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REPORT

DISASTER WASTE MANAGEMENT PLANNING

Prepared for Environment Canterbury, Waikato Regional Council and Bay of Plenty Regional Council

May 2017

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Executive Summary

This project has set out to develop the detail required for a user-friendly and comprehensive tool for dealing with every possible context of disaster waste management planning. The literature has been exhaustively surveyed to obtain best practice examples of disaster waste management planning, both nationally and internationally and the key persons active in this area in a national context have been interviewed and their views included in the report's considerations.

Lessons learned from past events are particularly critical to the iterative process of continually refining and improving the philosophy of and practical approach to planning for waste management following disaster events.

In particular, the learnings inherent in the Canterbury earthquakes response, the Rena grounding and the recent Kaikōura/North Canterbury earthquake event have all been drawn upon in the derivation of this report.

In the international arena, the lessons learned from the Hurricane Katrina response and the 2011 Great Japan earthquake and tsunami have each provided a wealth of detailed and applicable material to support our findings and recommendations.

Ultimately, and as required by the brief for this project, a blueprint has been prepared for the content and delivery of a national tool for disaster waste management planning. This includes a series of detailed recommendations under various headings, including:

- Roles and responsibilities
- Identification of likely hazards and impacts
- Waste quantity and composition
- Existing waste systems and capacities
- Temporary waste handling and treatment
- Waste collection and transportation
- Recycling, recovery and treatment options
- Waste disposal
- Hazard and risk management
- Contractual and operational management
- Record keeping and monitoring
- Public communication and engagement
- Funding
- Regulations

It is also important to note that the DWMP should include a formal procedure for regular review. This should ideally take place annually to ensure that the DWMP remains relevant and all details are up to date.

The next step in this project is to use the ideas presented to prepare an operative and supported DWMP template-based tool for general use in the future for disaster events in New Zealand.

Environment Canterbury, Waikato Regional Council and Bay of Plenty Regional Council

Disaster Waste Management Planning

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1 Introduction

MWH, now part of Stantec (MWH) was commissioned by Environment Canterbury, on behalf of its co-sponsoring partners Waikato Regional Council and Bay of Plenty Regional Council, to prepare a technical report setting out the detailed requirements for an effective and generic Disaster Waste Management Plan (DWMP). This is in order to enable relevant stakeholders to prepare for and manage the various waste streams and associated volumes that would be generated in a disaster event occurring in New Zealand.

The Request for Proposal (RfP) document set out the following key elements to be addressed as part of this project:

- Review of existing documents produced by territorial authorities and CDEM groups
- Identify and analyse two selected international DWMP examples with a view to their relevance to and potential at least partial contribution to a New Zealand DWMP template
- Review disaster waste management measures and associated lessons learned from the Christchurch earthquakes and the Rena grounding
- Identify the specific requirements for a New Zealand DWMP template
- Identify key stakeholders
- Recommend the format options and the best platform on which to host a DWMP template.

Subsequent to the preparation of the RFP document and the key elements to be addressed, the Kaikōura earthquake occurred in November 2016. Accordingly, and as recorded throughout the body of this report, the learnings from the Kaikōura event, the Rena grounding and the 2011 Christchurch earthquakes with respect to disaster waste management have all been used to illustrate issues of disaster waste management and, as much as possible, the resolution of these and the indicated way forward for future disaster waste management planning.

MWH's fundamental approach to this study was to not "reinvent the wheel" but instead undertake a detailed review of existing New Zealand and selected international examples of Disaster Waste Management Plans and related research documents, in order to reach a concise understanding of the most important and effective elements for inclusion in a generic DWMP template. A list of references used in this project is provided at the end of this report.

This document provides a comprehensive report that addresses these key elements needed to facilitate the development of an effective generic DWMP template, as part of MWH's contracted outputs. The report has been compiled from the research and consultation presented in three milestone reports previously provided to the sponsoring stakeholders. To illustrate the information and research investigated the three Milestone Reports are provided as Appendices A, B and C to this Final Report.

2 Structure of a Disaster Waste Management Plan

2.1 Overview comments

Any pre-disaster waste management solution needs to be completely flexible because the exact nature of a particular disaster in any geographical area is unknown. Unless the generic DWMP template incorporates this flexibility it is likely to be impossible to apply a template across-the-board for various hazard events and scales.

Disasters can vary greatly from one to another, and the waste management issues after disasters can also vary. Typically, management of disaster waste (and disaster management in general) is described in three phases:

- Emergency response (debris management to facilitate preservation of life, provision of emergency services, removing immediate public health and safety hazards such as unstable buildings, etc.)
- Recovery (debris management as part of restoring lifeline restoration and building demolition)
- Rebuild (debris management of wastes generated from and used in re-construction).

The phases are not distinct and the duration of each phase varies significantly between disasters.

The literature reviewed as part of this project contains many useful examples of the analysis of waste management after past disasters, both national and international. It is clear that, in spite of the great differences between disasters, waste managers are faced with similar key decisions, without regard to geography. These decisions, in turn, have been influenced by a range of common factors.

2.2 Drawing from Japan's disaster waste management experience

It is important to be prepared; for example, Japan has had decades of experience in planning for, and responding to, disasters. This can be extremely beneficial as it allows the government authorities to move swiftly into "emergency mode" after a disaster. Japan's Ministry of the Environment has developed clear guidelines for the local municipalities on how to deal with disaster debris. This includes a guidance note on segregation, storage and treatment of disaster wastes. This guidance enables the municipalities to have a consistent framework to deal with the debris. Individual municipalities trying to decide on a sorting strategy might otherwise create different waste streams in different municipalities, thus making any final consolidation difficult.

Based on Japan's experience from the 2011 earthquake/tsunami event a set of essential recommendations has been published; this is said to be framed to assist "developing countries" but the blueprint is universally applicable. The major elements are:

- Preparation of a disaster waste management plan in advance, with the major focuses on classification of disaster waste types, securing the necessary equipment and temporary storage sites for disaster waste, having sufficient individual modules in the plan for disasters of different scales, and allowing for periodic review of disaster waste management plans to continually incorporate the lessons learned from other international disasters.
- Building of cooperative structures and connections with relevant organisations and institutions to assist with the smooth management of disaster waste. Effective management of the sheer volume of waste generated in large-scale disasters is greatly aided by strong relationships with local authorities in the immediate vicinity of the stricken area. This includes collaboration in the handling, transportation, recycling and disposal of waste.
- Particular districts also developed their own disaster waste management plans, for example focusing first on protection of public health by dealing with temporary sewage disposal as a first priority and with this taking precedence over hard debris management. Systems for separating, processing and recycling disaster waste have been set up, in cooperation with local businesses, to ensure an ultimate economic benefit to the community. Goals setting and timeframes were typically included as key drivers of these plans in various Japanese municipalities. Post-disaster needs assessment became a particular focus for changes in disaster management planning. Sharing of information between the public and private sectors was viewed as essential to initiatives aimed at swift disaster response and smooth recovery and reconstruction.

2.3 Hurricane Katrina and relevant learnings

Hurricane Katrina struck New Orleans early on 29 August, 2005, with heavy rain continuing for many hours, followed by a storm surge that was as high as 9 metres in some places. This overwhelmed many of the city's unstable levees and drainage canals. Eventually, nearly 80 percent of the city was under water, with devastating outcomes for commercial buildings and residential dwellings, many of which were irreparably damaged in the storm or subsequently needed to be demolished. The quantum of waste arising from the Hurricane Katrina disaster was massive.

One of the most significant identified shortcomings in the response to waste management with respect to this disaster was the lack of effective debris waste management capability and planning. This resulted in ad hoc disposal (some of which generated significant and long-lasting environmental impacts), inappropriate disposal endpoints for certain waste types (e.g. infectious wastes improperly disposed) and various other issues such as land and surface water contamination all stemming from the lack of a coherent and coordinated debris disposal approach.

The upshot has been a strong emphasis on disaster management planning. The lessons of Hurricane Katrina in this regard have had a significant degree of uptake by other US states and/or city jurisdictions and there are many literature examples available for scrutiny and derivation of best practice approaches, most of which are directly applicable to a New Zealand context.

2.4 The New Zealand context

New Zealand is precariously situated between two active tectonic plates, in the middle of a deep ocean, and is thus vulnerable to tsunami, earthquakes, storms, floods, and volcanic activity. A wide range of natural disasters are therefore possible.

DWMPs are needed across New Zealand that can be activated effectively and more or less immediately on Day 1 of a disaster event. This report is the initial step in deriving the detailed template for a generic DWMP. It draws from various case studies and research and identifies the following content as essential elements to be included in a DWMP template structure:

- Roles and Responsibilities
- Identify likely hazards and impacts
- Identify existing waste systems and capacity
- Waste composition and quantity
- Waste collection & transportation
- Temporary waste handling and treatment
- Recycling, recovery and treatment options
- Waste disposal
- Hazard management
- Strategic and operational management
- Record keeping and monitoring
- Public communication and engagement
- Funding
- Regulations

These items are essentially a reflection of the material covered in considerable detail in the Charlotte Brown and/or Mark Milke papers referenced in Appendix A. Each of these matters is discussed in more detail in Section 3.

3 Content of a Disaster Waste Management Plan

The following sections describe the detailed content inherent in an effective disaster waste management plan. The discussion is illustrated with national examples from the experiences of the Christchurch earthquakes of 2011, the Rena grounding of 2011 and the 2016 Kaikōura earthquake event, as well as considerations of the Hurricane Katrina and Great Japanese earthquake responses.

In essence a plan is needed that can be activated effectively and more or less immediately on Day 1 of an event. The experiences from each of the disaster events investigated for this project continually reinforce this fundamental requirement for rapid activation of a detailed planning template.

3.1 Roles and responsibilities

Planning for disasters is extremely beneficial as it allows those responsible for responding to an event to move swiftly into “emergency mode” after the disaster.

