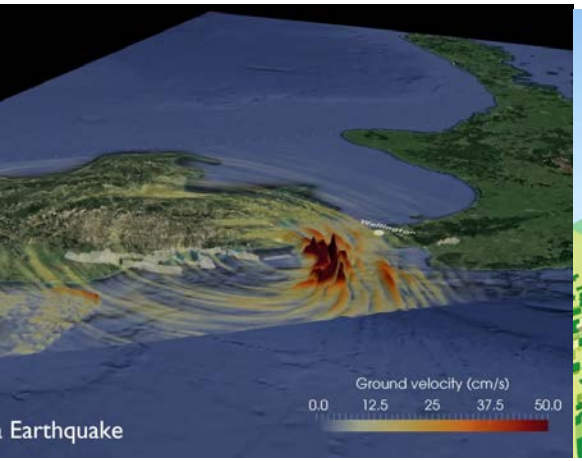
How Earthquake Impact Scenarios Can Inform Pre- and Post-Event Decision Making

A New Zealand Perspective



Nick Horspool
GNS Science

POST DISASTER CITIES PDC ENGINEERING FOR RESILIENCE

QuakeCoRE
NZ Centre for Earthquake Resilience

RiskScape

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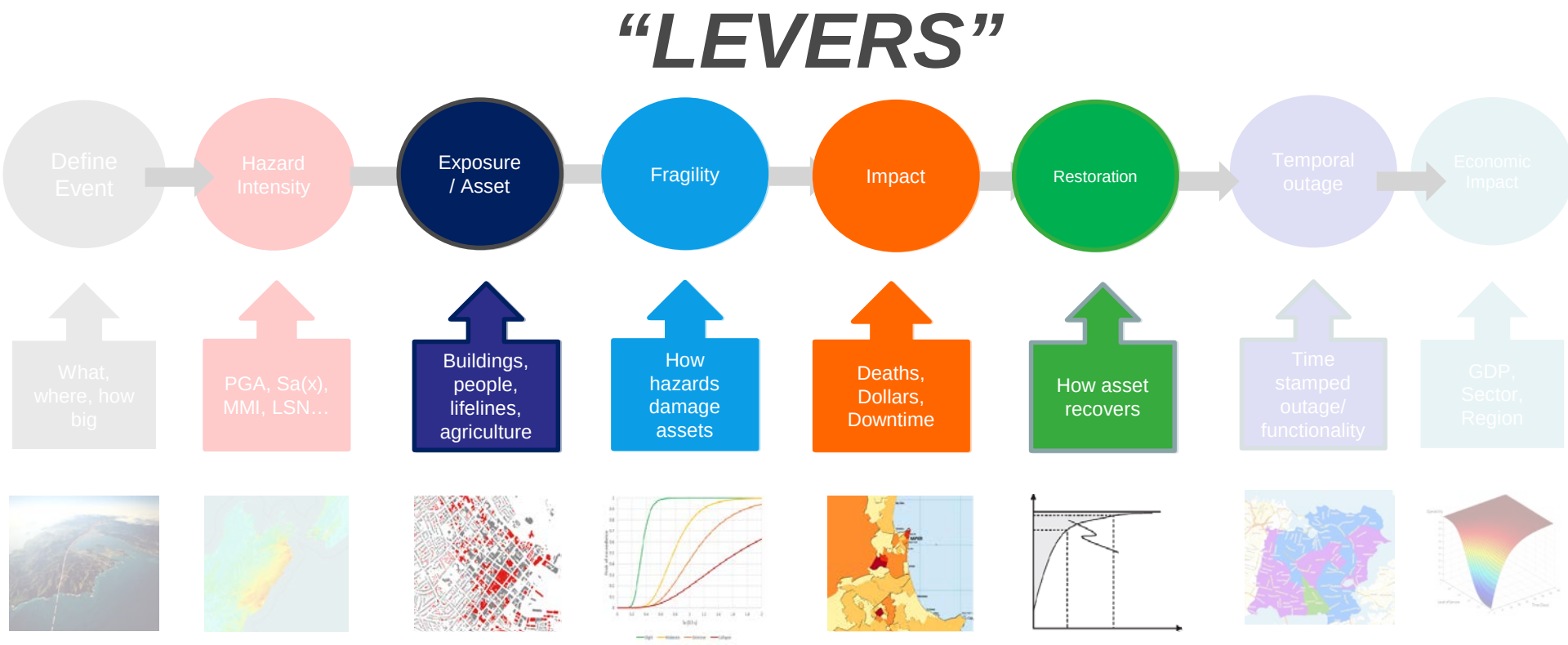
The Short Answer……

- Through scenarios we can tell a story
- Scenarios (and counterfactuals) can be easily understood
- They fit within existing legislative requirements
- Impact Scenarios are truly transdisciplinary
- They are a vehicle for direct engagement with stakeholders

Earthquake Impact Model Framework



	Resource Management Act	Civil Defence & Emergency Management Act	Local Government Act	EQC Act	RBNZ Insurance Act	Building Act
Casualties						
Repair costs						
Downtime						
Lifeline outage						
Economic Impact						
Environmental Impact						

EAST COAST LAB

LIFE AT THE BOUNDARY

National Science Challenges

RESILIENCE TO NATURE'S CHALLENGES

Kia manawaroa – Ngā Ākina o Te Ao Tūroa

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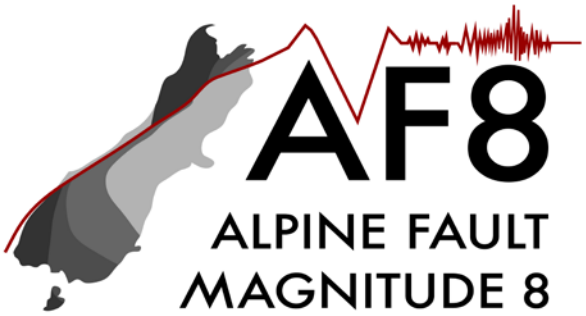
NZ Centre for Earthquake Resilience



WELLINGTON LIFELINES REGIONAL RESILIENCE PROJECT

Wellington LIFELINES Group

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m.e market economics environment • spatial

Resilient ORGANISATIONS

Hazard and Damage Models

RiskScape

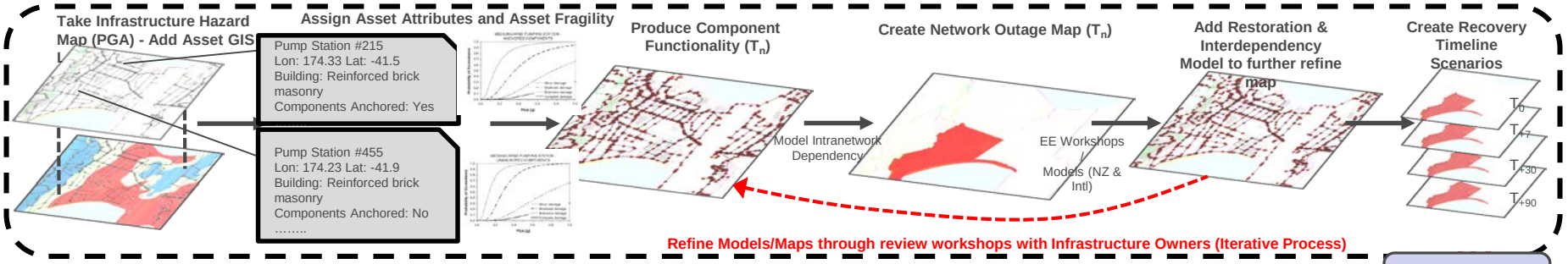
Disruption and Outage Models

POST DISASTER CITIES PDC ENGINEERING FOR RESILIENCE

Socio-Economic Impact

- 11 lifeline sectors
- Wellington Fault M7.5 Earthquake Scenario
- Shaking + secondary impacts (landslide, liquefaction, fault rupture, subsidence)
- Baseline Impact
- Impact with resilience ‘packages’ of 30+ projects
- Quantify ‘benefit’ for Treasury Better Business Case Submission

