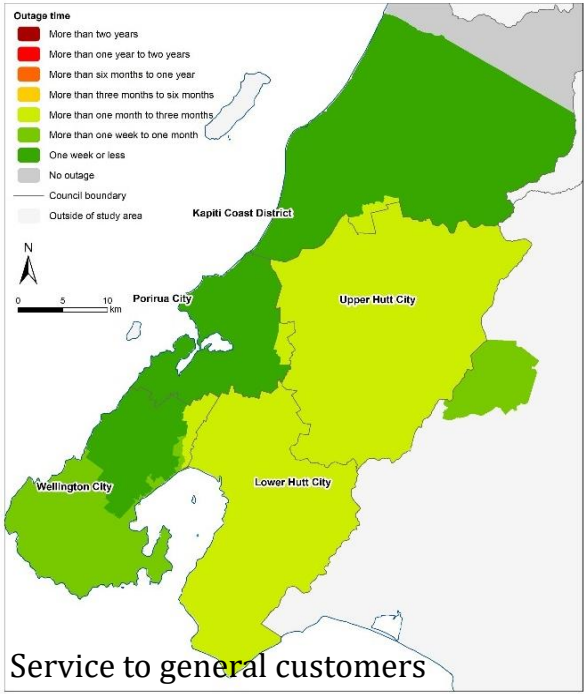


Seaview fuel storage facilities, with the location of all facilities in Wellington shown in inset