As part of planning, authorities need to consider strategic management and operational roles and responsibilities for disaster waste management. Organisational processes need to be stream-lined, where possible, to avoid potential organisational inefficiencies or confusion over responsibilities. There is also significant value in assigning these roles pre-event so that organisations and individuals can start to develop working relationships which would be called on in a disaster event.

A disaster waste management plan (DWMP) should be written for roles and not individuals and new staff should be made familiar with the plan. It should clearly state where it fits within the CDEMP and structure, and where authority for decision making lies.

The nominal titles and associated descriptions for the various roles identified in the generic DWMP may not align precisely with those used by some territorial authorities but the role description should make it unequivocally clear as to what is expected of the individual assigned to each role, so that TAs can identify how their own structures and job descriptions fit in. As an example, the Solid Waste Manager is

a clearly identified role in any TA organisation, even if the actual title and possibly elements of the scope of the role may differ somewhat among TAs.

A DWMP also needs to develop a cross-organisational coordination structure ensuring that it is scalable for larger disasters and disasters involving different agencies. It should also be written collaboratively with all relevant agencies.

Waste activities should be managed under the recovery organisation where waste management activities have a strong interconnectedness with other recovery activities. This is particularly relevant where there are a high number of displaced persons, high disruption to the road network and high human health impacts.

In the United States, the Federal Emergency Management Agency (FEMA) Guidelines of 2007 note that specific disaster waste management plans should be the responsibility of individual municipalities; i.e. devolved down from the federal level. Much of this guidance stems from an analysis of the responses to Hurricane Katrina. For a New Zealand context, it is considered more appropriate and commensurate with the geographical size of this country to derive individual DWMPs on a regional basis, with these being individually generated from the generic DWMP template approach that is advocated in this report.

An important lesson derived from consideration of the responses to the recent earthquake near Kaikōura is that a clear direction is needed to delineate the operational activities and associated priorities needed in the immediate recovery phase after an event. The DWMP needs to identify the strategic direction and associated processes required to facilitate recovery; i.e. personnel needed, roles and responsibilities of the recovery team and integration with the Business Administration Unit for each Local Authority. Details on how to up-skill people and how to revamp or reorganise the existing systems to cope with the additional volumes of waste material were also prepared as responses to this particular event, in association with Kaikōura District Council and Environment Canterbury.

It is recommended that a DWMP should include a formal procedure for regular review and that such a review should ideally take place annually to ensure that it remains relevant and contact details are up to date.

3.2 Identify likely hazards and impacts

It is important to clearly understand the types of hazards for a specific area and what each type of disaster would mean for the generation of waste. Most CDEMPs already identify the likely hazards for their specific area (see Table 3-1 on the following page) but have little or no information about the consequent waste types (and quantities) that can be expected to be generated. It is important to understand that the CDEM ambit is much wider than disaster waste management, which of course is a defined subset of the overall CDEM envelope.

The DWMP therefore needs to expand on this work already completed in developing CDEM Plans to identify the potential areas affected by each type of disaster (e.g. flooding around rivers and flood plain only, tsunamis around coastal areas only, earthquake damage to buildings and infrastructure) and the scale of waste generation, including nature and quantities of debris that are likely to arise.

Maps should be developed as part of the DWMP showing high risk areas following certain events. These can then be used to calculate the potential numbers and types of properties likely to be affected, and the amount of waste potentially generated (see section 3.3.3).

Table 3-1: Examples of Typical Hazards and Risk Summaries Identified in a CDEMP[1]

HAZARD	RISK ANALYSIS		
	LIKELIHOOD	CONSEQUENCE	RISK RATING
Lifeline Utility Failure: Electricity	Possible	Catastrophic	Very High
Human Epidemic	Possible	Catastrophic	Very High
Volcanic Eruption: Distant Source Eruption	Likely	Major	Very High
Cyclone	Likely	Major	Very High
Flooding: River/Rainfall	Almost Certain	Moderate	Very High
Erosion: Coastal Cliff	Almost Certain	Moderate	Very High
Erosion: Landslide/Land Instability	Almost Certain	Moderate	Very High
Volcanic Eruption: Auckland Volcanic Field	Rare	Catastrophic	High
Animal Disease/Epidemic	Possible	Major	High
Crash: Aircraft	Possible	Major	High
Earthquake	Unlikely	Major	High
Hazardous Substance Spill	Likely	Moderate	High
Lifeline Utility Failure: Water Supply	Possible	Moderate	Moderate
Lifeline Utility Failure: Waste Water	Possible	Moderate	Moderate
Introduced Species/Pests	Possible	Moderate	Moderate
Lifeline Utility Failure: Communications	Possible	Moderate	Moderate
Lifeline Utility Failure: Fuel	Possible	Moderate	Moderate
Lifeline Utility Failure: Roading	Possible	Moderate	Moderate
Criminal Acts: Terrorism	Possible	Moderate	Moderate
Criminal Acts: Civil Unrest/Riot	Possible	Moderate	Moderate
Crash: Rail	Possible	Moderate	Moderate
Flooding: Tsunami (regional/local)	Unlikely	Moderate	Moderate
Crash: Road	Likely	Minor	Moderate
Drought: Agricultural	Likely	Minor	Moderate
Flooding: Tsunami (distant)	Likely	Minor	Moderate
Fire: Urban	Possible	Minor	Moderate
Lifeline Utility Failure: Airport	Possible	Minor	Moderate
Lifeline Utility Failure: Gas	Possible	Minor	Moderate
Lifeline Utility Failure: Port	Possible	Minor	Moderate
Flooding: Storm Surge	Possible	Minor	Moderate
Drought: Water Supply	Possible	Minor	Moderate
Lifeline Utility Failure: Gas	Possible	Minor	Moderate
Dam Failure	Unlikely	Minor	Low
Crash: Marine	Unlikely	Minor	Low
Fire: Rural	Likely	Insignificant	Low
Tornado	Likely	Insignificant	Low

[1] Auckland CDEMP

3.3 Waste quantity and composition

The collection of waste data and the importance of pre-event waste quantity estimations cannot be overstated. This sort of information allows accurate pre-planning of disaster waste responses, including transportation requirements and disposal options, both temporary and permanent.

The types of waste streams generated by disasters include:

- vegetative debris or green waste
- sediment / soil and rock
- household hazardous waste (refrigerants, oils, pesticides, etc.)
- construction and demolition debris from damaged buildings, and from infrastructure such as roads, pipe networks and other services
- industrial and toxic chemicals, including fuel products
- putrescible wastes (such as rotting food)
- vehicles and vessels (from maritime disasters)
- recyclables (plastics, metals etc.)
- electronic and white goods
- waste from disaster-disturbed pre-disaster disposal sites
- human and animal corpses

Understanding the typical waste streams that could be associated with each disaster type is key to planning on how to manage these wastes. Table 3-2 provides an example of this.

3.3.1 Waste quantity

Estimating the volume of disaster debris is an important technical challenge facing any authority in the wake of a disaster. In order to scope the damage and calibrate the response, it is important that a reasonable estimate of the disaster debris is available to decision makers as quickly as possible. The actual composition and quantity of the waste depends on the nature of the built environment affected

Table 3-2: Typical waste streams per disaster type[2]

		Typical Waste Streams								
		Vegetative	Construction and Demolition (C&D)	Personal Property / Household Items	Hazardous Waste	Household Hazardous Waste (HHW)	White Goods	Soil, Mud and Sand	Vehicles and Vessels	Putrescent
Types of Disasters	Hurricanes/ Typhoons	X	X	X	X	X	X	X	X	X
	Tsunamis	X	X	X	X	X	X	X	X	X
	Tornadoes	X	X	X	X	X	X		X	X
	Floods	X	X	X	X	X	X	X	X	X
	Earthquakes		X	X	X	X	X	X	X	X
	Wildfires	X	X	X	X	X	X	X	X	
	Ice storms	X				X				
	Volcanic eruption	X	X	X	X	X	X	X	X	X
	Pandemic				X	X				
	Industrial disaster	X	X	X	X	X	X	X	X	

[2] Source: Brown, C. (2012) Disaster Waste Management: a systems approach.

and the severity of the disaster and therefore any estimate will still need to be refined post-disaster. An adaptive response is thus required and the DWMP should include provision for this to be undertaken and should provide the tools to facilitate it.

As an example of the inherent difficulties, waste managers were challenged in their response to Hurricane Katrina by the mixture of hurricane- and flood-generated debris, each of which was different in character and in disposal requirements. Different fundamental management approaches were in fact required for each of these waste types.

The experience of Hurricane Katrina demonstrated unequivocally that disaster debris management planning is significantly aided by pre-disaster waste quantity estimations. Such estimates are also useful for post-disaster response planning and management and can be effectively carried out using GIS / hazard maps. It is strongly recommended that these approaches are included in the generic DWMP template tool being underpinned by this report.

Pre-estimates prepared as part of the DWMP allow authorities to better understand the quantities of waste that could arise with each disaster type and evaluate the effectiveness of existing infrastructure to meet the demands, or the potential need for additional or temporary sites.

There are three quantity estimation approaches recommended in the Brown and Milke papers that would allow for high level calculations to be made pre-event. These are described below.