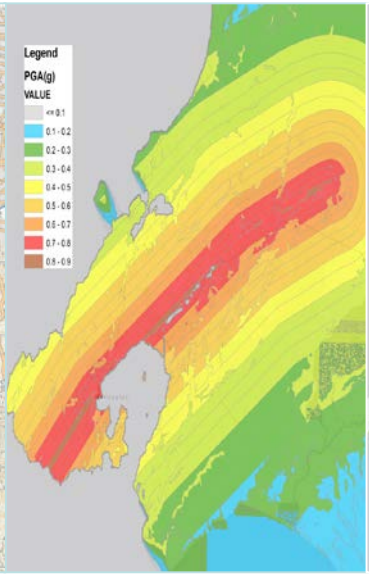
ECONOMICS of RESILIENT INFRASTRUCTURE

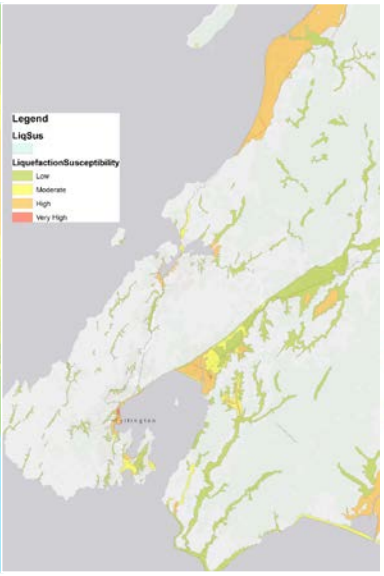

Take Infrastructure Hazard Map (PGA) - Add Asset GIS
Assign Asset Attributes and Asset Fragility
Pump Station #215
Lon: 174.33 Lat: -41.5
Building: Reinforced brick masonry
Components Anchored: Yes
Pump Station #455
Lon: 174.23 Lat: -41.9
Building: Reinforced brick masonry
Components Anchored: No
……..
Produce Component Functionality (T_n)
Model Intranetwork Dependency
Create Network Outage Map (T_n)
EE Workshops / Models (NZ & Intl)
Add Restoration & Interdependency Model to further refine map
Create Recovery Timeline Scenarios
T_0
T_{+7}
T_{+30}
T_{+90}
Refine Models/Maps through review workshops with Infrastructure Owners (Iterative Process)

RiskScape Output
Dynamic Equilibrium Model
(Industries, Labour, Capital, Commodities, Households, Government, Enterprise, Factors, Investment & Savings, Rest of World)
ECONOMIC IMPACT REPORTING
Net additional domestic/export/import transport margins per unit of commodity
Net additional household consumption of transport-related commodities
Industry operability index
Industry employments
Direct Transport Cost Analyser
Business Behaviours
Non-transport Infrastructure impacts
Non-infrastructure (Buildings) impacts
Change in transport time & distance
Transport Analysis
Transport infrastructure impacts

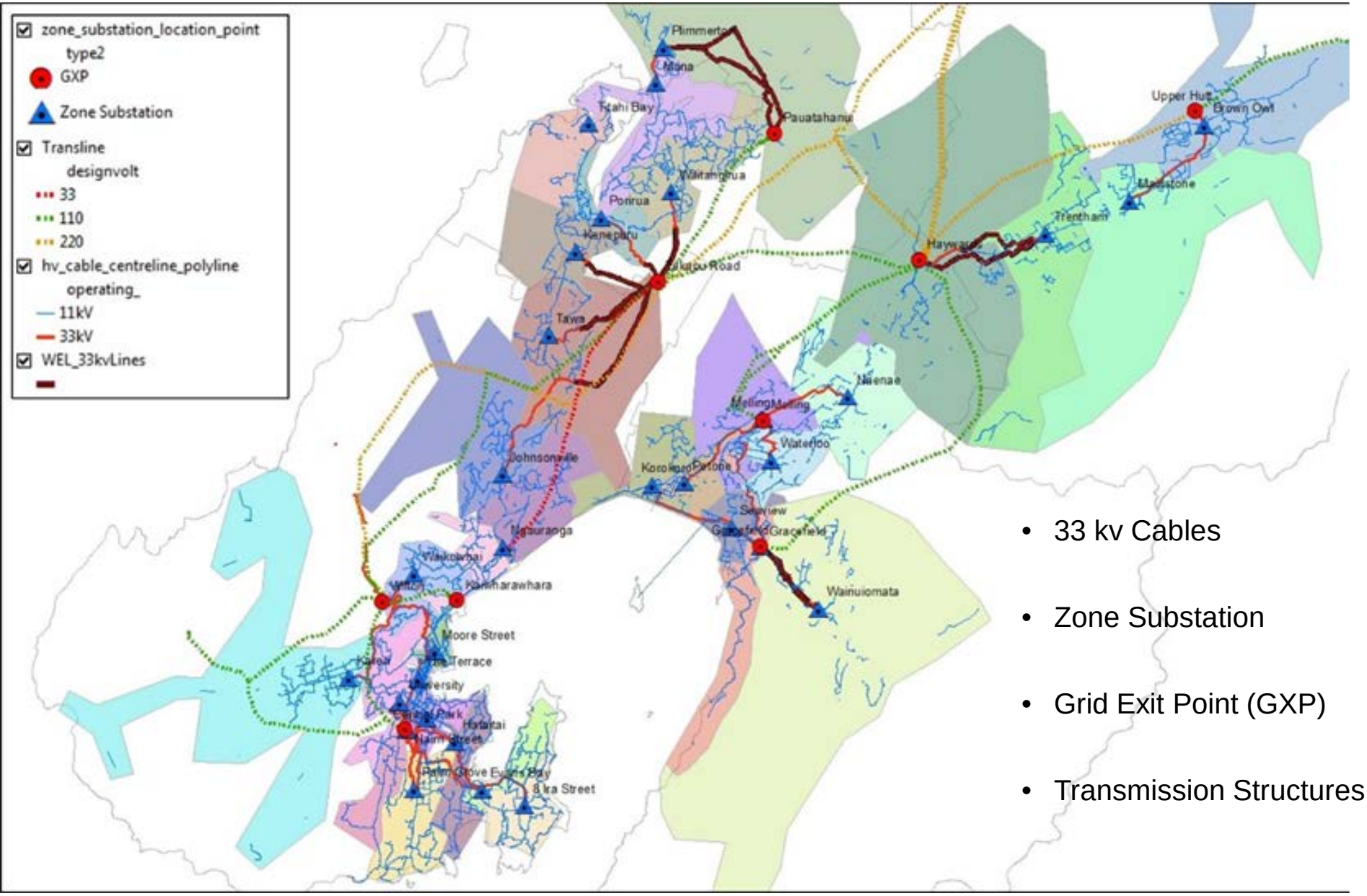
M7.5 Wellington Fault Earthquake Hazards

Fault Rupture | Subsidence | Ground Motion | Liquefaction | Landslide





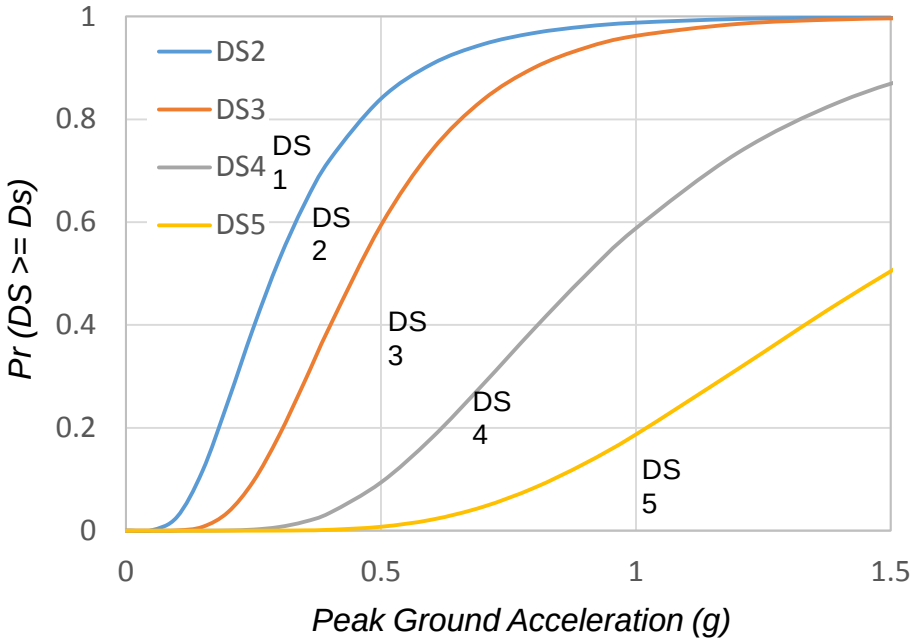
Electricity Network Assets & Configuration



