

Critical infrastructure recovery: Key lessons

Authors: Hugh Mace (PhD candidate, University of Canterbury, hugh.mace@pg.canterbury.ac.nz),
Charlotte Brown (Resilient Organisations, charlotte.brown@resorgs.org.nz)

Reviewers: Liam Wotherspoon (University of Auckland), Grant Maxwell (Stantec),
Felix Mendonca (Fulton Hogan)

July 2023

Damage to critical infrastructure caused by the recent North Island Extreme Weather Events will take years to recover. The attributes, challenges and potential outcomes of these events can be compared to events with similar characteristics which have occurred internationally. Accordingly, recovery programmes following international natural hazard events can provide a number of lessons to support effective critical infrastructure recovery.

Grey and white literature from over a dozen large international natural hazard events¹, as well as cross event analyses, have been reviewed. This brief provides a high-level overview of the key attributes of a successful recovery programme. The lessons apply, to varying degrees, to a diverse range of end-users with various roles in recovery activities, including those within central and local government, infrastructure owner/operators, contractors, and recovery offices.

¹ Canterbury Earthquake Sequence 2010/11, New Zealand; Kaikoura Earthquake 2016, New Zealand; Maule Earthquake/Tsunami 2010, Chile; Great East Japan Earthquakes/Tsunami 2011, Japan; L'Aquila Earthquake 2009, Italy; Van Earthquake 2011, Turkey; Hurricane Katrina 2005, USA; Hurricanes Maria, Irma and Beryl 2017/18, Puerto Rico; Cyclone Debbie 2017, Queensland Australia; Victorian Bushfires 2009, Australia; Cyclone Oswald 2013, Queensland Australia; Cyclone Marcia 2015, Queensland/NSW Australia; 2019 Australian Bushfires; Camp Fire 2018, USA;

Recovery principles

Principles to guide critical infrastructure recovery programmes have been a feature of many past natural hazard event recoveries. While these principles should, ideally, be community derived, recovery principles from past events tend to converge on a handful of central themes. These include:

- Clearly articulated recovery goals/outcomes
- Community-focused recovery
- Equitable connectivity and services
- Economic recovery
- Resilient infrastructure
- Cross sector collaboration
- Transparency in recovery activities
- Resource capacity development
- Leveraging regional strengths
- Utilising technological innovation
- Continuous learning

Governance

Particularly for large scale critical infrastructure recovery efforts, a governance body is useful for monitoring and guiding recovery programmes to ensure they are effectively utilising funding, meeting recovery goals, and meeting needs of stakeholders. A governance body provides strategic oversight, direction, promotes transparency and makes space to identify longer term opportunities alongside immediate recovery priorities. This ensures urgent short term activities are balanced against important longer term recovery objectives.

The governance body is separate to operational recovery team(s) and is brought together to focus specifically on recovery efforts, functionally separate from business-as-usual activities. The governance structure should facilitate deep collaboration with stakeholders, including recovery funders. Representation in the governing body may change over time as the characteristics of the recovery change. Including key community stakeholders within the governance body can help to enable a community-centred recovery.

Recovery programme management

For large programmes, a coordinating team with an operational focus is useful to provide oversight of work, resource allocation, progress, and stakeholder communications. It also provides a vehicle to establish a shared set of values and culture across delivery organisations; providing a common set of objectives and operating procedures to unite an often diverse set of delivery organisations. This team may have stakeholder representation.

This operational oversight enables effective utilisation of resources and expertise, across delivery organisations, to undertake design and construction works. Coordination ensures alignment of individual projects with overarching recovery objectives and facilitates communication, efficient decision-making and the ability to address cross-programme challenges that arise during the recovery process. By sharing planning efforts and establishing platforms for collaboration, works can be coordinated with efficient use of resources. Transparency in communication between this team, governance bodies, delivery organisations, and any other stakeholders is important.

Maintaining a work pipeline with a consistent flow of projects across the recovery programme gives visibility to contractors undertaking works, allowing better resource planning and continuity of recovery. This requires effective coordination between organisations and teams involved in the recovery efforts. A well-managed work pipeline ensures that resources and timeframes are optimised according to recovery priorities.

Recovery sequencing and coordination

Sequencing of recovery work programmes should be centred around the needs of the network or service users. In the initial stages of recovery, prioritising infrastructure that is essential for the well-being of the affected population alleviates immediate hardships, enhances public health and safety, and creates a foundation for further recovery efforts. Utilising target Levels of Service (LoS) allows prioritisation of basic necessities such as water, electricity, and transportation connectivity to enhance performance levels established in the response phase. Providing temporary connections and interim solutions can quickly provide vital infrastructure support to communities, enabling people to remain in place if appropriate. As recovery progresses, modified LoS can act as interim recovery goals and are a good way to keep communities informed and manage expectations. LoS also demonstrate to the community the anticipated pathway to permanent or end-state works, which is particularly important where interim or temporary measures are put in place.