Table 3-3: Estimating the quantities of waste

Type	Calculation	Description
Unit:	$\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n N_n}$	The total waste is calculated as the sum of the number of houses in each category (N) multiplied by the quantity of waste (W, in mass or volume as needed). With this formula estimates can be built up based on how much waste is expected from a single type of property and the level of damage sustained. For example, for residential areas, the affected properties could be categorised with respect to the level of damage (say, full demolition, partial repair and minor repairs). Each level could then be divided further based on the type of construction of the property, its age and size.
Volume:	$Total\ waste\ (tonnes) = 1/3\ Building\ volume\ (m^3)$	For variably shaped buildings, a volume estimation technique may be most appropriate. This is calculated as the weight of debris in a commercial building as one third of the volume of the erect building. Note that this varies widely and would be significantly less for lightweight buildings such as steel framed warehouses, for example. This approximation could only be used for buildings being fully demolished and where the volume of the building is known. Building volumes could be obtained using LIDAR images or using local authority-held building data (say building height or number of storeys and floor area).
Area estimates	$\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n A_n}$	Area estimates are based on the amount of waste over a particular area, be it floor area of a building or land area. For buildings, waste quantities per unit floor area (in m²) could be estimated based on damage level and building type. These area estimates can then be multiplied by the total floor area of that building, damage level and building type. This technique is similar to the unit estimates except that instead of estimates per building (N) the estimates are based on floor area (A). Area estimates are especially useful for earthquake damage that is spread over a large area, such as waste

		resulting from liquefaction and tsunami damage. Aerial images can be used to determine the extent of the damage. If desired, the areas can be split into damage levels. For each area, unit (per m²) waste quantities (and composition, if desired) can be assigned. This technique was used in Japan following the 2011 Tohoku tsunami.

Note: Each of these methods may be further refined by splitting the buildings into construction type and assigning approximate waste compositions for each building type.

Building data can be collected, including building dimensions, building materials, hazardous materials (asbestos, LPG, etc.), building use (to identify problematic waste sources e.g. putrescible waste), owner and tenant details, with this information collectively allowing for more accurate calculations to be made. As an example, it is known (as derived subsequent to the Canterbury earthquakes of 2011) that the average residential property contains approximately 220 tonnes of demolition waste material. It is expected that this will be a typical average quantum per residential dwelling for each region in New Zealand although areas where brick or concrete building stock predominates may well exceed this yardstick quantity.

The DWMP template should provide for easy calculation of potential waste arisings online and allow this to be refined post-disaster. After an event the template should also be able to classify the quantities of waste for each of the following phases related to the event response, as each phase has different requirements and associated time pressures; i.e.

- Emergency response (preservation of life, provision of emergency services, stabilising buildings, clearing roads etc.)
- Recovery (restoring lifelines, debris removal, building demolition)
- Rebuild (construction of major structures and houses).

3.3.2 Waste composition

Various waste classification schemes and scenarios for disaster waste in relation to composition have been formulated. An example following the Japan earthquake and tsunami event of 2011 identifies the following categories:

- Waste consumer electrical appliances and electronics, and various household effects;
- Waste wood, concrete, tiles, rubble, etc.;
- Trees, shrubs, plants and other natural materials;
- Large structural items, etc.;
- Deposits such as liquefaction silt;
- Wrecked vehicles and boats;
- Hazardous wastes (asbestos, pesticides, PCBs, general chemicals, etc.)
- Infectious wastes and animal carcasses.

In addition to disaster-generated waste, other waste streams can be indirectly generated post-event, including excessive unwanted donations, large amounts of health care wastes, rotten food resulting from power outages and emergency relief food packaging.

The appropriate treatment and disposal methods for each waste type need to be determined on a case-by-case basis, while keeping in mind the possibilities and opportunities for recycling.

Depending on their nature and severity, disasters can create large volumes of debris. In some cases the equivalent of many years' worth of waste can be generated in a single event often overwhelming existing solid waste management facilities and personnel. It can also affect both the response and long term recovery of a disaster-affected area. Immediately after an earthquake, debris can block roads, which in turn impedes rescuers and emergency services reaching survivors. In the longer term, poor management of debris can result in a slow and costly recovery. Rebuilding and repair cannot be carried out before the waste is removed. It is also a public indicator of the speed of recovery.

For liquid wastes particular considerations are required; thus, following the Rena grounding event various liquid wastes had to be analysed before a decision could be made on whether disposal to the Tauranga City trade waste sewer could be allowed. If a liquid waste did not comply it was sent to Auckland for speciality disposal. Any liquid waste containing oil and/or detergent / dispersant had to be particularly carefully monitored. The local landfill was used for disposal of some oily liquid waste that did not meet Council trade waste acceptance criteria.

Some components of disaster waste streams pose a potential health risk which can be exacerbated post-disaster where waste volumes are significantly increased. These include; asbestos, arsenic treated timber, gypsum leaching and organic pollutants. Other inert materials will take up vital engineered landfill space unnecessarily and therefore a good network of cleanfills is important. If managed effectively some of this material can also become a valuable resource in the recovery and rebuilding process and can have a positive effect on social and economic recovery. This has been the experience gained from review of the Christchurch earthquake waste arisings management (Brown et al; 2011) and has also been a fundamental approach underpinning the deconstruction of Kaikōura's impacted residential houses and the subsequent reuse of building materials resources as either part of the direct rebuild or in other reuse contexts.

Normally generated municipal waste must also continue to be managed if the disaster-affected community is still living in the area. The need for continuation of established municipal waste collections should be considered when planning and/or implementing a disaster waste management system.

3.3.3 Summarised requirements for generation of comprehensive data about disaster waste quantities and types

A sequential approach to the sourcing and use of data to calculate the extent of waste generation in various disaster scenarios should be based on the following steps:

- Use the maps developed for each hazard type (see section 3.2) to identify the areas that are likely to be affected by each type of potential disaster event.
- A further use for these maps would be to classify the identified critical areas into "high", "medium", "low" and "no" impact; however the costs of this level of modelling may be prohibitive; this has not yet been defined.
- Use Councils' data to identify how many properties are located within the identified affected areas, the property types and building materials, property uses and property zonings. This step makes the assumption that this level of data will be available electronically and already exists within a GIS format. If this is not the case (as is likely for some Councils) this type and level of data will be expensive to produce.
- Use the calculations set out Table 3-3 (depending on the level and quality of data available) to establish the likely quantities of waste that would be generated.
- An alternative approach is to utilise the Christchurch earthquakes-derived estimate that the average residential property contains approximately 220 tonnes of demolition waste material; this approach would be indicated as a fall-back position if only limited information is available.
- Use the following 'rule of thumb' for estimating composition:
    - Typical residential property 3 bedroom (lightweight timber cladding, steel roof)- 60% concrete, 25% wood, 5% metal, 10% other by weight
    - Typical residential property 3 bedroom (brick cladding with tile roof) – 90% concrete /brick/ tile, 5% wood, 5% other by weight
    - Commercial buildings - 60% concrete/brick, 10% wood, 5% metal and 25% other by weight
    - Building construction can generate approximately 2 tonnes waste / 100m^2 of new building
    - Use HAIL register or other Council data (such as property use databases) to estimate the potential for hazardous materials to be present, particularly in industrial/commercial buildings
- Use Council and LIDAR data and aerial maps to calculate potential debris generation or landslip areas although these would only be high level estimations as some debris may simply be left in situ post-event

This type of sequential data generation template should be built into the DWMP tool.

3.4 Identifying existing waste systems and capacities

All territorial authorities have identified existing waste infrastructure and services as part of their waste assessments and waste minimisation and management plans. Municipal waste management contingencies are already well developed in Councils' incident response plans which include contingencies for managing disruption to the municipal solid waste collection and disposal services. These plans are generally updated and tested in a simulated emergency exercise each year and the documents are refined based on lessons learned from the yearly exercises.

The DWMP should expand on this information by preparing an inventory of existing services, waste handling facilities, resources and personnel (including for hazardous materials) and detailing the acceptance criteria and consent conditions, operational capacity, total capacity and contact details for all:

- Recycling / sorting facilities
- Waste handling facilities
- Waste treatment facilities (including for hazardous wastes)
- Final disposal facilities / end use (including cleanfills)
- Demolition contractors
- Hazardous waste contractors
- Current waste transportation operators
- Other transport operators or equipment supplies that could provide assistance in an emergency.

These considerations need to include all private operators, as well as Council-owned facilities and services. Regulatory mechanisms may be required to enable this and should utilise existing databases / resources e.g. the Christchurch recycling directory.

A key point made in discussions about the response to the Rena grounding event was that relationships with waste disposal contractors have to be in place before an incident. While it is obviously not possible to predict the occurrence of an incident, if suitable relationships (even to the extent of pro forma contracts) are already in place this makes the mechanisms for dealing with the waste from an actual incident much smoother and more effective. Some form of accreditation or pre-approval system for contractors and waste handling facilities should also be considered. A risk assessment should also be carried out on existing facilities to understand their vulnerabilities in the event of a disaster.

Maps should be developed as part of the DWMP showing the location of each waste acceptance facility, with these maps being embedded with relevant metadata (such as landfill acceptance criteria, consent conditions, operational capacity, total capacity and contact details) associated with each facility. Section 4 expands further on the proposed use of embedded GIS maps in the template-based tool for DWMP development.

3.5 Temporary waste handling and treatment

With the capacities of existing solid waste management facilities likely to be far exceeded in a large scale disaster event some pre-planning and forethought into potential debris management options needs to be carried out by:

- considering available alternative disposal options
- considering temporary storage sites
- assessing possible environmental impacts and risks with using each site
- investigating alternative recycling or reuse options
- identifying potential capacities of each facility or site
- establishing MOUs between local authorities and contractors where appropriate
- consulting with the community and preparing post-event communication strategies with regard to temporary waste management and the community's role

Temporary staging sites are a common tool used in the management of disaster waste as they provide additional space to separate waste into recyclable and non-recyclable material and to create a buffer to ease the pressure on existing waste facilities. For example, a plan for large scale disaster debris management is currently being prepared by Taranaki Regional Council. This will link with the New Plymouth District Council Incident Response Plan. As part of the plan a number of temporary storage

sites have been identified such as old landfill sites, cleanfills and quarries. Consideration has also gone into possible skip bin set-down areas for community waste collection operations

As an approximation, the space required for a temporary staging area is 50 hectares per 1,000,000 cubic metre of debris.

Identifying potential sites as part of a DWMP through a clear site selection process allows for the possible environmental impacts and risks with using each site to be considered upfront. Factors requiring consideration include space requirements, environmental factors, noise and dust, pre-disaster site identification, land-use planning issues and cost. Where possible operational management arrangements (e.g. stand-by contract), operational protocols (e.g. environmental and human health standards, payment mechanisms), environmental baseline measurements, and land use arrangements (lease and land-use consents where necessary) should all be established.