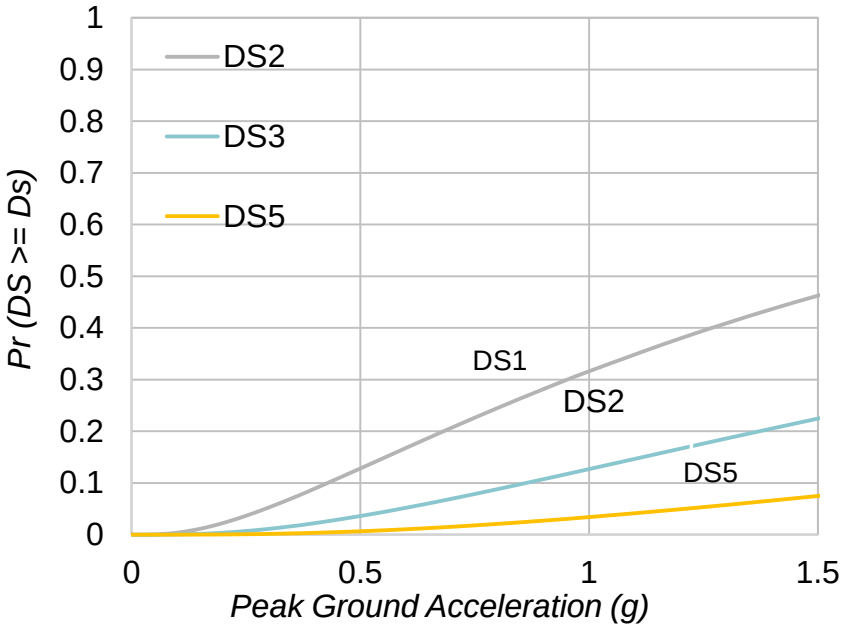
- 33 kv Cables
- Zone Substation
- Grid Exit Point (GXP)
- Transmission Structures

Electricity Fragility

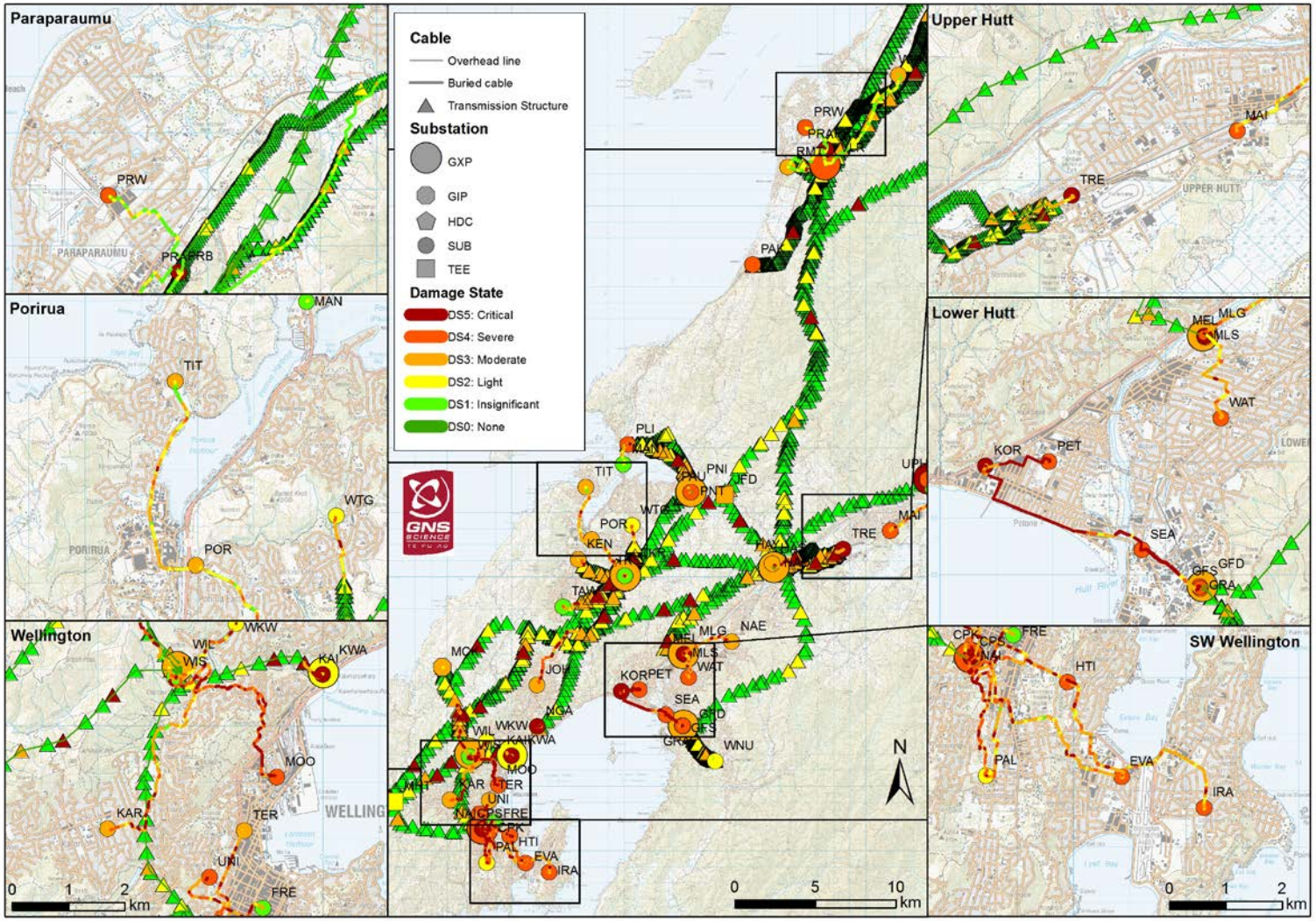
Low Voltage Substation with Anchored Components