As well as direct user needs, wider community benefits should also inform recovery sequencing. Infrastructure works that stimulate economic activity, create employment opportunities, and attract investments can contribute to the overall recovery and resilience of the affected region. Priority may also be given to (temporary or permanent) works that provide protection from future or cascading hazards or threats which could cause further impact communities during the recovery period. This requires analysis of existing hazard information and ongoing monitoring to balance work priorities. These priorities may be separate from and create conflict with business-as-usual activities which need to be coordinated within recovery and delivery organisations.

At a community scale, temporal, spatial, and strategic coordination of infrastructure recovery works between programmes and stakeholders provides an integrated approach to recovery. Effective coordination of infrastructure works involves managing dependencies between networks and minimising impacts on communities; such as for works requiring underground or in-road works, ensuring that recovery works are carried out in a manner that minimises disruptions. By aligning infrastructure recovery efforts with related recovery programmes, such as housing and social services, synergies can be leveraged to maximise the impact of the overall recovery process.

During the recovery process, as networks are re-routed or reconfigured to enable repair work, infrastructure networks may experience dynamic loading and flows. To maintain services, accommodate increased loading and mitigate potential bottlenecks, the reinforcement and maintenance of network nodes/links and alternate routes and paths may be necessary. Parts of the network that have not been heavily utilised in normal operations may need reinforcement to ensure their reliability and capacity to handle increased loading/flow. The dynamic nature of recovery efforts necessitates flexibility in scheduling and allocating work in response to new information and changing conditions.

Recovery resourcing

Due to the scale of recovery works, it is likely that individuals and organisations will need to be brought together quickly and specifically for the purpose of recovery works. For these teams to work

effectively a clear set of values and behaviours which foster a culture of collaboration needs to be established by governing and operational leadership teams and embedded within contractual and organisational processes. There may be challenges in aligning values between large organisations where approaches and processes are ingrained, therefore initiatives to make recovery values distinct from business-as-usual may be required.

There may be existing pre-event agreements suitable for the execution of recovery works and this provides a baseline of existing resources to initiate the recovery process promptly. Allocating work based on pre-existing mechanisms may be a necessity to make a timely and effective start to works. Over time incorporating allocation based on delivery performance promotes accountability and encourages continuous improvement. Engaging trusted contracting and consulting resources through these agreements ensures a reliable foundation for recovery efforts.

Alternatively, or in combination with direct work allocation, it may be necessary to utilise a multi-party procurement process for selection of appropriate organisations to undertake the works. This process may take the form of traditional contracting engagement using standard contract families; however the scale, complexity, and inherent uncertainty of the recovery works may also require structures such as alliancing. The use of target costs to provide commercial flexibility to manage spend with significant uncertainty and pain/gain mechanisms to provide incentives can further drive performance and ensure that recovery works are completed effectively and within designated timeframes. Procurement that recognises the inevitable overlap between design and construction and utilises single point responsibility minimises the inefficiencies present in commercial interfaces. The use of local organisations, labour, materials and plant can also be encouraged as part of the procurement process.

Involving contractors early in the recovery process as is normally applied in Early Contractor Involvement (ECI) brings valuable expertise and perspectives. Contractors who hold longer-term contracts and build established relationships with recovery agencies can contribute stability and continuity to the works. Subcontractors, on the other hand, often work on shorter time horizons and follow market forces, providing flexibility and scalability to the recovery efforts.

While recovery efforts are generally focused on certain geographic areas in New Zealand, contracting resources are often sourced from across the country. The impact of economic development and growth in other geographical areas, such as cities experiencing significant growth or specific large-scale construction projects outside of the recovery area, can impact resourcing for recovery works. Competing demands for construction skills can strain the availability of resources, potentially impacting the pace and quality of recovery efforts. It is important not to underestimate these pressures and to proactively address any potential challenges through strategic planning, resource allocation, and in collaboration with relevant stakeholders and the recovery leadership and coordinating teams.

Specific consideration of the health and wellbeing of all personnel involved in the recovery programme is important, particularly those who live locally and may be experiencing natural hazard event impacts felt by their whanau, iwi and community. Individuals may still be recovering from the shock caused by the initial events and will be faced with ongoing pressures as they adapt to work on the recovery programme and within their day to day lives. These pressures need to be acknowledged and managed appropriately as part of recovery efforts.