After wastes have been sorted, they can be treated in a number of ways including recycling, reuse, composting, or use as land reclamation and engineering fill. If the waste is contaminated with hazardous materials or is wet, recycling or reuse may not be feasible. These factors need to be taken into consideration when designing any temporary staging sites or adapting existing facilities.

As with existing sites maps should be developed as part of the DWMP showing the location of each facility and having relevant metadata (such as potential capacity, any consents required and contact details) associated with each facility. It is important to note that where the proposed location is privately owned, formal identification of land as having a possible future role for waste storage or disposal may affect the land use and value of the land.

3.6 Waste collection & transportation

It is best practice to keep the extent of transportation of disaster waste and the number of times the material is handled to a minimum. Waste transportation capability, including machinery inventory and location, is yet another essential matter that needs pre-planning and contractual consideration between contractors and persons responsible for disaster waste planning.

A DWMP needs to consider limitations of existing waste collection infrastructure, such as a maximum truck travel distances or dependence on specialised trucks and equipment (e.g. hook lift bins) and the capacity of the local fleet. Trucks not usually used for waste management may often be needed.

The DWMP also needs to consider and manage any potential risks associated with transportation. Measures to be considered include dust suppression (either by water application or dust covers), wheel washes, truck weight limits, dedicated truck routes (for example, to avoid dangerous roads), truck travel hour limits and waste tracking.

The procurement of additional services and equipment should happen as quickly as possible, if necessary. This can be done by establishing MOUs between local authorities and contractors pre-event or by including disaster waste management provisions within existing collection contracts. It may also be useful to establish stand-by contracts for applicable resources to assist Urban Search and Rescue (including demolition, construction and vehicle removal) and post-disaster demolition of ‘unsafe’ buildings. The DWMP template-based tool (see section 4) should provide templates for such agreements. This approach should also include provisions for reporting and waste tracking post-event, as discussed later.

Any event can affect multiple networks across an area, and deny access to properties and facilities. The DWMP should identify all collection routes and routes to disposal facilities and have the capability to assess these immediately after a disaster. Any damaged routes should be identified quickly following an event to allow for alternatives to be found or priority given to reopening certain routes as rapidly as possible. This can be coordinated with other lifeline groups’ requirements.

From the Kaikōura experience the collection and out-of-district disposal of hospital wastes had to be dealt with as a primary priority because protection of public health is typically of paramount importance. A local waste management contractor made available one of their specialised vehicles to transport the medical waste over a very difficult temporary access road to the out-of-district disposal point. The possible requirement for multiple use of existing vehicles needs to be kept in mind as part of a DWMP.

3.7 Recycling, recovery and treatment options

The choice of disaster waste treatment options should be considered as part of a DWMP and should not only include costs but also environmental and engineering risks.

A comprehensive understanding of post-disaster recycling is required. Factors such as: the effect of surplus materials on existing recycling markets; the need for establishment of post-disaster markets (e.g. environmental land remediation, land reclamation, waste-to-energy and housing reconstruction applications); the logistics involved; space requirements and associated land-use issues; and the economics of post-disaster recycling, all require further analysis in order to aid disaster planning and response.

Recycling feasibility is affected by the following factors:

- As the volume of waste increases, the need to recycle will generally increase.
- As the volume of waste increases, the economic viability of recycling will likely decrease.
- As the volume of waste increases, resource shortages (primarily labour) are likely to limit recycling capacities.
- As the geographical extent of damage increases, the feasibility of recycling likely decreases.
- Geographical isolation will decrease likelihood of post-disaster recycling being feasible.
- As the human health hazard increases, the feasibility of recycling decreases.
- The more mixed the waste is (i.e. the more difficult it is to handle), the less feasible recycling is.
- Recycling is dependent on the availability and relative costs of alternative waste management options.
- Funding mechanisms and policies need to consider indirect costs, as environmentally beneficial options such as recycling are not always the least expensive option.
- Public perceptions with respect to recycling should be assessed and considered during the decision-making process.

The Kaikōura reuse approach (as opposed to recycling) offers a positive way forward and has engendered a feeling in the community that the reworking of the fabric of deconstructed buildings into replacement structures provides continuity at a personal level.

Many areas already have waste management goals for their region and it is important that these are considered when planning a response post-disaster. Every location is different and a solution that works for one place may not be the best solution for another.

As an example of this from the Kaikōura experience, Innovate Waste Kaikōura (IWK) is a community enterprise that aims to help Kaikōura to achieve zero waste to landfill. It came into existence in 2000, as a joint venture between Kaikōura District Council and Wastebusters Trust Kaikōura. With the hard work of Kaikōura's community IWK was reportedly achieving 75% diversion from landfill prior to the earthquake and over the years there has been a shift in community attitudes and behaviour around waste. Since the earthquake struck IWK has been working hard to deal with their town's earthquake-related waste while sticking to their zero waste principles.

Consideration needs to be given to both on and offsite post-disaster reuse and recycling.

- Site separation is more feasible when there are more demolition resources available. Generally, the more mixed the waste (difficulty in handling), the less likely site separation is feasible. The ability to rely on public participation for site separation (on residential properties) decreases as the number of displaced persons increases; however the ability for contractors to site-separate waste (on residential properties) increases as the number of displaced persons increases.
- Offsite separation is more appropriate where (physical) human health hazards exist as human and environmental health hazards can be better managed by off-site waste separation. It also reduces the time required onsite to demolish structures. Offsite separation is dependent on access to a suitable waste handling facility, relatively close to the affected area. Separation offsite will allow for greater consolidation of truck movements if there is significant disruption to the road network.

Environmental risks around both onsite and offsite separation also need to be considered.

As part of the recovery plan for Kaikōura it was agreed that there should be deconstruction of buildings onsite where possible, rather than having an approach of demolishing everything and taking it off site for processing or disposal. Salvaging as much as possible onsite allows for less contamination and better opportunities to separate and reuse items. There was also a desire in Kaikōura to up-skill local people and provide opportunities for people to stay and work in the area while it recovers and tourism returns, rather than people being forced to leave an area in search of work in order to support their families.

Environmental standards, such as the level of recycling, the use of open burning, waste acceptance criteria and disposal regulations are often reduced to expedite recovery. However, the risks or effects of changes in environmental standards need to be considered as part of the DWMP before any changes are made post event.

3.8 Waste disposal

Ultimately some or all of the waste will have to be permanently disposed in a landfill. Shortage of space in existing landfills may be a problem, or a site may be damaged and therefore alternative disposal sites should be considered as part of a DWMP. This should include both for municipal waste, hazardous materials and cleanfill material.

Identifying these sites pre-event through a clear site selection process allows for the possible environmental impacts and risks with using each site to be considered upfront. As for temporary staging areas, it is important to note that where the proposed location is privately owned, formal identification of land may affect the future land use and value of that land. Other factors requiring consideration include space requirements, traffic impacts, noise and dust, land-use planning issues, waste acceptance criteria, engineering design and cost.

As an example of the unintended consequences of overly-hasty disaster waste disposal, the aftermath of Hurricane Katrina saw a significant quantity of waste being disposed directly into unlined landfills. The ensuing environmental impacts of this disposal are currently under investigation and definitive results are not yet available; however the impacts are already known to be considerable. The issue is a concerning one and must be considered in the identification of any potential disposal sites in pre-disaster planning for New Zealand.

Again turning to a local example, land reclamation was identified as part of the solution for Kaikōura as it has the potential to rapidly reduce the total volume of debris to be handled. However the long term environmental effects of using an area for land reclamation need to be closely considered.

Liquid wastes may have to be analysed before a decision can be made as to whether the simple expedient of disposal directly to the trade waste sewer can be made (providing that the reticulation system is unaffected by the disaster) or else diversion to be spread at a landfill may be required. Tis was the dilemma faced following the Rena grounding event but, ultimately, most liquid waste could indeed be disposed as trade waste, as confirmed by analysis.

The decision to recover, move and dispose of deposited soil following an event should be based on an analysis of the physical and chemical properties of the sediments and an analysis of how the residual soil may adversely impact future land uses.

Waste-to-energy was a management option used on a small scale in dealing with a limited portion of the waste from Hurricane Katrina. There would be scope for considering this option in a New Zealand context but only if a suitable nearby facility was available (and undamaged).

3.9 Hazard and risk management

Disaster waste can include numerous environmental and public health hazards, including rotten food, asbestos, faecally contaminated material, treated timber, and household and industrial hazardous materials. These hazards need to be assessed and risks mitigated as soon as possible after an event.

Consideration should be given to each of these specific materials as part of the DWMP and sites or processes identified for the treatment and safe disposal of these hazardous waste types. Procedures should also be developed as part of the DWMP that can be easily distributed to those affected post-disaster. The setting up of a single, shared Integrated Hazardous Waste Management area for the

treatment and safe disposal of hazardous wastes should also be considered, probably on a regional basis.

Environmental and human health risk decisions must be made in the context of the wider community recovery and as transparently as possible. In the absence of data and a full understanding of the risks, a higher level of uncertainty may need to be accepted and the potential effects mitigated against as far as possible.

When changing environmental and human health standards post-disaster, authorities must consider who owns the risk in the short and long term. Short and long term risk ownership should rest with the same entity, where possible. Entities are more likely to act responsibly where they have long term ownership of the risk.

To improve public perception and trust in a risk management approach, consistent standards across the recovery effort are important. Basic notification or reporting should be required for any risky activity to assist authorities in planning and monitoring. It is also important to involve the community in risk management decisions as far as practical, and in particular for activities that will be operational in the medium to long term.

3.10 Contractual and operational management

There are many different authorities and industries involved in waste management. It is important that they are all included in the planning and implementation of the disaster waste management system. Memoranda of Understanding (MOUs) should be considered between regional and local authorities to allow for a collaborative approach, agree how best to ensure recovery objectives are met, coordinate with other activities, allocate shared resources and prioritise works.