Transmission Structures

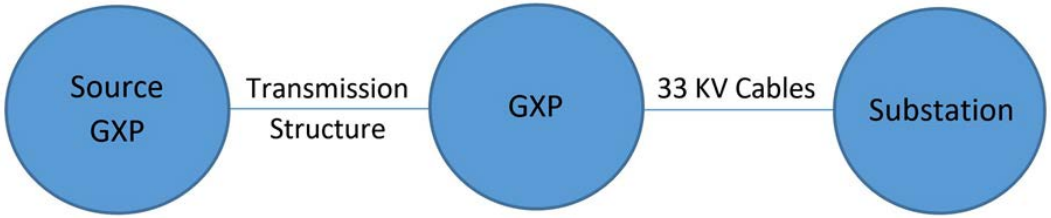


Electricity Network Component Damage

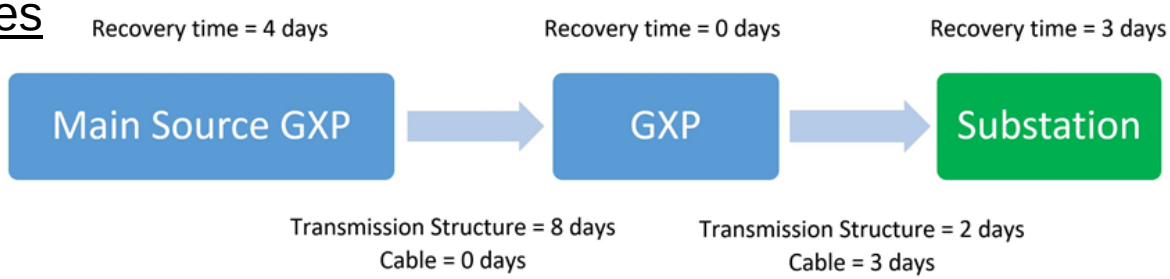


Electricity Outage & Restoration

1) Establish Connectivity



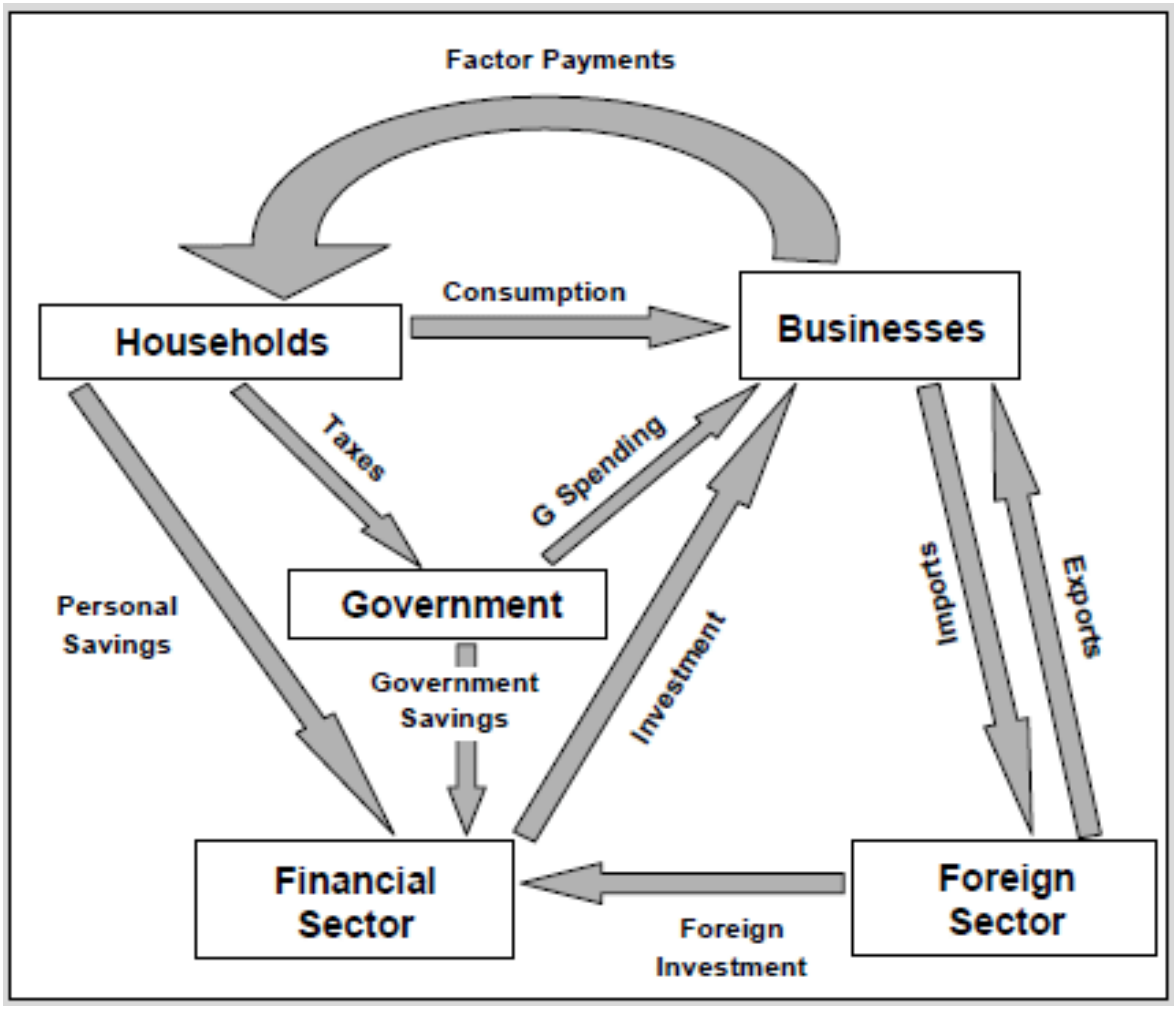
2) Apply Intra-dependent Restoration Times



3) Apply Inter-dependent Restoration Times

→ Road access

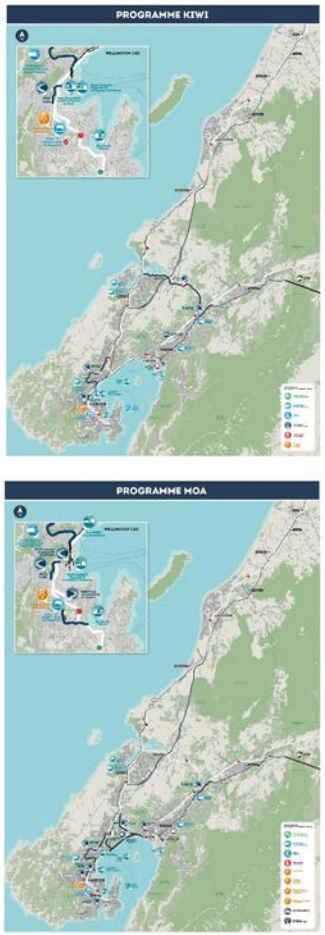
MERIT Dynamic economic sub-module



ECONOMICS of RESILIENT INFRASTRUCTURE

Quantify Resilience Programme Benefits

130 resilience projects (wish list) refined to 30 and split between two programme ‘packages’