Estimated Fuel Service Outage Times - Base Case

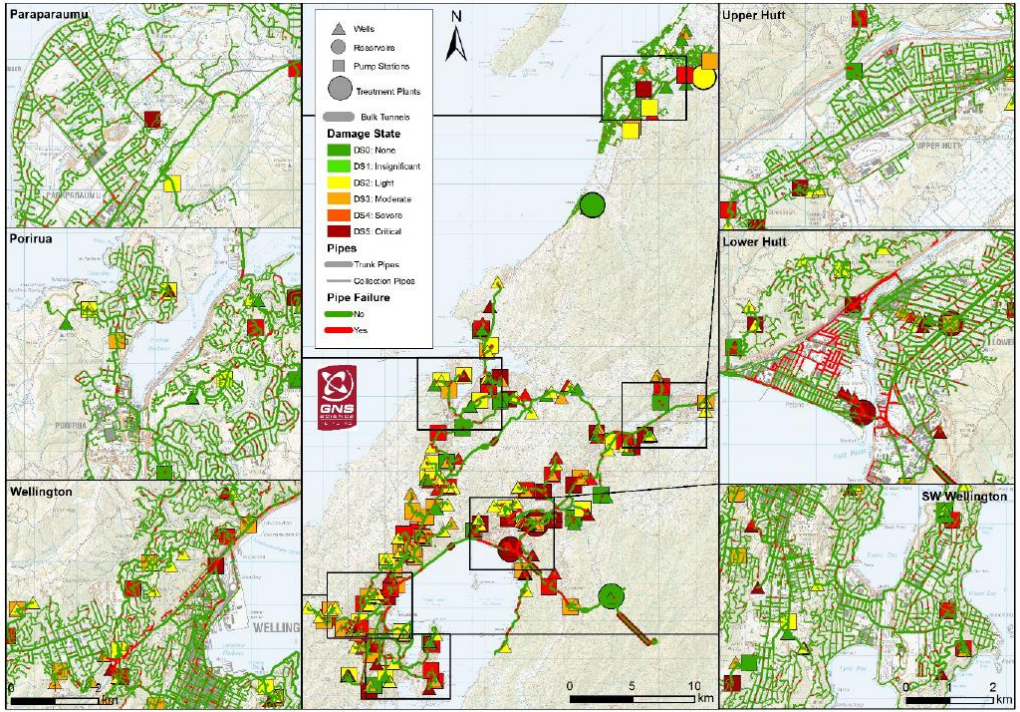


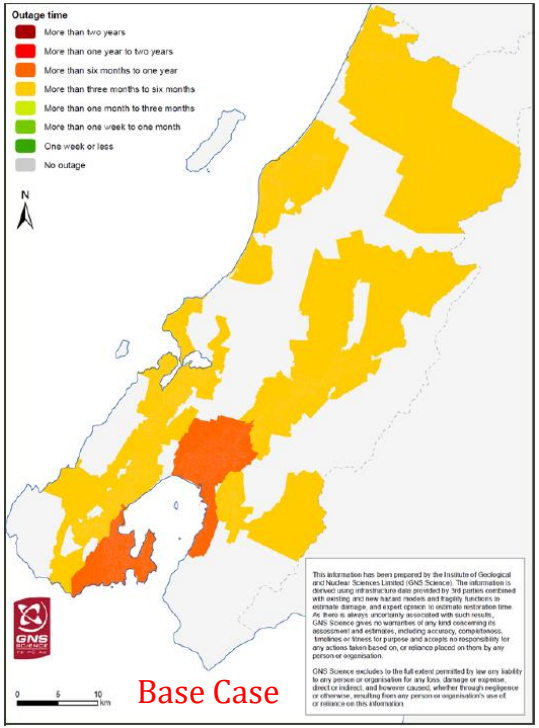
Service to critical customers



Service to general customers

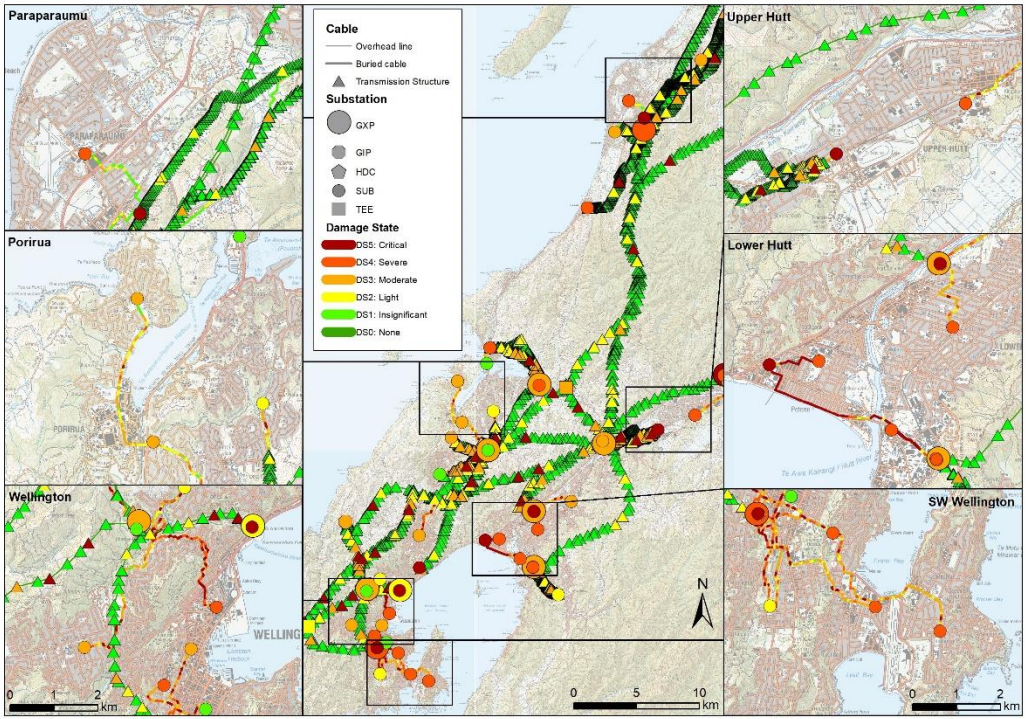
Potential damage & outage map for water supply – Base Case