For some specific post-disaster activities formal / commercial agreements, such as stand-by contracts for emergency road clearance or urban search and rescue assistance, can be put in place as part of the DWMP process. However, it is important to appreciate that the exact disaster impact, location and nature are not known. Contracts must allow for circumstances where other entities may be better placed to provide services than those contracted.

The importance of having pro-forma contracts already in place pre-event with waste management providers has been highlighted by Charlotte Brown's studies of the response to the Christchurch earthquakes. These contract must be appropriate to deal with the expected quantum of waste potentially resulting from a disaster (particularly for an earthquake scenario) and these contracts must be in place "now".

Contract types and terms need to include recycling. This includes temporary storage area provisions and the availability of waste sorting areas. The ability of a contractor to handle particular special waste types needs to be taken into account and a clear idea is also needed of recycling and ultimate disposal options that are available via each contractor. Space availability is also an important matter when establishing pro forma contracts as part of disaster waste planning.

The following principles should be considered:

- Transparent post-disaster procurement policies need to be established.
- All existing waste collection contracts should be reviewed to allow for provisions for handling additional material after an event. Waste ownership should be appropriately incorporated into contracts. Waste ownership will be different depending on contract type.
- Regardless of the procurement strategy (and funding mechanism) contractor cash-flow must be facilitated to ensure recovery works can continue. Cost reimbursement contracts have the potential to reduce incentives for contractors to adopt risky behaviour that may be negative for environmental or human health, particularly in cases where there is a high human and environmental health hazard inherent in the waste. Cost reimbursement contracts can also simplify payment chains as service providers can directly charge the Principal (rather than the subcontractor).
- Where possible, contracts let during the emergency phase should be time-limited to allow for full procurement procedures to be followed for long term operations. Legislative provisions need to

consider procurement requirements for contracts which commence in the emergency period and endure through the recovery phase.

- All strategies need to consider how project risks should best be managed including: consequences of poor risk management; ownership of risk; incentives to minimise risky behaviour; and appropriate mechanisms to mitigate risks.
- Contract conditions can be written to mitigate risks. However due to large scale of works, the likely speed of management and the likely lower skilled workforce (due to the resource demand post-disaster) it is inevitable that the quality of the works (intentionally or unintentionally) will be lower. Therefore, regardless of the desired standards, mitigation measures need to be in place to protect people and the environment against potential negative effects. Councils may also need to accept higher risks.
- Mechanisms should be included for information gathering, to thus enable strategic planning.
- Allowances may be necessary to facilitate higher volumes of truck movements
- Generally it is better to maintain a skilled workforce on higher risk jobs as these personnel have a vested interest in long term quality of their work and should be able to identify and act where additional mitigation measures are required.

Wastes must be delineated between personal property and building materials. From the Rena example, incident response started on the day of the event itself – the waste officer was made responsible for the management of all wastes arising from the ship, including the hardware of the ship itself and the cargo units. However oil was not one of her responsibilities and that remained the domain of Maritime New Zealand. She was however responsible for “oily waste”. In broad terms she dealt with oily solid waste, oily liquid waste, general refuse and recycling opportunities for solid waste. She also dealt with the food waste from the containers but this appears to have been somewhat of a grey area in that the salvors also had an interest in the contents of containers since, under maritime law, once a salvor is formally appointed, that entity can realise any value of the cargo; i.e. can sell it or otherwise dispose of it.

3.11 Record keeping and monitoring

The current barrier to this analysis being carried out is the availability and consistency of post-disaster waste data. Development of a standard method of reporting disaster waste composition and quantities would enable future analysis and comparison between events and improve the ability to develop better waste estimation methodologies.

Information and monitoring are invaluable when planning and operating a waste management system. Record keeping is also important for managing contracts and billing. Monitoring often acts as a deterrent to illegal or improper practices.

Waste data templates should be developed as part of a DWMP. These can then be quickly rolled out post-event or form part of the pre-agreed contracts mentioned above. These should provide a record of all wastes arising, the name and address of the facility used to dispose of or recover the wastes and the waste carrier.

3.12 Public communication and engagement

Overall, there is limited understanding of the impact of disaster waste management on community recovery and/or the impact of a post-disaster communities’ behaviour on waste management programmes. Waste managers need to recognise that communities can be changed by a disaster – their expectations, risk tolerance and needs will likely have changed significantly-- and so the social relations with the community must also change. It would also be beneficial to better understand the psychosocial implications of the speed of debris removal process. For example, the desire the recover personal belongings and the emotional attachment owners often have with their properties. Understanding these factors will enable better planning of disaster waste management systems.

Consultation and communication have been consistently identified as issues in post-disaster situations: both inter and intra-organisational. Failure to adequately communicate and consult with the public (including iwi) can lead to disruption in the recovery process. Negative public reaction to waste management efforts can also lead to delays and disruptions. It is important that a disposal strategy is formed so that advice is available to people as soon as possible after an event in order to minimise delays in answering affected peoples’ key question of “what happens next?” To improve public perception and trust in a risk management approach, consistent standards should be applied across the

recovery effort. A strong communications plan should therefore be developed as part of any DWMP and this should effectively communicate the waste management strategy at the earliest possible stage..

In fact an important lesson learned from the Kaikōura earthquake event was that a necessary communication and response plan needs to be in place pre-event to deal with questions of "what happens next?" This can however be stymied or at least muted if doubts exist about lines of funding, for example, such that key questions typically asked by the community in the immediate event aftermath cannot be satisfactorily answered (see section 3.13).

It is important to involve the community in risk management decisions as much as possible and particularly where the operations will be medium to long term. However, as mentioned previously, consultation requirements may need to be stream-lined to allow for efficient and effective decision-making.

Consideration should also be given to promoting local employment in disaster waste management by way of sorting, recycling, disposal, deconstruction and recovery of property activities to allow people to remain in an area post-event.

Defining lines of communications and firmly establishing responsibilities were identified as potential areas for improvement in the Rena example. One of the 'advantages' of an oil spill over other disaster events is that there is a lead-in time before the oil reaches the shore and modelling also gives an approximate location where the oil will land and resources can be deployed to that site. The advantage in the Rena case, however, was slightly reduced because the lead-in time fell on a Sunday and the logistics of organising extra equipment and PPE were difficult because business telephone numbers on record were not being answered or were answered overseas. Having personal contact numbers for key organisations is important post-event.

From the Kaikōura experience Council worked closely with iwi, businesses, homeowners, insurance companies, EQC and local builders and demolition companies to get 'buy in'. There was also thinking around how to handle hazardous material such as asbestos, and workshops with homeowners to ensure that there was clear communication on the options available. For example, WorkSafe New Zealand held a free event for the Kaikōura construction industry, residents of the properties affected by the earthquakes and other interested parties, to provide helpful Information on:

- risks related to demolition/deconstruction/repairs of buildings
- asbestos and current requirements when handling this material
- health risks around demolition and asbestos
- what you can do to protect yourself and your workers

As reported by Brown et al (2011) as a key learning from the Christchurch earthquakes experience, it is important that the following organisations are involved, to varying degrees, in the disaster waste management planning process:

- Disaster response and recovery authority representatives
- Waste management operational representatives (likely local authority but it is important to include industry where applicable)
- Waste management industry representatives
- Environmental authorities
- Health and safety authorities
- Public health authorities
- Hazardous substance authorities and industry
- Lifeline (critical infrastructure) authorities (particularly with respect to demolition works)
- Marine authorities (for tsunami events and/or events releasing debris in the marine environment)
- Transportation authorities
- Heritage building and archaeological authorities
- Non-domestic agencies (e.g. international governmental and non-governmental groups, if any)
- Local cultural groups (iwi)
- Community representatives

Careful consideration of the requirements of iwi is also needed as a number of tapu sites may be damaged during an event and special quiet areas are required to allow the recovery of these sites to be undertaken respectfully. This was an issue of particular sensitivity that arose from the response to the Kaikōura earthquake event and was also a finding reported with respect to an analysis of responses to the Christchurch earthquakes. It is clearly the case that this cultural sensitivity issue will apply to every region in New Zealand and its recognition is important.

3.13 Funding

The overarching critical issue, as clearly proven in the immediate aftermath of the Kaikōura earthquake event for example, is that is essential in determining effective disaster waste management that lines of funding are both available and their implementation is clearly understood. Funding must be available immediately after an event (or at least guaranteed) and must be accessible as soon as it is needed. Funding for management of disaster waste may come from a range of private and public sources. It is important that those responsible for releasing funds post-disaster are identified as part of the DWMP.

Current funding mechanisms often only consider direct costs and do not consider the longer term, indirect costs, of certain debris management options, such as reduction in landfill space use, environmental impact remediation resulting from inappropriate and/or illegal dumping, limited resource recovery, etc. There is also little guidance available for disaster managers on cost assessments. Development of an approach to assess the likely direct costs of various waste management options (recycling, waste to energy, landfill disposal, land reclamation, etc.) and indirect costs of those options (slower debris removal, long term environmental degradation, etc.) would greatly enhance disaster waste managers' abilities to respond appropriately to future disasters and should be considered as part of the DWMP.

Estimates for post-disaster demolition and debris management costs need to:

- Be updated regularly
- Be priced to match the local market
- Include a post-disaster premium (due to time and/or resource constraints and recycling market changes)

The DWMP should also consider, in more detail, to what extent public funding will be provided for private property clean-up in a disaster response / recovery. As a general principle, high risk waste management activities should be managed through low risk funds. Many historical disaster events led to the local authority providing a detritus material collection service (generally via skip bins) to affected communities. If this is to be a regular post-disaster service then funding policies and adverse event budgets (whether local or national) need to be set to include this service.