Reduced Impact (benefit) Package 1

Reduced Impact (benefit) Package 2

Treasury BBC

Absolutely Positively Wellington City Council
Me Heke Ki Pōneke

QuakeCoRE
NZ Centre for Earthquake Resilience

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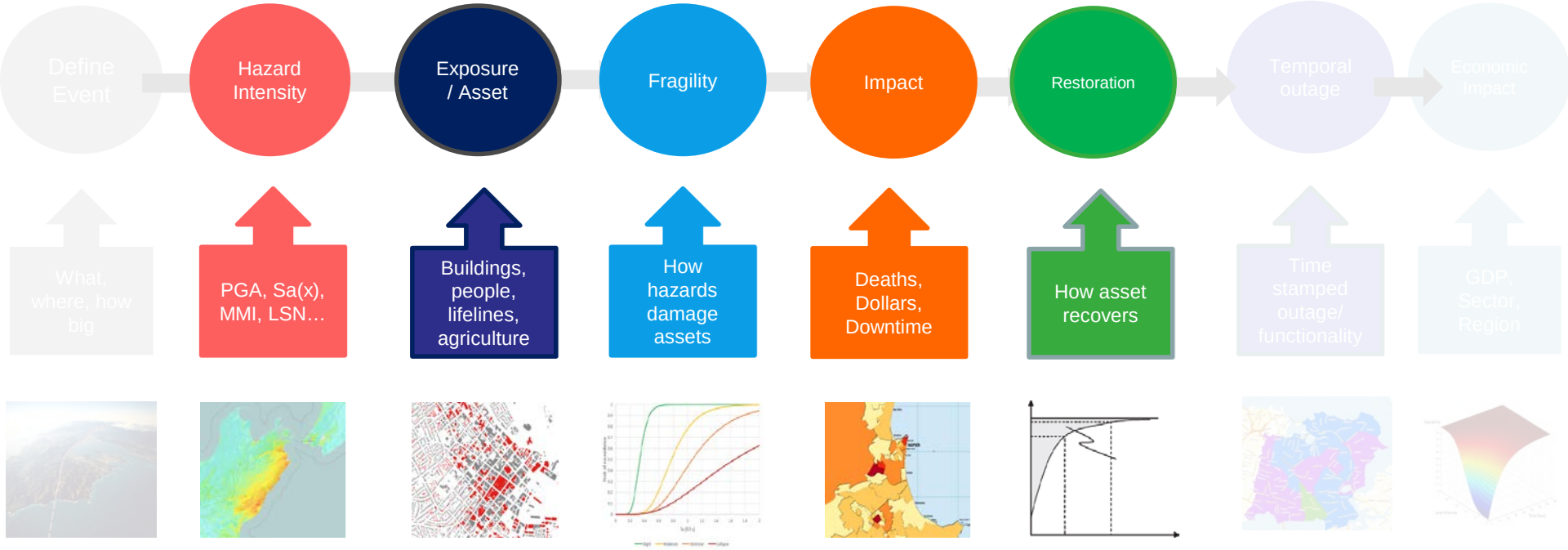
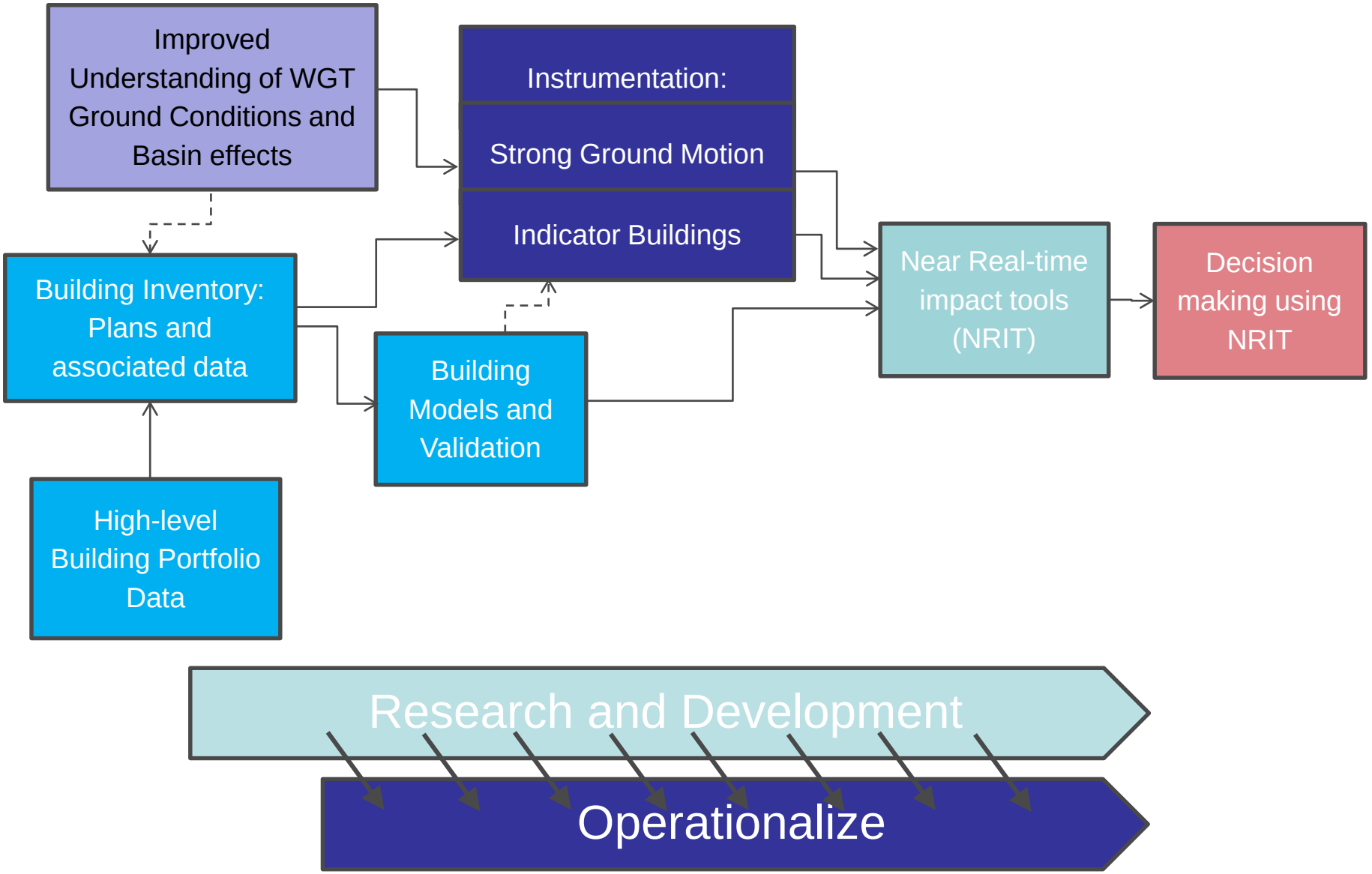
Smart Seismic Cities

Next Generation Earthquake Impact Model

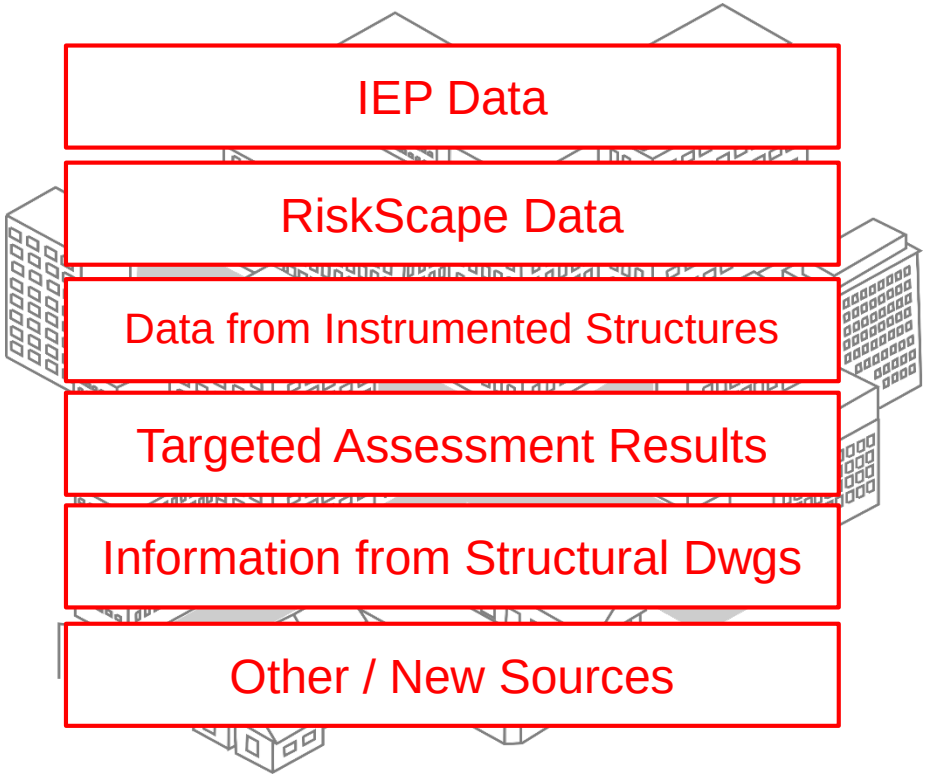
Simulation based, Dynamic, Scalable, Intelligent



