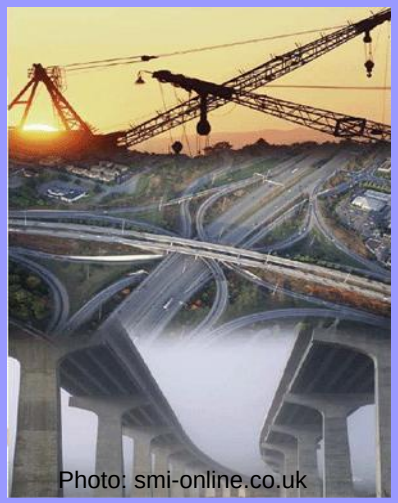

Building resilience in regional infrastructure systems

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University of British Columbia

AIDRC

Boulder CRRA Resilience meeting: July, 2009

UBC

The concept of resilience

- A significant concept to many fields including psychology, materials science, economics, and environmental studies

- characteristics of resilience according to the resilience Alliance:

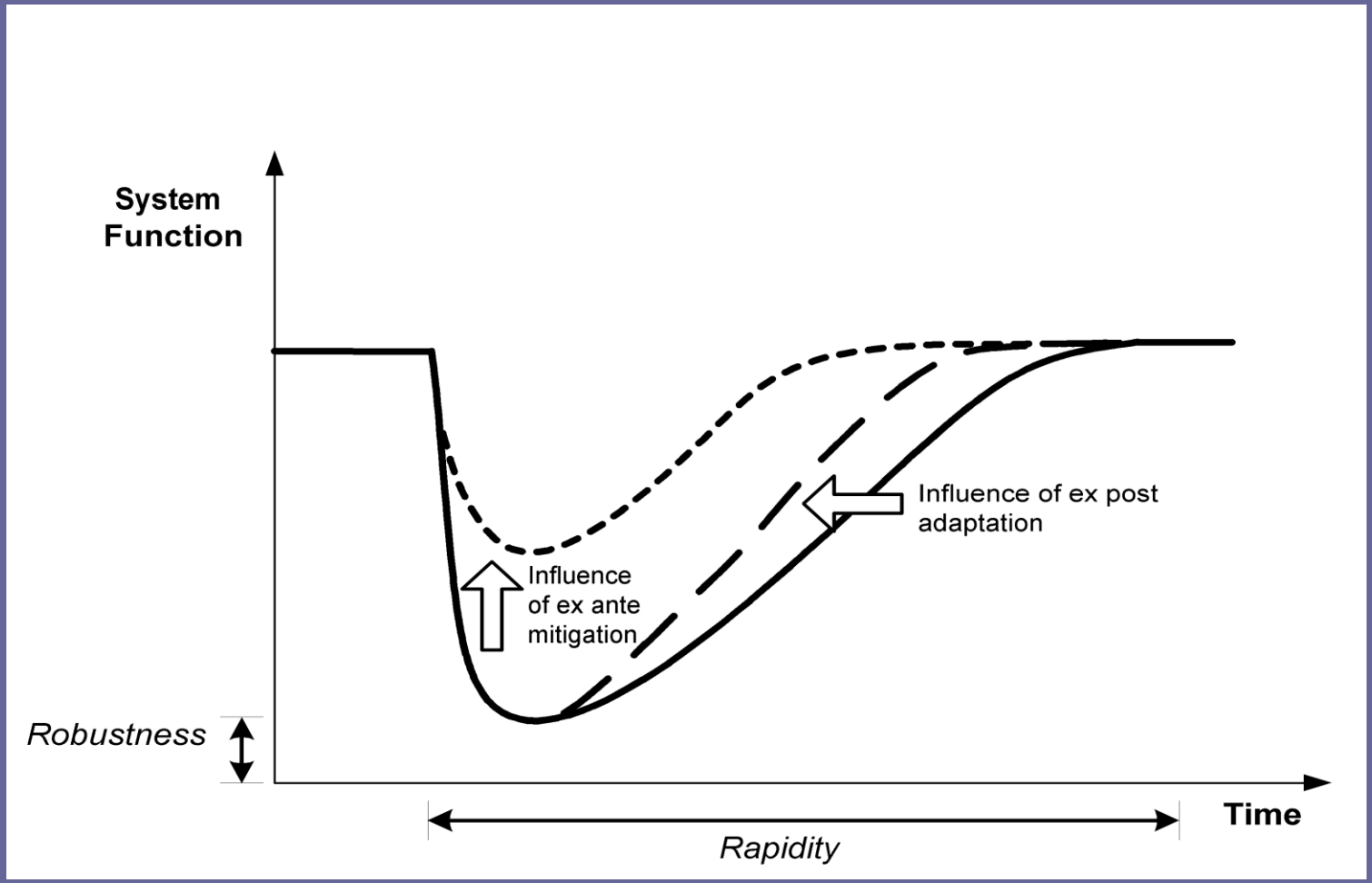
1. "The amount of change the system can undergo and still retain the same controls on function and structure"