The following principles should be considered as part of the DWMP (this has been taken by Charlotte Brown's research, principally into the response to the Christchurch Earthquakes):

- Funding mechanisms need to be scalable / adjustable to match the disaster scale.
- Funding mechanism policies need some flexibility to allow for effective and efficient waste management options. Funding policies should not only consider direct costs, but also environmental, social and economic effects (and must avoid perverse outcomes).
- Funding mechanisms and operational organisational strategies should be designed together to ensure systems can be effectively implemented and there are no funding gaps.
- Immediate funding to bring relief staff into an area to assist with waste management aspects of the emergency response, as well as long term funding, should be considered.
- Funding policies should include provision for data collection.
- Public funding for waste collection will be necessary where there is a high disruption to road networks.
- Where there is a high number of displaced persons and there is a desire to repopulate the affected area, public funding may be needed to ensure work on private property is completed where owners are absent.
- Where there are significant environmental or human health hazards, a publicly funded approach may be desirable.
- Communities susceptible to hazards that can cause trans-boundary movement of wastes should consider public funding mechanisms for debris management.

- Funding mechanisms that directly facilitate the waste management works are more effective at achieving recovery objectives than lump sum or reimbursement delivery mechanisms.
- If private funding approaches are preferred, mechanisms must be in place to ensure there is adequate cover across the community, including for residential, commercial and infrastructure.
- A single funding source for each property / building is preferable to avoid organisational complexities and improve recovery efficiencies.

Referring once again to the Japan earthquake disaster, this event produced such vast quantities of debris that the local municipalities would never have been able to handle the clean-up burden on their own, even during a normal period. However, the disaster debris had to be handled at a time when the local authority revenues had dropped sharply due to the reduction in economic activity and the relocation of local populations. The national government's decision to fully underwrite the costs associated with the disaster debris management has been the core factor behind the success of the disaster debris management operation in Japan, following the earthquake and tsunami.

In the USA, FEMA has introduced an incentive programme, by way of a promised increased cost share from the federal government for any future disaster debris management responses, to thus encourage municipalities to prepare their own specific plans.[3]

With respect to the Kaikōura event, no immediate funding was available to allow for skilled waste management staff to go to Kaikōura and so a 'Give a Little Fund' was set up, with funds raised going to IWK to assist them to pay the costs of getting experienced waste diversion people in to support their staff, to modify their centre to cope with damaged plant and to cope with the huge volumes of waste. Based on this experience consideration should be given to making national funding available immediately after an event to allow skilled workers to reach a site and provide assistance to local staff, where appropriate. The Territorial Authorities and Environment Canterbury have also made an application to the Ministry for the Environment for funding to provide ongoing project management assistance, noting that the additional workload associated with a project of this scale is likely to be outside the capacity of existing staffing.

3.14 Regulations

The literature includes a number of examples where legislative frameworks were a hindrance to expedient disaster waste management. As noted by Kobayahsi (1995), "the greater progress we make toward recycling and advanced waste treatment methods, the more our ability to cope with disaster decreases. Complex treatment and disposal processes with strict environmental standards are not designed for large acute influxes of materials."

Regulations govern many parts of waste management by way of environmental, public health, building and waste ownership regulations. In many cases, emergency legislation is available to waive peace-time requirements to reduce threats to life, property and the environment. However disaster waste management sits in a grey area between an immediate hazard and a longer term threat to the economic, social and environmental recovery of a disaster-struck area. Emergency laws are often not written with disaster recovery in mind. The risks or effects of changes in environmental standards are however not always well understood and exemptions should be avoided where possible.

Going through some form of consenting process will enable site specific assessments to be made with respect to waste disposal locations, either permanent or temporary. It also ensures that authorities know the activity is taking place and can maintain visibility and monitoring of activities, and can intervene with respect to emergent risks if necessary. The DWMP should consider developing draft policies on waste facilities (waste collection, waste disposal, land reclamation, waste treatment etc.) to be implemented post-disaster including, establishing approval criteria, processes and standards for handling and disposal of waste (including hazardous materials) in a disaster situation. When considering permitting exemptions in a post-disaster situation, cost implications and opportunities for misuse need to also be considered.

[3] (USEPA, 2008: "Planning for Natural Disaster Debris" in: Office of Solid Waste and Emergency Response & Office of Solid Waste (eds)).

As an illustration of regulatory response, the Japan earthquake and tsunami of 2011 generated approximately 23 million tonnes of debris along the affected coastal area. Shortly after the disaster the Japanese government implemented emergency waste disposal measures; this included time extensions over which waste could be disposed and an allowance for the dumping at sea of rotting seafood from destroyed storage and processing facilities. This was followed by a law enabling local governments outside the disaster area to accept and manage disaster waste at the national government's expense, thus opening up significant nearby resources, including areas of land, for the disposal of disaster debris. The management of debris from the earthquake and tsunami was further assisted by the formal development of public-private partnerships to establish tracts of land dedicated to acceptance of waste in large volumes from future disasters.

Japan has now formulated a basic policy for the disposal of earthquake waste and the associated minimisation of environmental impacts, with essential points as follows:

- Waste to be treated and disposed as promptly as possible;
- Temporary waste storage sites to be designated and created;
- Recycling to have the highest priority for waste management; and
- Local employment and wide-area cooperation must be facilitated in disaster waste recycling.

In the USA, federal directions (via a Senate Committee) that arose from detailed scrutiny of the responses to disaster waste management with respect to Hurricane Katrina included:

- A critical need for waste stream characterisation and proper disposal avenues to have been developed in a proactive manner. To ensure this happened the Senate Committee recommended that it be made mandatory for waste stream characterisation to enable proper sorting of waste into pre-ordained streams with subsequent disposal based on waste characteristics.
- Debris management parameters and siting of facilities to be used for disaster waste disposal. Facility siting is required to take into account natural hazards, protection of water and air resources, and with a critical and fundamental focus on protection of human health and the environment
- Preparation of regionally-based waste management plans that include sufficient disposal options, with an emphasis on the protection of the environment and vulnerable communities. Disposal capacity was specifically identified as a critical matter.

The following is a list of recommendations for NZ disaster law, standards and protocols to facilitate disaster waste management developed by Charlotte Brown, principally after analysis of the Christchurch earthquakes waste management experience.

- Consider mandating demolition or remediation of disaster-affected properties to facilitate community recovery in the event of resident non-return. Note it is unclear which existing legislation (if any) this would be included in.
- Establish waste ownership of (or procedures for) recovered materials for government sponsored private property demolition or remediation works.
- Provide greater flexibility in transportation regulations in emergencies (i.e. in situations that do not threaten life and/or property as is currently provided for).
- Delegation of authority to facilitate decision-making across waste management regulatory bodies alongside CDEM recovery coordination structures (including delegation of authority within authorities in the event of personal harm or injury).
- Establish processes for expedient certification of waste handlers (hazardous goods, etc.) and transporters.
- Identify minimum hazardous material handling, transportation, disposal or temporary storage standards in a large scale disaster including the possibility of emergency arrangements under the Basel Convention for 'export' of waste materials.
- Establish standards for disposal of asbestos in a disaster situation; these must be based on the various guidelines and safe work procedures already established by WorkSafe New Zealand.
- Review the effect of the resource consent process for medium to long term emergency / recovery activities such as disaster waste management.
- Pre-identify and enable temporary waste management sites to minimise liability potential.

- Pre-identify and enable potential disposal / treatment options which are currently outside standard waste management options (eg. land reclamation and waste incineration).
- Establish payment responsibility for government clean-up works on private property (for cases where there is not a centrally sponsored clean-up process but works are necessary to remove public health threat or danger resulting from the disaster event).
- Establish liability for long term adverse effects resulting from emergency provisions.
- Introduce emergency clauses in waste management by-laws and/or the Waste Minimisation Act.

The following should be undertaken as part of the DWMP:

- Develop a policy on post-disaster waste handling facilities (waste collection centres, temporary storage areas) including: approval criteria and process, and operational (environmental, health and safety and engineering) standards.
- Develop a policy on post-disaster waste treatment (combustion, onsite processing, temporary staging areas) including: approval criteria and process, and operational (environmental, health and safety and engineering) standards.
- Develop a policy on post-disaster waste disposal (land reclamation) including: approval criteria and process, operational (environmental, health and safety and engineering) standards), ownership and operation, payment, and liability issues.

4 Discussion of the Format and Mode of Delivery of the DWMP Tool/Template

4.1 Outline of proposed tool components and operational basis

The DWMP tool is envisaged by MWH to be fundamentally a template-based, web-supported tool with a comprehensive series of individual subject modules and, for each of these, a series of drop-down menus ("pick boxes") allowing selection of pre-populated text (in some cases) with, in other cases, the drop-down boxes being free text and allowing freedom for Disaster Waste Management Plan developers to insert their own wording.

There should also be a built-in ability to edit the existing pre-populated text if desired. As an additional component however, it must be possible to limit editing rights, lock certain sections out completely and, in general set a desired level of security on what the template-based tool will allow as outputs.

The subject modules within the DWMP template-based tool should reflect the various sub-headings and proposed content discussed above in sections 3.1 to 3.14. The tool should thus be configured on those subject lines and in that order, and with the contents broadly as described in detail in section 3 above.

A further option in some circumstances and under certain subject modules must be to have check-box options available that will produce particular paths for the DWMP content to follow, depending on the type of disaster and/or specific waste types expected to be generated. It should further be possible to map these options and present them in PowerPoint or other format; this in turn should be editable.

The entire system will, most desirably, be cloud-based as this will provide greatest flexibility and multi-user availability for the tool.

4.2 Interactions of the DWMP Tool Elements

To illustrate the DWMP tool concept using the format of a flow diagram, Figure 4-1, as set out on the following pages, has been developed. This diagram shows the components of the DWMP tool, with these divided into those elements of each that can be developed pre-disaster event and those that will be initiated post the disaster occurrence.

The content of each component is outlined in a high-level manner, with further detail to be developed as the tool itself is constructed.

Those aspects that inform several topic areas are shown as vertical bars that feed in as appropriate. It may be that further refinement of the outline model presented in Figure 4-1 will occur as the DWMP tool itself is constructed in due course.