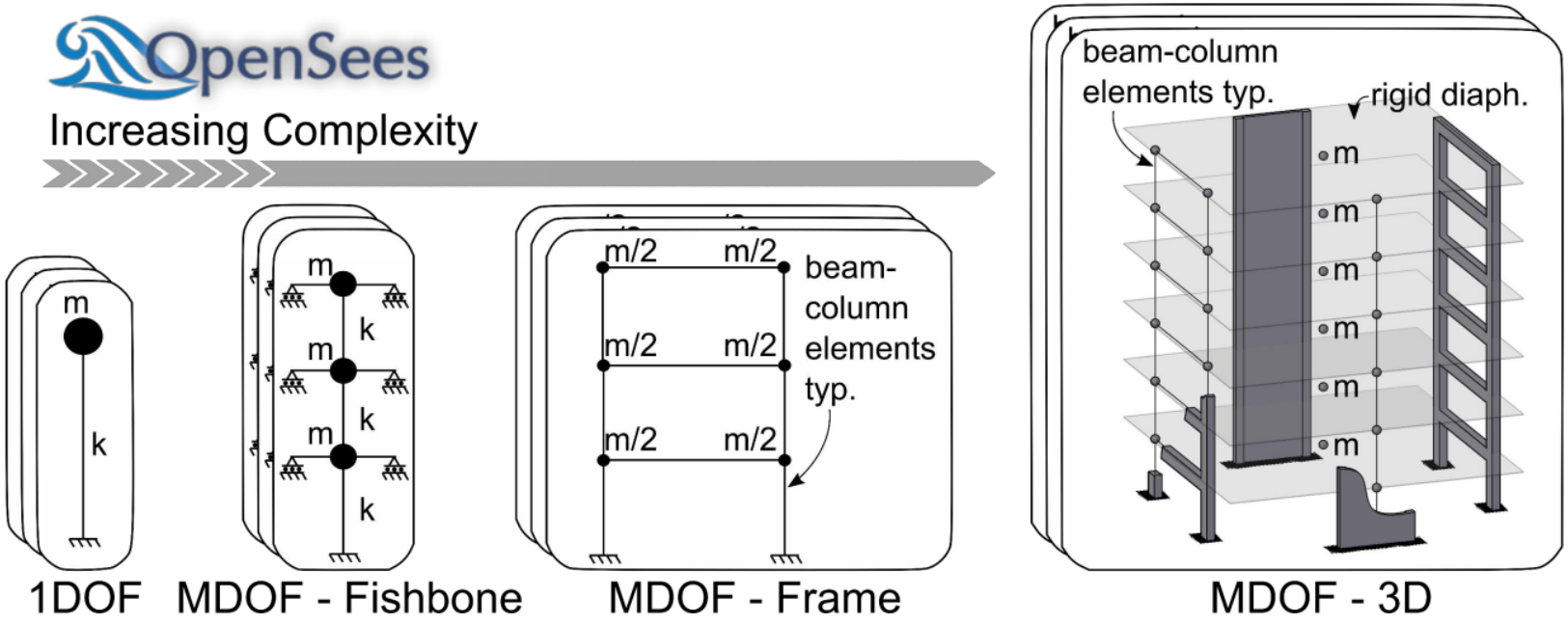
Smart Seismic Cities Framework



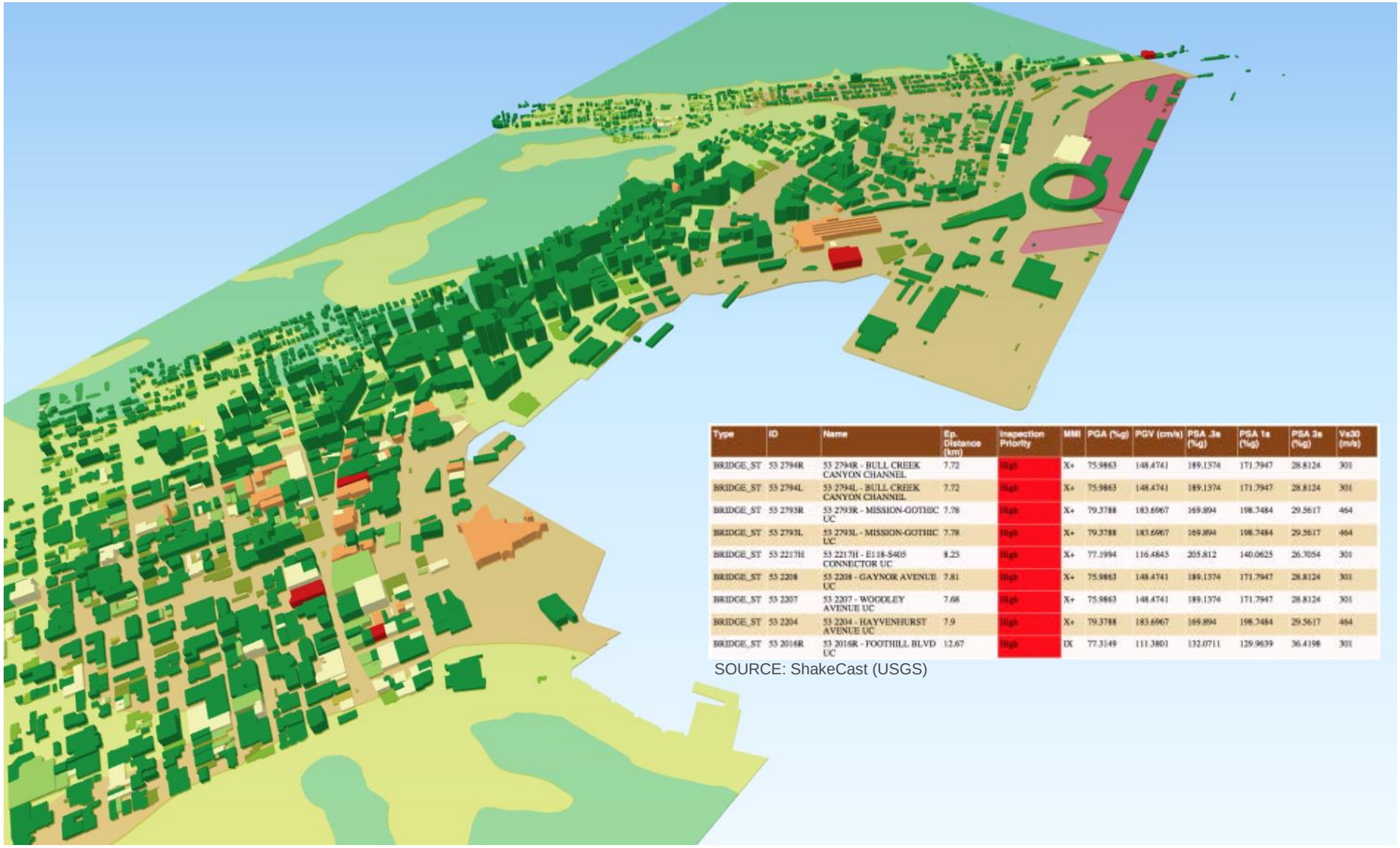
Inventory Data Sources



Numerical Model Development



Smart Seismic Cities Model



Type	ID	Name	Ep. Distance (km)	Inspection Priority	MMI	PGA (%g)	PGV (cm/s)	PSA .3s (%g)	PSA 1s (%g)	PSA 3s (%g)	Vs30 (m/s)
BRIDGE_ST	53 2794R	53 2794R - BULL CREEK CANYON CHANNEL	7.72	High	X+	75.9863	148.4741	189.1374	171.7947	28.8124	301
BRIDGE_ST	53 2794L	53 2794L - BULL CREEK CANYON CHANNEL	7.72	High	X+	75.9863	148.4741	189.1374	171.7947	28.8124	301
BRIDGE_ST	53 2793R	53 2793R - MISSION-GOTHIC UC	7.78	High	X+	79.3788	183.6967	169.894	198.3484	29.5617	464
BRIDGE_ST	53 2793L	53 2793L - MISSION-GOTHIC UC	7.78	High	X+	79.3788	183.6967	169.894	198.3484	29.5617	464
BRIDGE_ST	53 2217H	53 2217H - E118-S405 CONNECTOR UC	8.23	High	X+	77.1994	116.4843	205.812	140.0625	26.7054	301
BRIDGE_ST	53 2208	53 2208 - GAYNOR AVENUE UC	7.81	High	X+	75.9863	148.4741	189.1374	171.7947	28.8124	301
BRIDGE_ST	53 2207	53 2207 - WOODLEY AVENUE UC	7.68	High	X+	75.9863	148.4741	189.1374	171.7947	28.8124	301
BRIDGE_ST	53 2204	53 2204 - HAYVENHURST AVENUE UC	7.9	High	X+	79.3788	183.6967	169.894	198.3484	29.5617	464
BRIDGE_ST	53 2016R	53 2016R - FOOTHILL BLVD UC	12.67	High	IX	77.3149	111.3801	132.0711	129.9639	36.4198	301