See: http://www.resalliance.org/576.php

Resilience defined

- While definitions of resilience differ, they concur that resilient complex systems (including ecological, engineering or even governance systems) are those that can absorb shocks while still maintaining function
- Resilience in engineering versus ecological systems: Holling, 1996; extreme view of stability in engineering systems

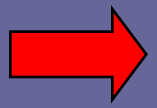
Effects of decision-making on resilience



* From McDaniels, Chang et al, forthcoming in Global Environmental Change

Fostering infrastructure resilience

- Cross-sectoral planning for infrastructure resilience faces at least three notable challenges: (1) incomplete incentives, (2) partial information, & (3) few opportunities for learning.



Our approach addresses these challenges through structured data-gathering and information-sharing

Overview of Process

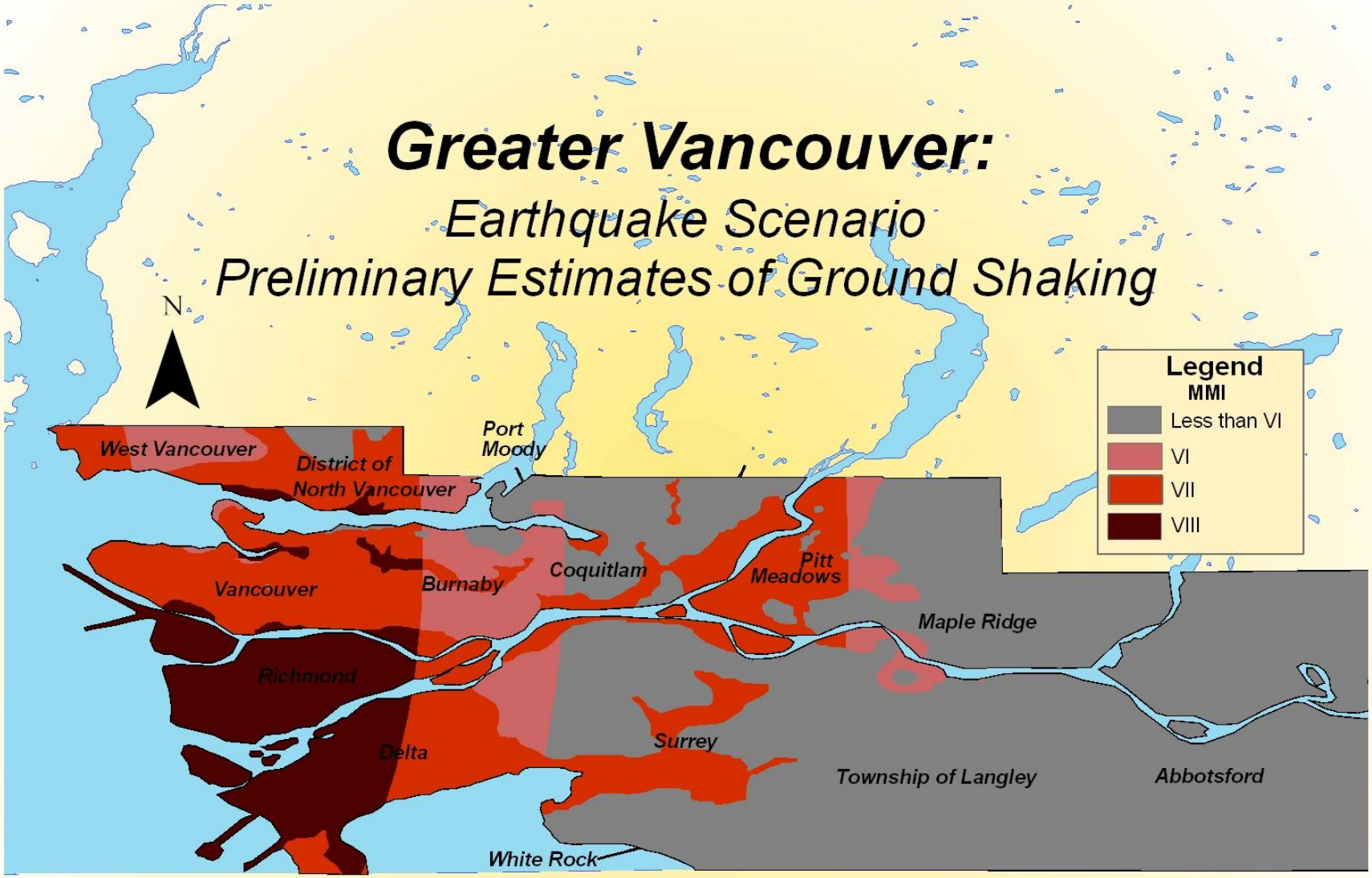
Goal: Facilitate cross-sectoral consensus on actions that promote resiliency in a multi-stakeholder region