Resourcing issues during recovery operations tend to magnify pre-existing or business-as-usual challenges. Factors such as lifestyle preferences and cost considerations can significantly impact the

availability of skilled personnel for recovery works. To mitigate these challenges, initiatives such as temporary accommodation, improvement of accessible amenities and competitive wages can be provided to improve conditions for individuals involved in the recovery efforts. By making working on recovery programmes more attractive, the resourcing pool can be expanded, enhancing the overall effectiveness of recovery works. For particularly long-term recovery programmes, accessing skilled resource may require international recruitment initiatives to meet the needs of the recovery works.

Purposefully uplifting the capability of the sector-wide workforce where required and plausible, allows effective delivery of recovery works. This includes infrastructure owner organisations, contractors/sub-contractors, and those delivering specialist infrastructure activities. Investing in training and upskilling programs not only enhances the quality and efficiency of the works but also addresses unemployment by delivering new skills to the employment market. In addition, engaging subject matter experts may be required to ensure resolution of complex challenges during the recovery process.

Iwi/community engagement

Recovery efforts should ideally be centred around empowering and involving affected communities in decision-making processes, ensuring that their voices are heard, and their unique needs are addressed. Iwi, in particular, should be active partners. By actively involving the community, recovery projects can foster a sense of ownership, promote social cohesion, and build resilience from the ground up.

For large, and transformative recovery programmes, this requires going beyond consultation and striving for genuine involvement, including actively involving the community in setting priorities for recovery works and keeping them informed as works progress. Engaging communities from the start enables active participation and involvement in decision-making processes. This engagement may uncover potential improvements to pre-event infrastructure arrangements that can be accommodated within recovery works. Ongoing engagement strategies should be employed to maintain a continuous dialogue with the community throughout the recovery journey. Any community engagement efforts by critical infrastructure providers should be done in consultation and/or coordination with local councils and/or recovery agencies to ensure coordination of engagement efforts and to avoid consultation fatigue.

It should be noted that prolonged community engagement may lead to frustration and inefficiency in the delivery of recovery works. Balancing the need for engagement with the need for timely and efficient recovery is essential. Effective engagement means using clear timelines, efficient processes, and transparent decision-making.

Proactive engagement and communications can be used to build trust. Face-to-face interactions are useful particularly where trust is low and desires for community input is high. However, use of other mediums to cater for large and both culturally and spatially diverse audiences may be necessary. Clear language and messages are essential. Following through with intended actions is crucial to maintain credibility and strengthen trust between recovery agencies and the community.

Information needs

Comprehensive and timely damage impact assessment is crucial for both the response and recovery processes. Accurate information about the extent and nature of the damage allows for informed decision-making and prioritisation of recovery efforts. Initial impact assessment provides a baseline knowledge that is essential for planning and resource allocation.

A centralised information sharing platform is useful to facilitate efficient sharing and access to relevant information among all parties involved in recovery works. This can serve as a repository for data on infrastructure damage, resource availability, recovery plans, and progress tracking. Comprehensive data can better enable the sequencing and coordination of works carried out in parallel across various infrastructure networks. It can also facilitate access to previous lessons learned and capture emerging learning. Utilising tools, such as Geographic Information Systems (GIS) and remote monitoring, can improve the provision, accessibility, and utilisation of information. Note that establishing such a platform may present organisational rather than technical challenges (e.g. data standards, data sharing, access and management protocols).

Recovery reporting and monitoring is useful to track progress, measure performance against objectives, and ensure accountability. Suitable metrics covering areas including health and safety, environment, economics, resourcing, and stakeholder engagement can be used to evaluate the effectiveness of recovery efforts and identify areas requiring improvement.

Decision making

Effective decision-making is a critical aspect of recovery. Establishing documented goals, priorities, and timelines for the recovery is an important part of this process as it provides a framework that guides decision-makers throughout the recovery. Creation of a comprehensive master plan is useful to capture an agreed approach.

Decision-makers need to strike a balance between making timely decisions and ensuring that all relevant factors have been adequately considered. This can be difficult as the recovery process often requires making decisions based on limited or uncertain data sets. Opportunities to use standardisation of approaches to improve the speed of recovery works need to be balanced against opportunities to optimise recovery work design and performance. Importance and urgency in recovery efforts also needs to be consciously balanced. While the window of opportunity to make positive change after a natural hazard event may require swift actions, it is important to carefully evaluate options and implications to ensure decisions are in alignment with recovery goals and are considered with appropriate levels of governance.