SOURCE: ShakeCast (USGS)

Benefits of Earthquake Impact Scenarios

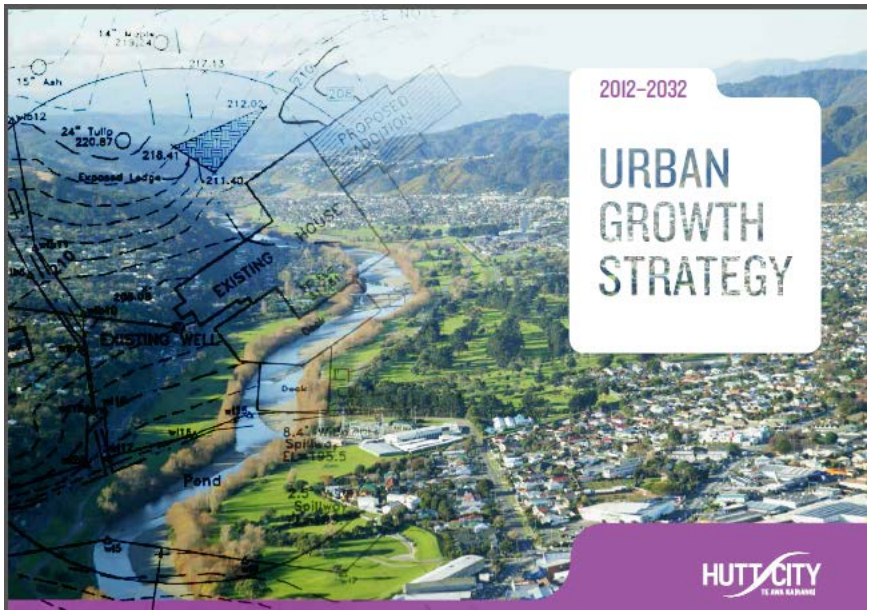
- Through scenarios we can tell a story
- Scenarios can be easily understood
- They fit within existing legislative requirements
- Impact Scenarios are truly transdisciplinary
- They are a vehicle for direct engagement with stakeholders

- **What are earthquake impact scenarios (local scale models vs dave global view)**
  - Science components flow diagram
  - Multi-disciplinary – how each component developed.
  - Direct/in direct impact (multiple impact tyles)
  - Translation of science/engineering into models
  - Modular, slot in and out different components
  - Cascading hazards
  - Probabilistic vs scenario benefits etc
  - Not just baseline modelling but what if
  - Difference between pre and post event
- **Stakeholder needs, where does this sit across NZ situation**
  - Various actors
  - Different needs
  - Challenges in communicating results
- **Scenario vs Probabilistic selection? (or up above)**
  - How to choose event?
  - Ease of communication.
  - Planning is essential all plans are useless. Doesn't matter what event
- **Case studies (3 applications) strengths limitations**
  - WelRes (Resilience investments)
    - Benefit of mitigation and business case
  - Hutt City (LUP)
    - Future impacts not just today
    - Decision making tool for planning
  - SSC (Contingency and Post event response)
    - Pre nad post event planning
    - Future direction, can apply at urban scale
    - NZ unique in can get access to inventory data
    - Pre and post event

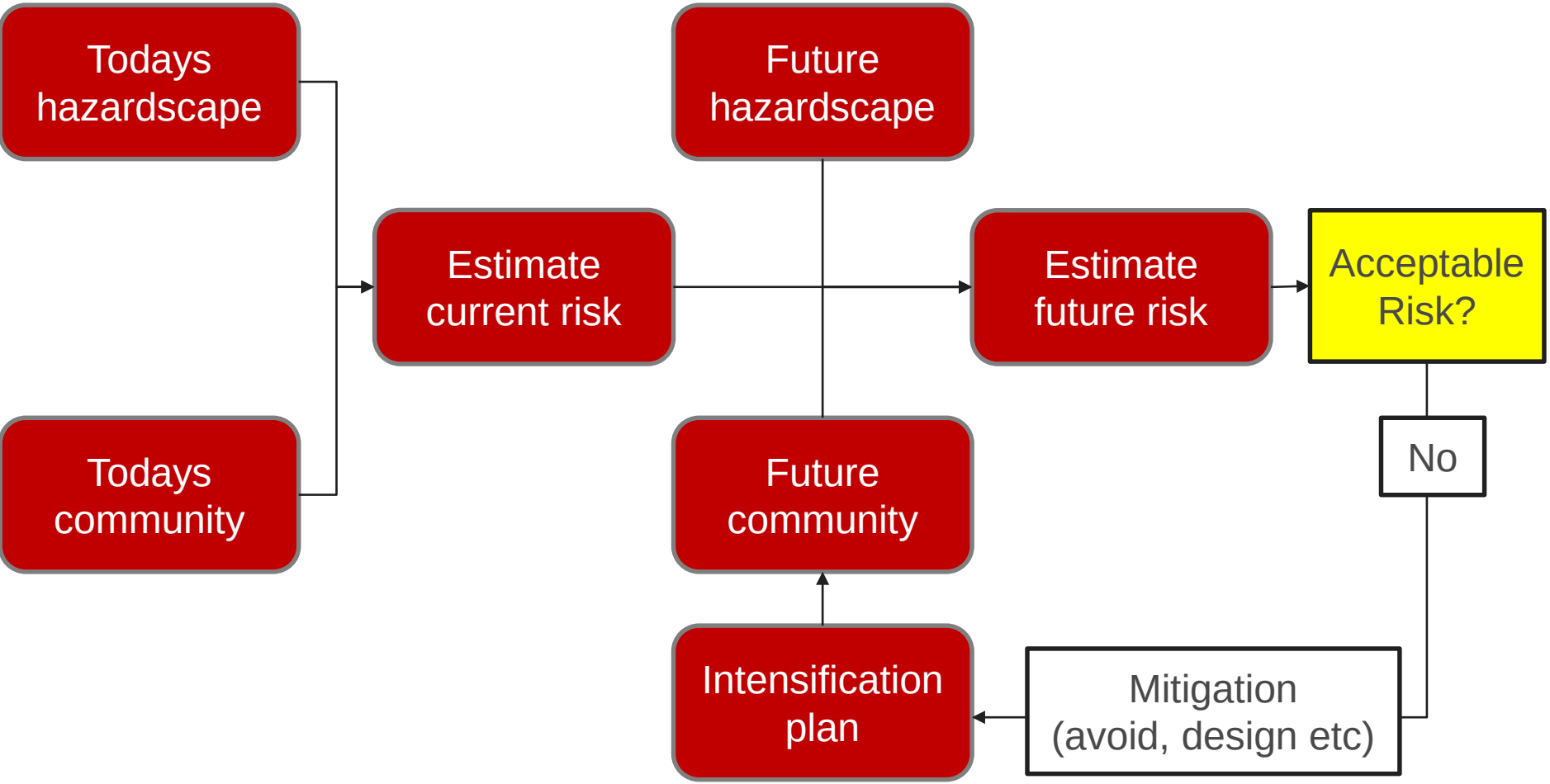
Using Impact Scenarios to Plan for Tomorrows Risk Today

Hutt City – Risk Informed Growth

- **District plan change (RMA Act)**
  - Identify and mitigate risks
- **Use multi-hazard impact scenarios to quantify risk**
  - Today
  - Planning horizon
  - Inform land use planning