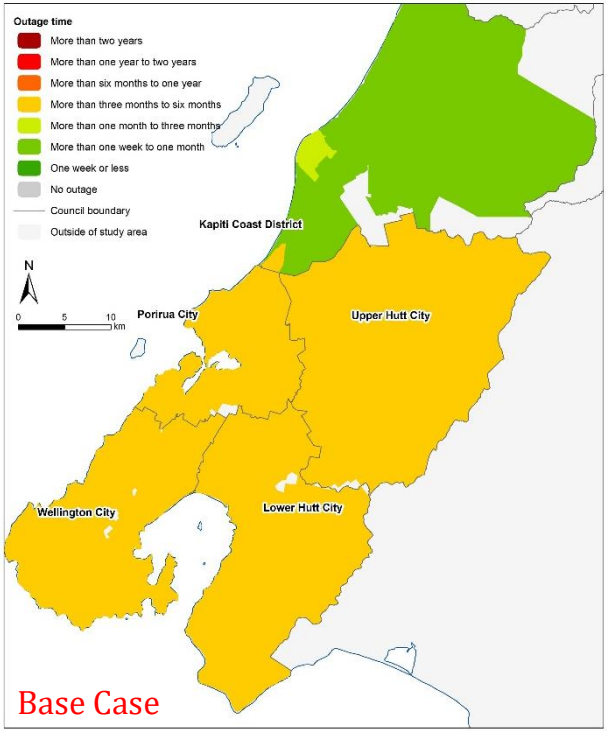




Sadashiva VK, Nayyerloo M, Williams J, Heron DW et. al. (2020): Potential benefits of implementing water network resilience projects in Wellington region of New Zealand. Paper No. C002641. 17WCEE, 17th World Conference on Earthquake Engineering, Sendai, Japan.

Potential damage & outage map for electricity – Base Case

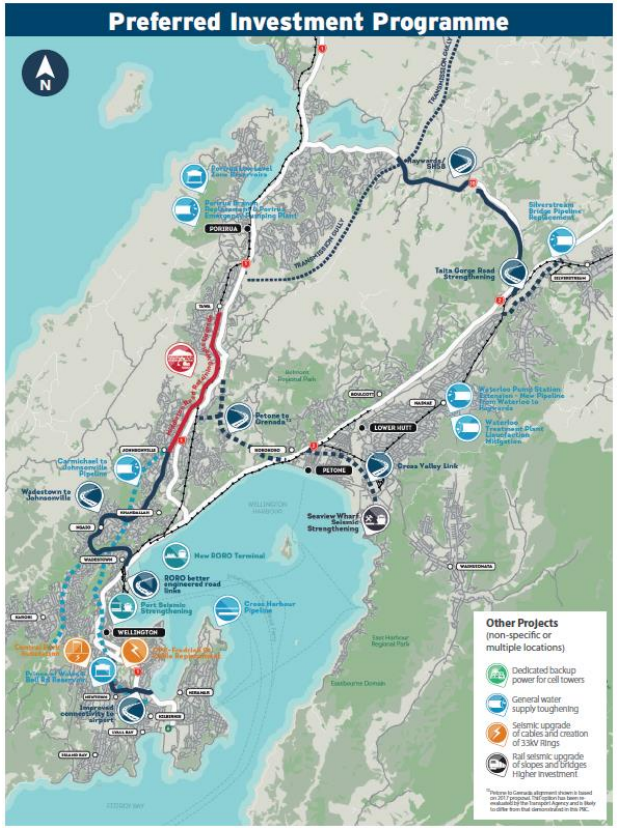




Infrastructure Investment Programmes

- Staged workshops carried to assess how proposed projects (originally a long list) perform against benefit statement and investment objectives
- Many projects already on long term asset plans and have funding approved
- It considers the interdependencies
- If the projects are delivered in a priority order and accelerated, there will be added significant benefits

Recommended / Preferred Programme



INTEGRATED PROGRAMME

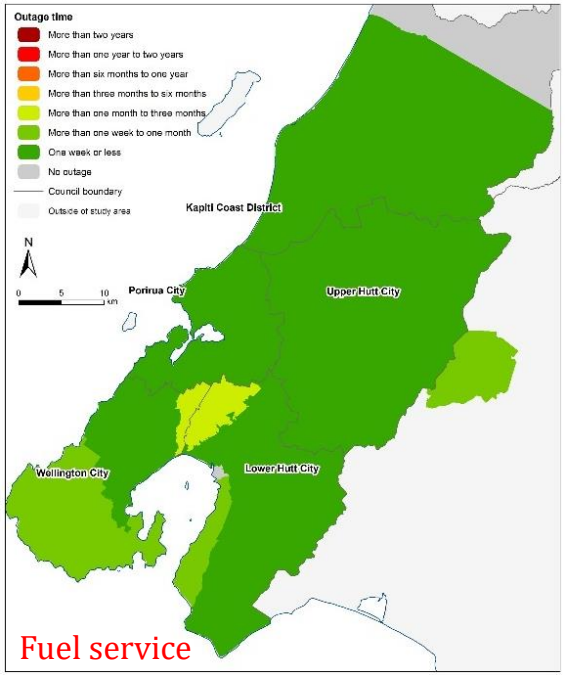
	GROUP #	PROJECT GROUPING	ICON	PROJECTS
Primary infrastructure strengthened or alternative achieved	1	Road		Seaview Wharf strengthening
				SH58
				Taita Gorge
				Wadestown to Johnsonville
	2	Road		Airport connectivity to Newtown
	3	Electricity		Central Park
				Central Park to Frederick Street cables
				Seismic strengthening 33kV
	4	Water		Cross Harbour pipeline
				Prince of Wales and Bell Road reservoir upgrade
				Silverstream Bridge Pipeline replacement project
				General toughening of pipes
	5	Comms		Dedicated backup power for cell towers
	6	Port/Road		Port Seismic strengthening
				Better engineered road links to existing RORO terminal & port area
	7	Rail		Rail Seismic upgrade of slopes and bridges
Primary infrastructure strengthened or secondary alternative achieved	8	Electricity		Seismic strengthening 33kV
	9	Water		Carmichael to Johnsonville
				Porirua Branch replacement
				Porirua low level zone reservoirs
				Waterloo Treatment Plant
				General toughening of pipes
	10	Road		Petone to Grenada
				Cross Valley Link
	11	Port		New RORO Terminal
	12	Rail		Rail seismic upgrade of slopes and bridges
Strengthening completed	13	Road/Gas		Middleton Road retaining walls upgrade
	14	Electricity		Seismic strengthening 33kV
	15	Water		Waterloo Pump Station extension and new pipeline from Waterloo to Haywards
				General toughening of pipes