Employing a scalable risk-based decision-making process can provide a structure to make decisions linked to the complexity of the issue at hand. Decision-makers must carefully assess the available information, consider potential uncertainties, and adopt strategies to mitigate risks associated with incomplete or evolving data. This may include the use of scenario planning, input from subject matter experts or seeking further information. In some cases, the situation may lend itself to the adoption of temporary or short-term infrastructure solutions to increase levels of service to communities in the short term, but to allow for deeper consideration of longer term options. This is particularly relevant where there is significant longer-term uncertainty relating to changing hazards and demographic shifts.

See the companion brief, *Curran and Brown (2023) Building resilience through recovery: Investment decision making* (resorgs.org.nz/wp-content/uploads/2023/07/NIEWE_critical_Infrastructure_resilience.pdf).

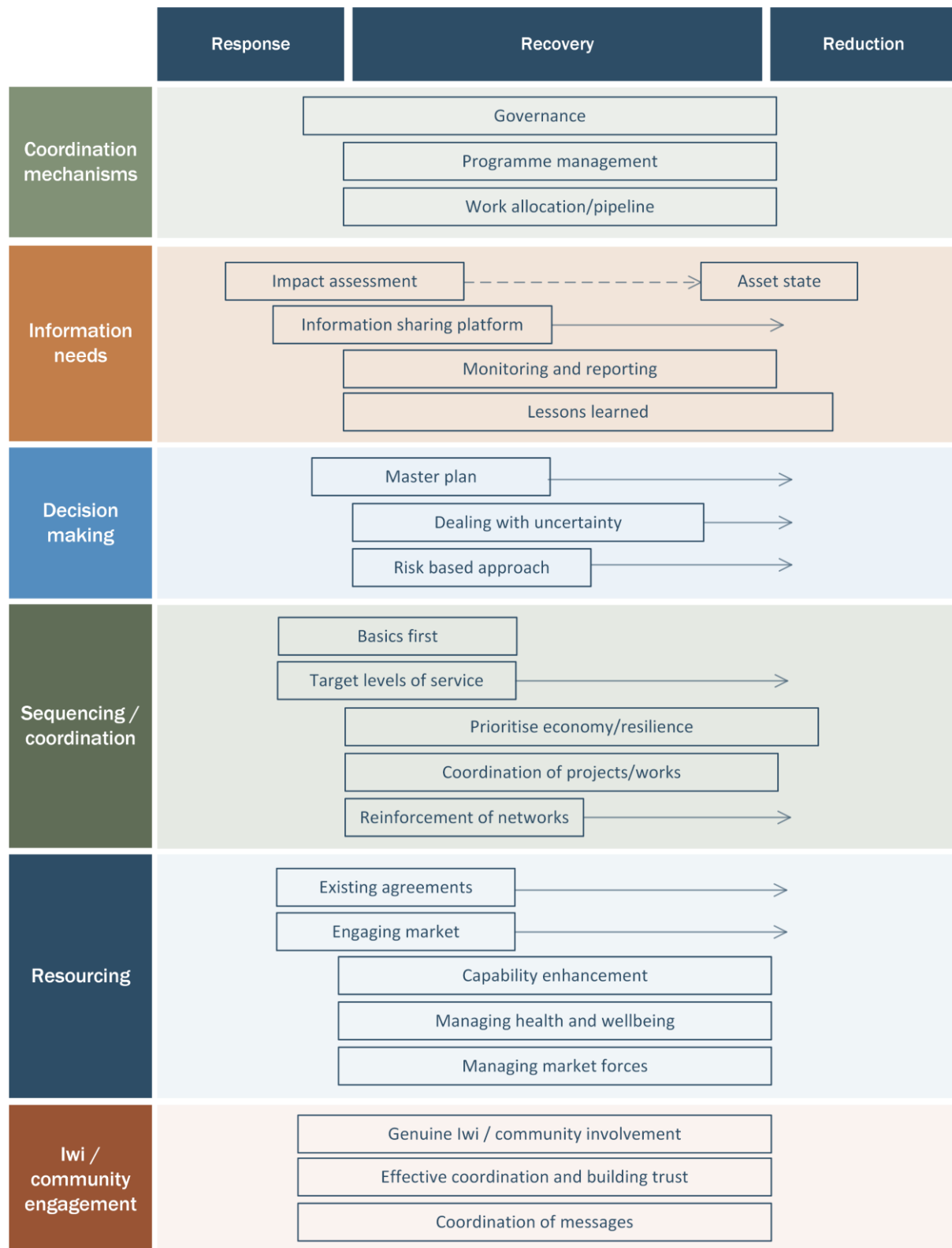


Figure 1: Key components of a critical infrastructure recovery programme