Modelling Framework

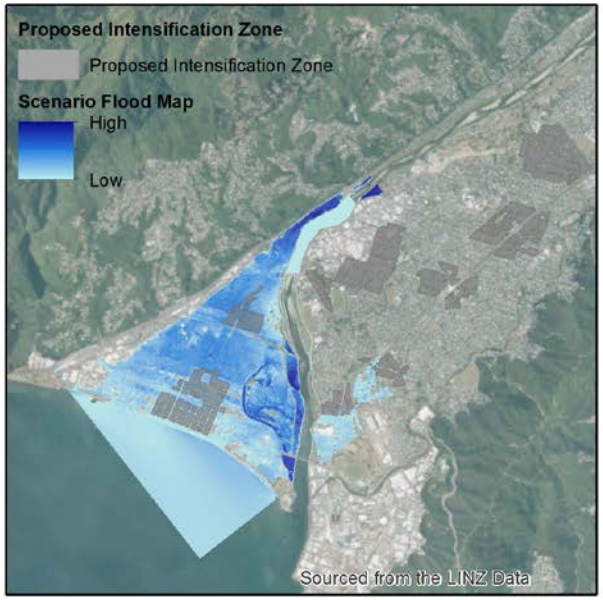


HCC Proposed Intensification Areas

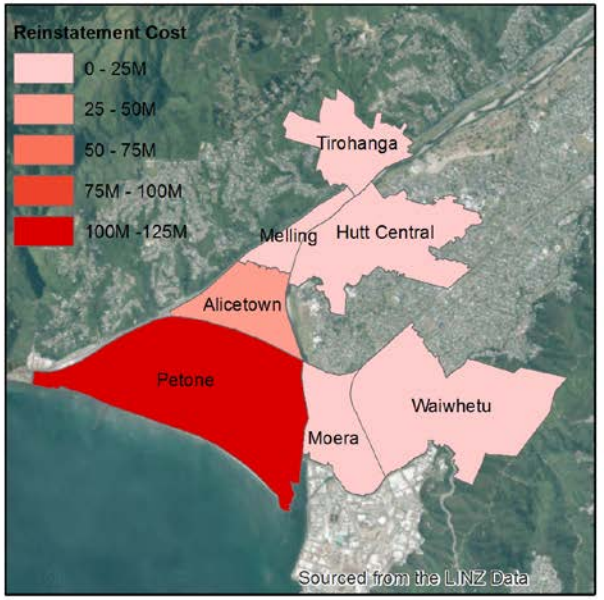
Flood

Mitigation:
- Avoidance
- Min. floor heights
- Use restrictions

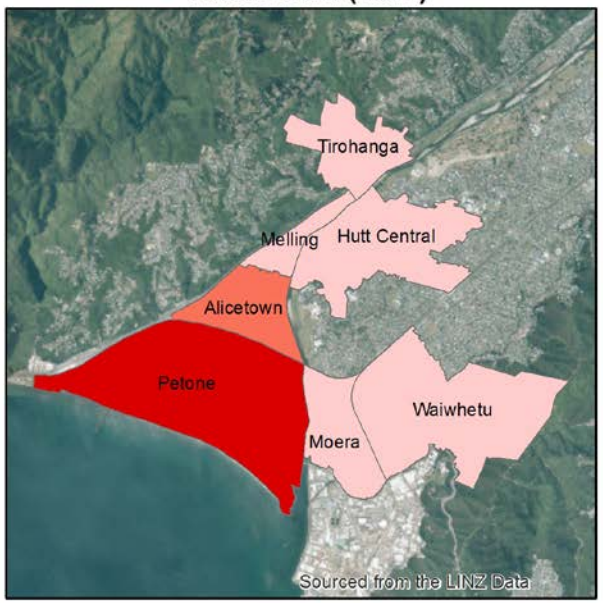
Flooding Scenario & Proposed Intensification Zones



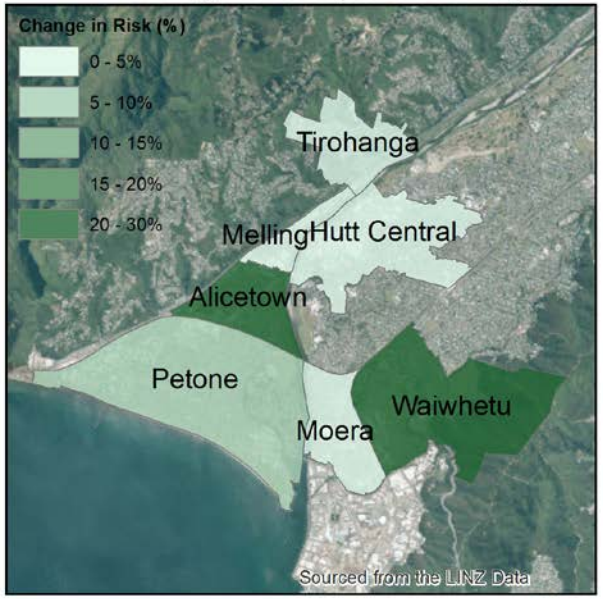
Current Risk (2016)



Future Risk (2032)



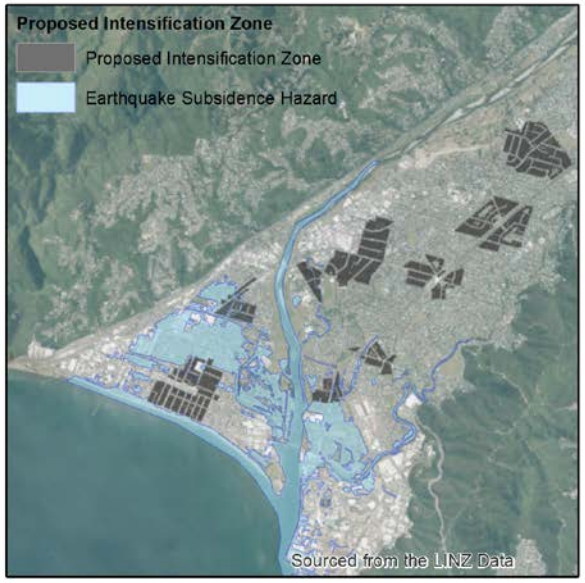
Change in Risk (2016 vs 2032)



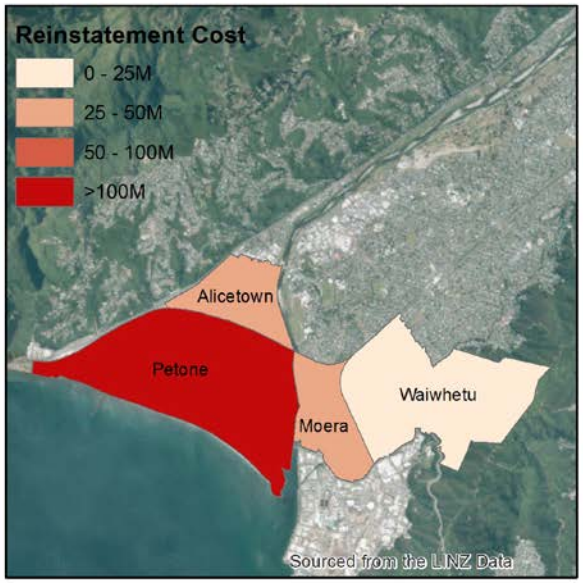
Earthquake
- **Shaking**
- **Liquefaction**
- **Subsidence**

Mitigation:
- Avoidance
- Foundation design
- Use restrictions
- Fault set back

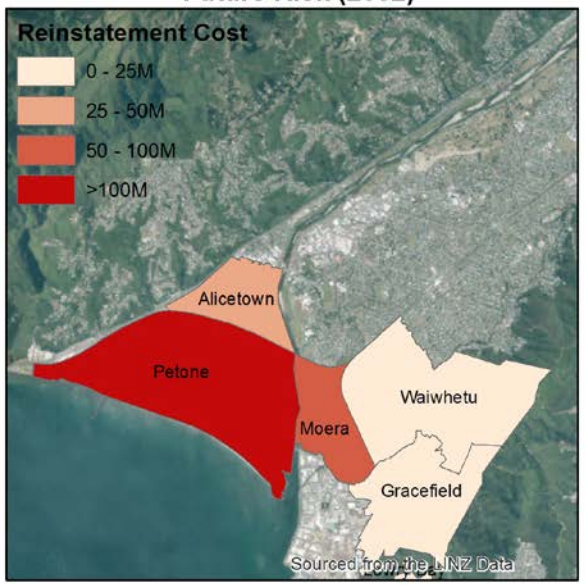
Subsidence Scenario & Proposed Intensification Zones



Current Risk (2016)



Future Risk (2032)



Change in Risk (2016 vs 2032)