1. Archetypal vulnerabilities
   - Literature review; IFI database
2. Regional expectations
   - Expert interviews; Our judgements
3. Strategic alternatives
   - Areas of focus; Potential mitigations
4. Setting priorities
   - Facilitated discussion; Evaluation and ranking

Greater Vancouver:

Earthquake Scenario

Preliminary Estimates of Ground Shaking



References: Natural Resources Canada, ESRI Canada, Geocommunity

Cartographer: Rajan Dhariwal

Created for the KOA Project at UBC, July 2007

Not Intended for Distribution

Infrastructures Interviewed

Utilities

- BC Hydro
- MetroVancouver (water & wastewater)
- Terasen Gas

Transportation

- Ministry of Transport
- Translink
- Airports (YVR and Abbotsford)
- Port of Vancouver

Telecom

- Telus

Health

- Fraser Valley Health Authority
- BC Children's & Women's Hospital

Government

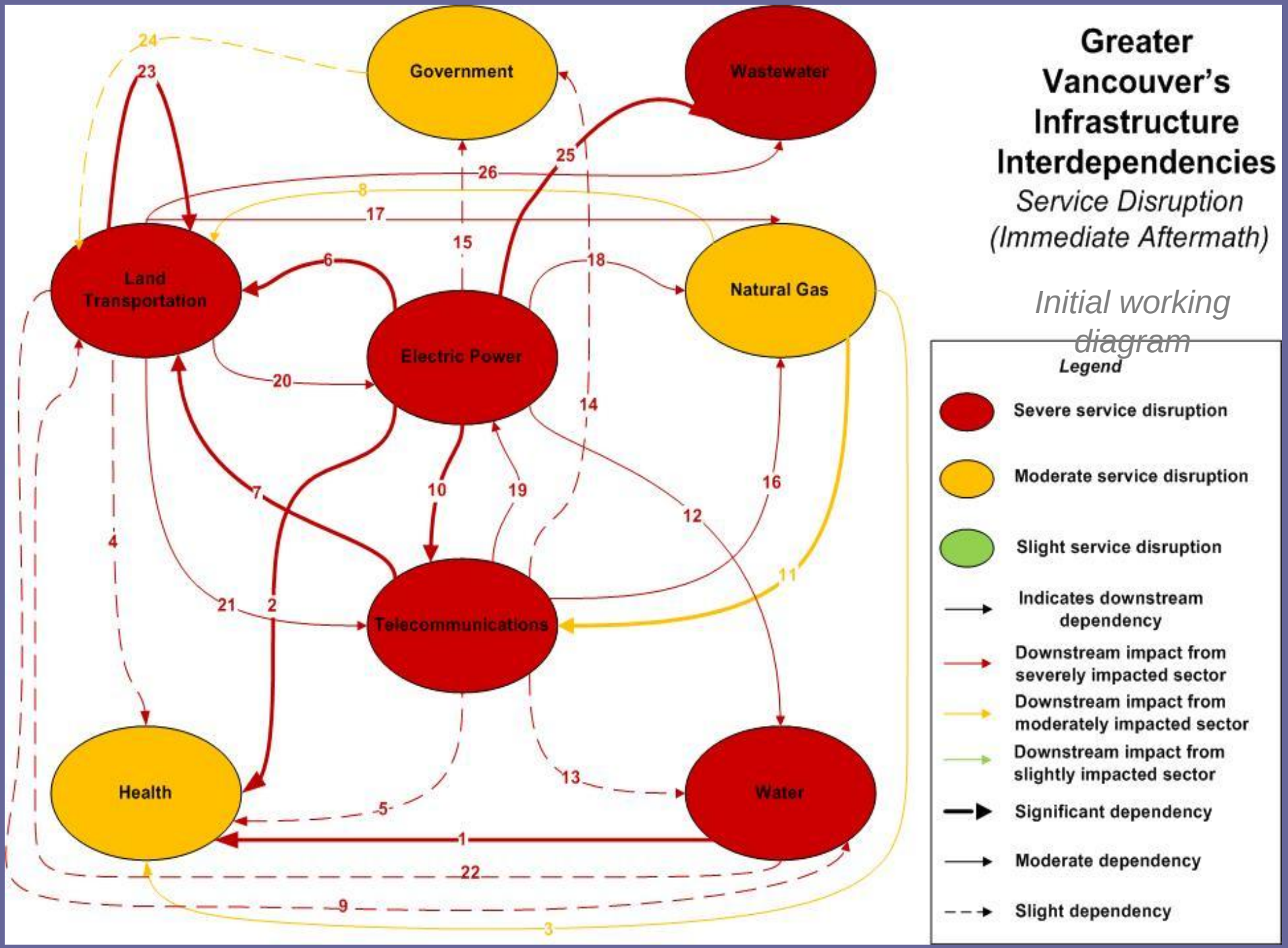
- BC PEP
- Coquitlam (municipality)
- JELC