Phase 1: 0-7 years

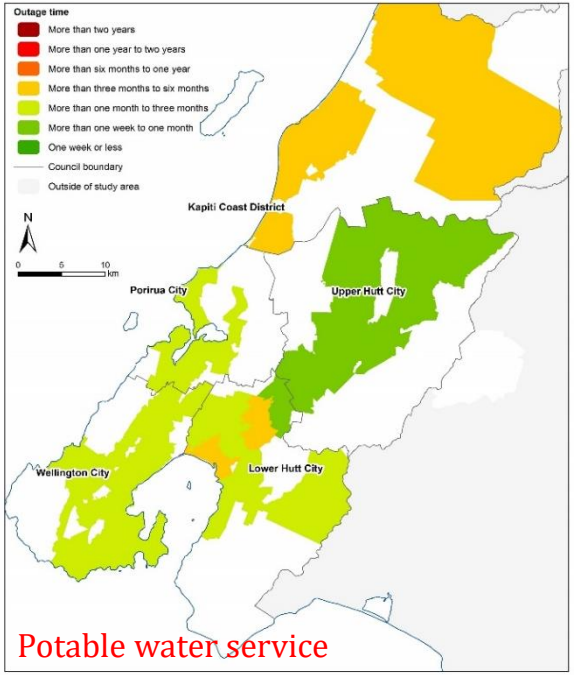
Phase 2: 8-14 years

Phase 3: 15-20 years

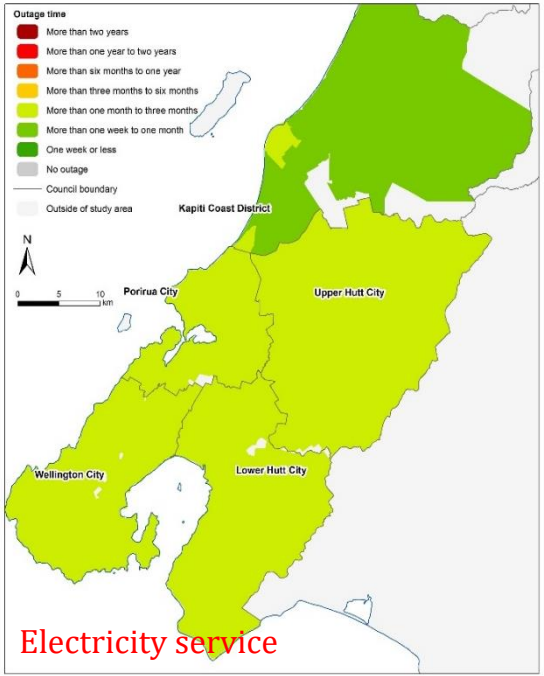
Improved Resilience Case outage map examples