4.3 Use of GIS overlays

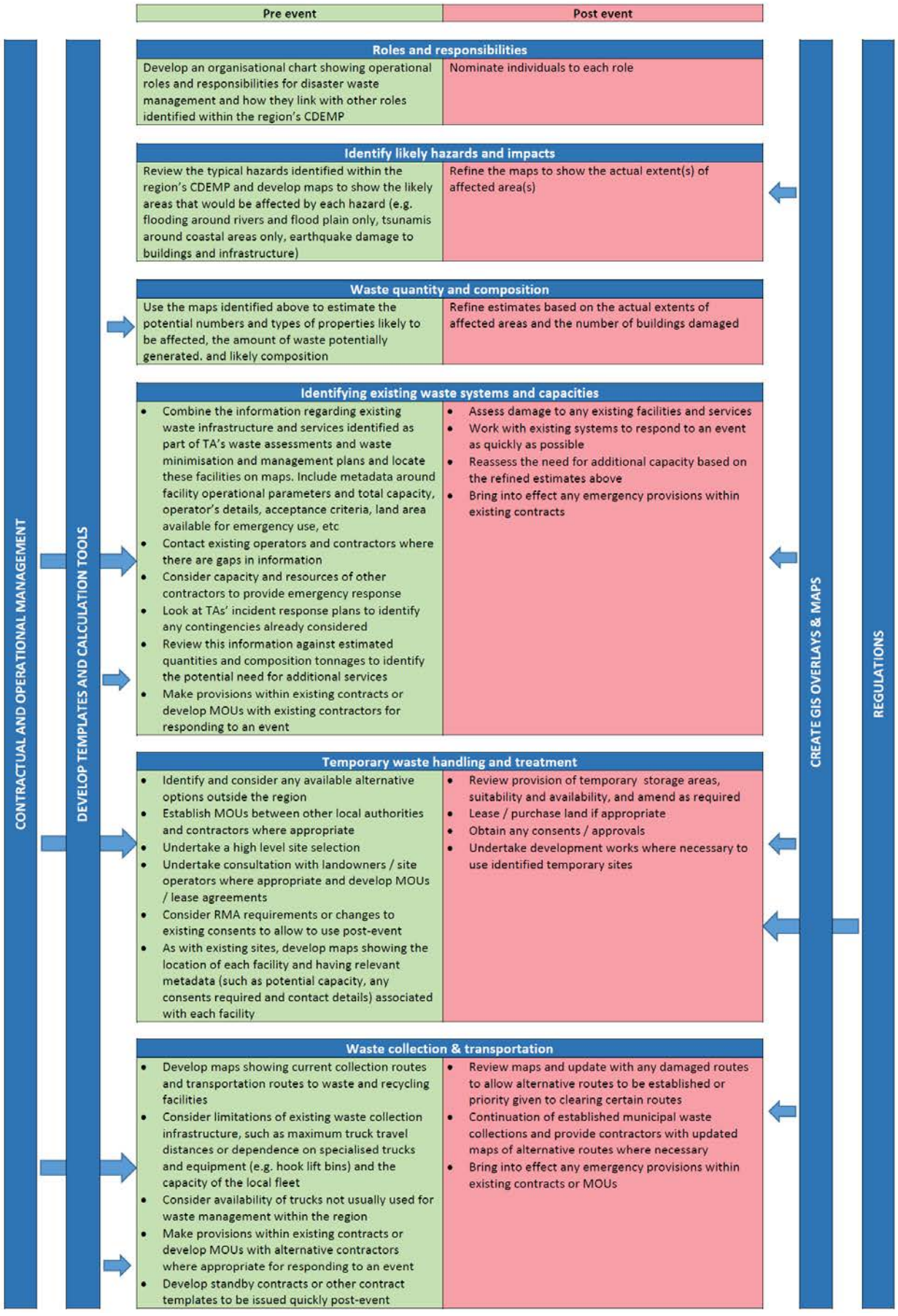
A particular element that MWH believes will be essential to the DWMP tool is the application of GIS mapping in the form of a series of hidden overlays which can be brought into play by hovering a mouse pointer over a particular icon or section of text. This approach has very broad utility and can be applied in various contexts as further described below.

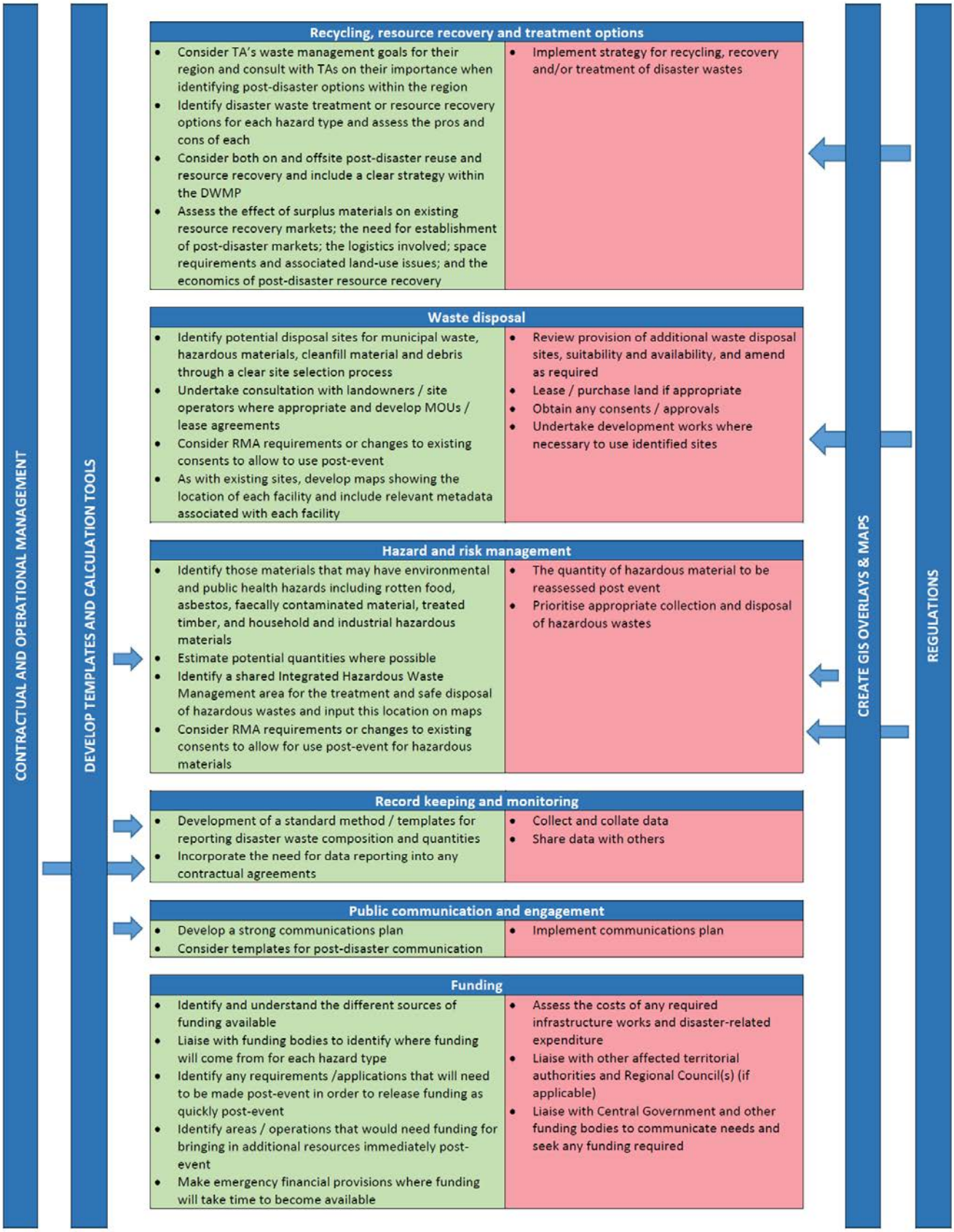
However as an initial example of how this would work in practice, it would allow the selection of, for example, the best available transport routes for disaster debris to landfill, to selected temporary storage area(s) or to sorting areas. The relevant GIS layer could be activated and, if a route to a landfill (for example) is ruled out because of earthquake damage, that route would be "greyed out" in the overlay presentation. Alternative route(s) and/or alternative landfill disposal sites that are still available and operational would appear as specific options. This could drill down to a considerable level of detail, such as available storage space at the selected landfill(s), the landfill classifications, types of waste that can be disposed therein and through to suggested routes and distances to be travelled, types of trucks that can traverse those routes, etc.

4.4 Need for MOUs with agencies that have developed key databases

This note on the utility of GIS within the template-based tool points to a related requirement where it will be necessary in building the tool to obtain, via Memoranda of Understanding (MOUs), the agreement of relevant agencies to make their databases available for interrogation by the template-based tool on an

Figure 4-1: Interactions of DWMP Tool Elements





as-required basis. Access must be immediate and ideally unrestricted. Examples of the types of database resources envisaged as being essential to support the DWMP template-based tool include the New Zealand Transport Agency (NZTA) database of New Zealand road routes, various databases of

information held by regional councils and local authorities, the CDEM database and the Meteorological Service database.

4.5 Additional important tool components

An essential output of the tool will be an ability, based on a thorough set of baseline information having been provided as input, to develop relatively detailed flow diagrams. This approach will have wide applicability, as described below.

The same general approach will be applicable to risk assessment. This lends itself well to (broadly speaking) “yes / no” answers, with the decision paths then determined by the answers given. A template configured to enable thorough risk assessment exercises to be undertaken in an intuitive way would be a valuable component of the template-based DWMP tool. The outputs could be presented graphically and/or exported to a suitable support program platform such as PowerPoint.

Another important requirement for the tool is that it must have embedded within it pro-forma contracts (or at least contract outlines) to be used to establish arrangements with waste contractors in a pre-disaster context.