Revised Estimates of Service Disruption Levels

Sector	Service Disruptions: 0 Hrs	72 Hrs	2 Wks
Power			
Communication			
Water			
Transportation (Intraregional)			
Transportation (Interregional)			
Healthcare			
Government			
Natural Gas			
Wastewater			

Loss of Service

- No Loss
- Slight Disruption
- Moderate Disruption
- Severe Disruption


Government
Wastewater
Land Transportation
Electric Power
Natural Gas
Telecommunications
Health
Water
Greater Vancouver's Infrastructure Interdependencies
Service Disruption (Immediate Aftermath)
Initial working diagram
Legend
Severe service disruption
Moderate service disruption
Slight service disruption
Indicates downstream dependency
Downstream impact from severely impacted sector
Downstream impact from moderately impacted sector
Downstream impact from slightly impacted sector
Significant dependency
Moderate dependency
Slight dependency

Key Findings

- Variation amongst sectors for types of information sources, and for the amount of cross-sectoral discussions
  - 31% drew information from both experience-based sources and regional cross-sectoral discussion
- Service level diagrams were changed, with sectors typically increasing the level of disruption
  - Greater disruption, over longer time period
- Trend towards increase in service over time, with no sectors completely recovered (no service loss) after two weeks
- Interdependency diagrams reveal core/peripheral sector distinction
  - Electric power is most connected, followed by land transportation and telecommunication
  - Water?

Results

- Upstream service loss expected to increase in the days and weeks after disaster
  - Backup resources depleted
- Each sector is highly interconnected with all of the others
  - Directly upstream sectors dependent on other sectors
  - High complexity
- Resolved discrepancies in expectations between sectors
  - E.g., Transportation/Healthcare's expectation on roads
- Developed or strengthened cross-sectoral contacts
- Increased practitioners' understanding of infrastructure interdependencies and their potential outcomes in disasters

Devising Strategic Alternatives

- Three areas of focus selected
  - Fuel Supply
  - Water Supply
  - Road Mobility
- Two mitigation principles adopted
  - Redundancy (diversify the vulnerable component, or the means of recovering it)
  - Hardening (make the component and its functional dependencies less vulnerable)

Example: Fuel Supply

- Supply/Re-Supply
  - bringing fuel into the affected region
- Access
  - distributing to stations within the region, and ensuring user access to these same stations
- Facility Functionality
  - maintaining integrity of the stations (building, pumps, and the payment/fuel release mechanism)
- User Entitlement
  - determining who should be entitled access to a potentially scarce resource

Example: Fuel Supply

- Element in Question: Access
  - Interregional Distribution & Intraregional User
- *Redundancy?*
  - **Build new** fuelling stations
- *Hardening?*
  - **Designate existing** fuelling stations
- *Other Considerations?*
  - Situate on **DRRs** or according to other **locational factors** or access routes(e.g. residential access, proximity to CI)

Example: Fuel Supply

Strategy	Implementation	Time (months)	Agencies Involved	Difficulty (Low-Medium-High)	Cost (Low-Medium-High)	Resiliency Gains	Ranking
1. Regulation							
Regulate fuel supply and distribution by establishing prioritization agreements	Provincial government, fuel providers, CI sectors	24	>10	H	L	Helps maintain baseline fuel supply for CI sectors, and establishes expectations about fuel availability and needs	
2. Disaster Response Routes							
a) Designate and seismically upgrade **existing** fuelling stations	Governments and commercial operators	12	>3	L	M	Helps maintain fuel supply and transportation, specifically on the emergency roadway system, and for entitled DRR users	
b) Build **new** seismically reinforced fuelling stations	Governments and commercial operators	36	>3	H	H		
3. Other Locational Factors							
a) Designate and seismically upgrade **existing** fuelling stations	Governments, commercial operators, CI sectors	24	>10	M	M	Helps maintain fuel supply and transportation, specifically for those selected according to locational factors	
b) Build **new** seismically reinforced fuelling stations	Governments, commercial operators, CI sectors	36	>10	H	H		
Other Strategies							

Cost: Low - $1-5 million. Medium - $5-10 million. High - >$10 million.