Fuel service

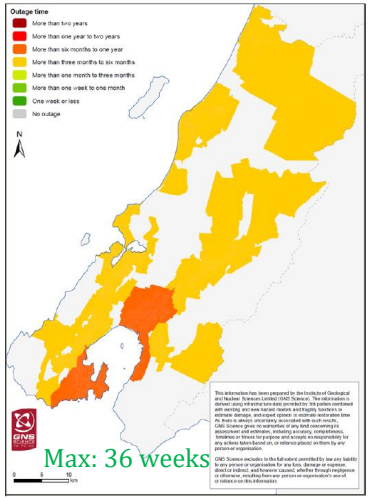


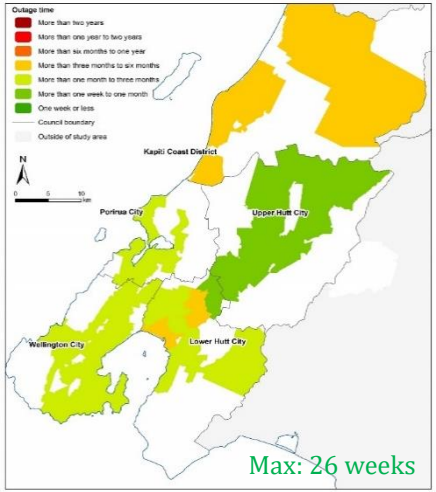
Potable water service



Electricity service

Reduced service outages with investments made - examples

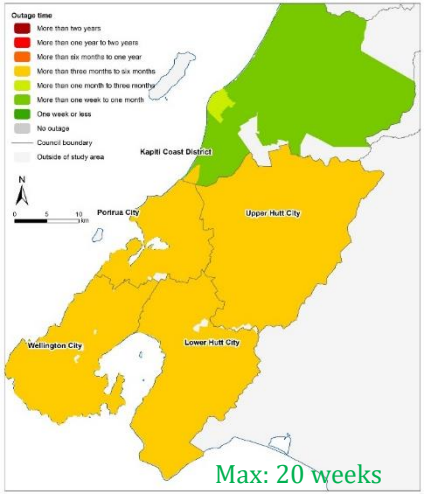


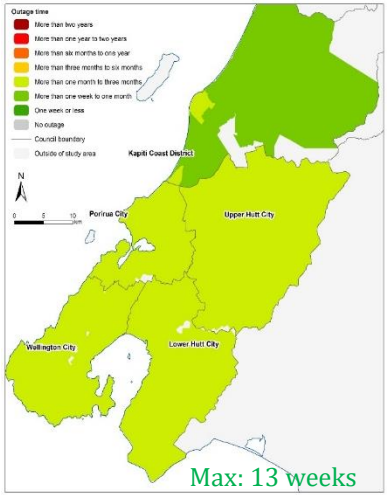


Base Case

Improved Case

Potable water service





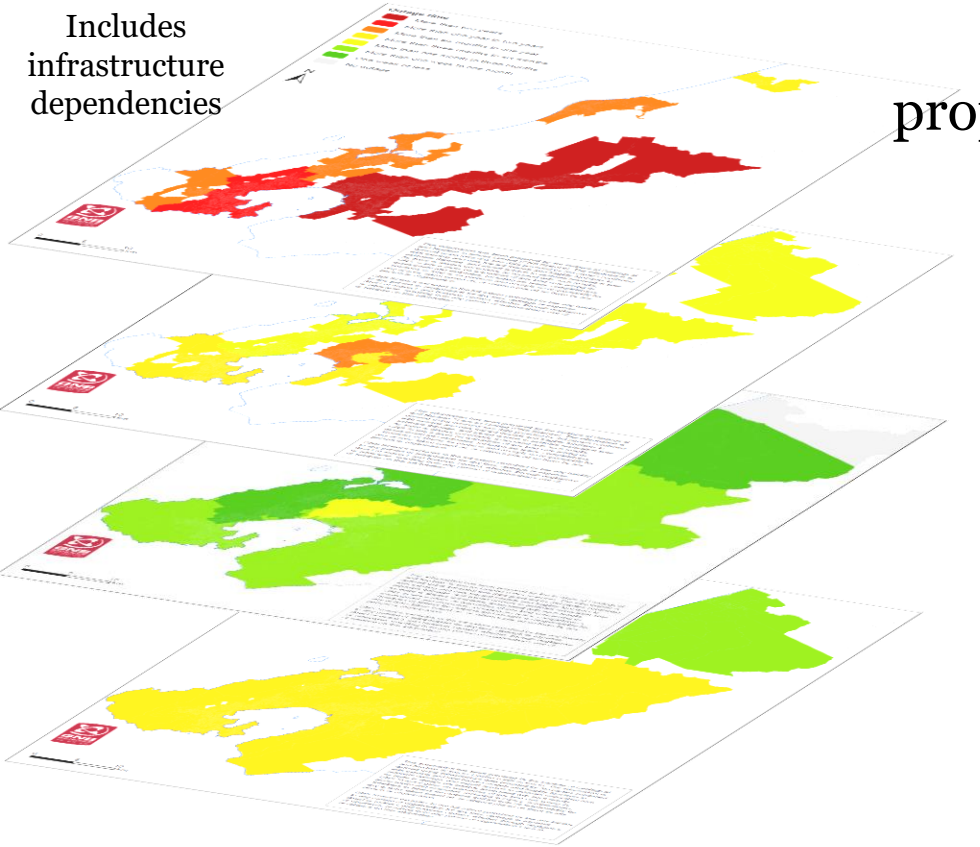
Base Case

Improved Case

Electricity service

Service Outage Maps Input to MERIT

Includes infrastructure dependencies



Same process for base case and proposed resilience improvement cases

To

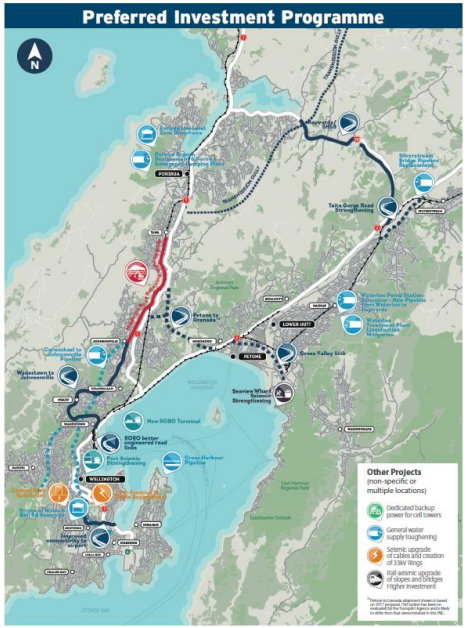
MERIT

Economic modelling tool

Modelled economic impact by investing in preferred programme (capital cost estimate: $3.9 billion)*

Cumulative change in GDP for Preferred Programme ($2016 Billion)

Lapsed Time Since Event	6 months		1 year		5 years	
Preferred Investment Scenario	None	Preferred	None	Preferred	None	Preferred
Wellington Region	-8.7	-5.7	-10.3	-6.3	-13.5	-8.0
Rest of NZ	-2.1	-1.7	-3.0	-2.2	-3.2	-2.6
Total NZ	-10.7	-7.4	-13.3	-8.4	-16.7	-10.5
MERIT	Net Reduction in GDP Loss when compared to the No Investment Scenario *i.e. Base-case (as-is infrastructures)*					$6.16B



Wellington Lifelines Group (2019): Protecting Wellington's Economy Through Accelerated Infrastructure Investment Programme Business Case. Revision 3.
** 2019 estimate*

Other potential benefits with investment made

- Proposed infrastructure improvements will also make the Wellington Region more resilient to smaller and higher frequency events
  - → Additional economic benefits
- Improved capacity for businesses to adapt
  - → The process of recovery commences earlier, faster return to normal levels of productivity
- Improved 'liveability'
  - → Number of people temporarily relocated likely to be still high, but number of permanent relocations can be expected to reduce
- Improved business 'viability'
  - → Less likely for businesses to choose to relocate
- Reduced isolation
  - → Less disruption to tourism

Thank you

Acknowledgements-

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Wellington LIFELINES Group
me market economics environment • spatial
New Zealand Lifelines
GNS SCIENCE TE PŪ AO
EY
TT
Resilient ORGANISATIONS
WAKA KOTAHI NZ TRANSPORT AGENCY
Electra
CentrePort Wellington
KiwiRail
poriruacity
Greater Wellington Te Pane Matua Taiao
Absolutely Positively Wellington City Council Me Heke Ki Pōneke
wellington electricity we
Wellington Water
POWERco
TRANSPOWER
Upper Hutt
HUTT CITY TE AWA KAIRANGI
nova energy
Kāpiti Coast DISTRICT COUNCIL