Overall the intention is to have a mix of automation in the tool in that it has already pre-populated the text for various options that can selected, with the important proviso however that this text remains editable to enable particular circumstances (which are often unique) to be incorporated and dealt with. The further key elements are the ability to interact in a graphical manner with GIS overlays to provide further levels of detail with respect to operational information, the ability throughout the various modules of the tool to download the outputs for presentation and/or rework using other programs and the interaction with external information sources such as critical databases provided by other agencies, with this based on established MOUs.

4.6 Specific examples of how the proposed tool could be utilised

The following notes are not comprehensive but are inserted to illustrate examples of how the tool could operate in practice.

Roles and responsibilities

If the appropriate input details and structural roles were prepared as inputs the template-based tool could prepare, as an output, a DWMP Organisational Structure diagram which could be exported to a platform such as PowerPoint. From such a diagram any gaps or weaknesses in the structure could be delineated and further possible linkages between roles identified.

Identification of hazards and impacts

The approach here would be predicated on a drop-down menu selection of feasible disaster types in a New Zealand context, together with the expected disaster waste types arising from the realisation of such disaster events. As an adjunct to this, a GIS overlay feature could be configured to show geographically, for the whole country, the likely impact zones of particular disaster types; this would be via a hover feature over an icon or text selection.

Waste composition and quantities

Here the tool would enable, via a pick box approach, decisions to be made on which wastes should go where, which disposal sites are the best options based on available capacity, viability of transport routes, etc. This is an aspect where the input of external database information would be critical to provide up-to-date information about waste management systems, landfill capacities, etc.

Section 3.3 above and, particularly, section 3.3.3 provide details of means to establish waste quantities, compositions and how these answers would be obtained, estimated and/or calculated. Typical inputs required include access to GIS maps, LIDAR data, aerial photography, and multiple types of Council-held data on rateable properties, HAIL sites, builds usage and any other available consolidated information, ideally held on database-type platforms.

Waste systems and capacities

Listings of available disposal facilities, temporary storage sites, waste treatment and sorting areas, recycling sites, waste management contractors, hazardous waste contactors, transport operators and heavy equipment providers could be configured as an embedded database within the tool to enable

check box selection of treatment, transport and disposal requirements for particular waste types to be decided and allocated.

Maps should be developed as part of the DWMP showing the location of each facility and having relevant metadata (such as acceptance criteria, consent conditions, operational capacity, total capacity and contact details) associated with each facility.

Waste collection and transport

Again, with the assistance of the right external database information input, decisions could be made about the type and availability of transport vehicles, waste moving/loading equipment, weight limits on bridges along indicated transport routes, best routes to avoid diving on dangerous roads, etc. The ability to interrogate GIS layer information to support these types of decisions would be very important.

Temporary waste storage, handling and treatment

This general parameter would be amenable to the use of drop-down menu boxes within the tool, with each box dealing in turn with parameters for alternative disposal sites, temporary storage sites, environmental impacts and risks for each site, recycling or reuse options, capacities of the sites and the state of establishment of MOUs between local authorities and contractors. Either pre-populated text would “drop down” for each box, with this being editable, or the boxes would be free text, allowing the insertion of whatever information in a local context is appropriate.

Hazardous waste

This issue requires consideration of public health and environmental risks posed by various waste types, the disposal methods and sites available, collection options and risk mitigation measures. A suitable way of presenting this within the toll would be via a tool-generated flow diagram, exportable to a platform such as PowerPoint and then editable to produce a stand-alone succinct blueprint for hazardous waste management in the event of a disaster.

Strategic and operational management issues

This relates broadly to the availability of templatised pro-forma contracts for various formal uses within the disaster waste management structure and can be made accessible in the tool via storage of such contracts in a cloud-based platform with retrieval and editing as required prior to use. Pre-population of relevant details into the contracts would be an aspect of the way in which tis part of the tool would work. One possible means of initiating the generation of these contracts may be on a key word basis, with the insertion of such word(s) in a search box generating the relevant contract outputs.

Records systems

This aspect will be easily configured within the tool, with an added facility being to have the tool pre-populate and update the records remotely based on ongoing inputs into the various other active modules of the tool.

Communication and engagement

Information would be prepared in advance (in a general manner) pre-disaster to be activated on demand via the tool. Such a communications platform that generates outputs from available information could also be linked to other websites to obtain relevant information and edit this into press releases and the like.

Funding

Funding agencies and their contact details would be a simple part of the tool and one that would be accessible via a particular tab. Clearly this can be pre-populated and updated (refreshed) as input information is fed into the tool.

The regulatory context

The regulatory climate around disaster planning, CDEM and waste management is relatively stable and can be easily summarised as a fixed (but editable/updatable) resource within the tool. Again, a single tab could activate this regulatory information base.

As part of regulatory issues, disaster waste policies are likely to be necessary and these can be added to the template as embedded resources, as for other parameters discussed above.

5 Recommendations

This section of the report consolidates all of the various recommendations made throughout the document into one area, to allow for ease of referral by the reader.

Roles and responsibilities: The disaster waste management plan (DWMP) should be prepared based on roles and not individuals. The DWMP should clearly state where it fits within the CDEMP structure and where authority for decision making lies. A cross-organisational coordination structure is needed that ensures that the DWMP is scalable for larger disasters.

It is considered more appropriate, and commensurate with the geographical size of New Zealand, to derive individual DWMPs on a regional basis, with these being individually generated from the generic DWMP template approach that has been advocated in this report.

The DWMP needs to identify the strategic direction and associated processes required to facilitate recovery; i.e. personnel needed, roles and responsibilities of the recovery team and integration with the Business Administration Unit for each Local Authority. A clear direction is needed to delineate the operational activities and associated priorities needed in the immediate recovery phase after an event.

Identification of likely hazards and impacts: The DWMP should identify the potential areas affected by each type of disaster (e.g. flooding around rivers and flood plain only, tsunamis around coastal areas only, earthquake damage to buildings and infrastructure) and the scale of waste generation, including nature and quantities of debris that are likely to arise.

Waste quantity and composition: The collection of waste data and the importance of pre-event waste quantity estimations cannot be overstated. This sort of information allows accurate pre-planning of disaster waste responses, including transportation requirements and disposal options, both temporary and permanent. In particular, understanding the typical waste streams that could be associated with each disaster type is key to planning on how to manage these wastes.

Maps should be developed as part of the DWMP showing high risk areas following certain events. These can then be used to calculate the potential numbers and types of properties likely to be affected, and the amount of waste potentially generated.

The DWMP template should provide for easy calculation of potential waste arisings online and allow this to be refined post-disaster. After an event the template should also be able to classify the quantities of waste for each of the following phases related to the event response, as each phase has different requirements and associated time pressures; i.e.

- Emergency response (preservation of life, provision of emergency services, stabilising buildings, clearing roads etc.)
- Recovery (restoring lifelines, debris removal, building demolition)
- Rebuild (construction of major structures and houses).

Normally generated municipal waste must also continue to be managed if the disaster-affected community is still living in the area.

Existing waste systems and capacities: The DWMP should include an inventory of existing services, waste handling facilities, resources and personnel (including for hazardous materials) and this should detail the acceptance criteria and consent conditions, operational capacity, total capacity and contact details for all:

- Recycling / sorting facilities
- Waste handling facilities
- Waste treatment facilities (including for hazardous wastes)
- Final disposal facilities / end use (including cleanfills)
- Demolition contractors
- Hazardous waste contractors

- Current waste transportation operators
- Other transport operators or equipment supplies that could provide assistance in an emergency.

Maps should be developed as part of the DWMP showing the location of each waste acceptance facility, with these maps being embedded with relevant metadata (such as landfill acceptance criteria, consent conditions, operational capacity, total capacity and contact details) associated with each facility.

Temporary waste handling and treatment: Identification of potential disposal sites as part of a DWMP through a clear site selection process allows for the possible environmental impacts and risks with using each site to be considered upfront. Factors requiring consideration include space requirements, environmental factors, noise and dust, pre-disaster site identification, land-use planning issues and cost. Where possible operational management arrangements (e.g. stand-by contract), operational protocols (e.g. environmental and human health standards, payment mechanisms), environmental baseline measurements, and land use arrangements (lease and land-use consents where necessary) should all be established.

Waste collection and transportation: Waste transportation capability, including machinery inventory and location, is an essential matter that needs pre-planning and contractual consideration between contractors and persons responsible for disaster waste planning.

A DWMP needs to consider limitations of existing waste collection infrastructure. The DWMP also needs to consider and manage any potential risks associated with transportation.

The procurement of additional services and equipment should happen as quickly as possible, if necessary. This can be done by establishing MOUs between local authorities and contractors pre-event or by including disaster waste management provisions within existing collection contracts.

The DWMP should identify all collection routes and routes to disposal facilities and have the capability to assess these immediately after a disaster. Any damaged routes should be identified quickly following an event to allow for alternatives to be found or priority given to reopening certain routes as rapidly as possible.

Recycling, recovery and treatment options: A comprehensive understanding of post-disaster recycling is required. Factors such as: the effect of surplus materials on existing recycling markets; the need for establishment of post-disaster markets (e.g. environmental land remediation, land reclamation, waste-to-energy and housing reconstruction applications); the logistics involved; space requirements and associated land-use issues; and the economics of post-disaster recycling, all require further analysis in order to aid disaster planning and response.

Environmental standards, such as the extent of recycling, the use of open burning, waste acceptance criteria and disposal regulations are often reduced to expedite recovery. However, the risks or effects of changes in environmental standards need to be considered as part of the DWMP before any changes are made post-event.

Waste disposal: Alternative disposal sites should be considered as part of a DWMP. This should include both for municipal waste, hazardous wastes and cleanfill materials. Identifying these sites pre-event through a clear site selection process will allow for the possible environmental impacts and risks with using each site to be considered upfront.

Land reclamation has the potential to rapidly reduce the total volume of debris to be handled. However the long term environmental effects of using an area for land reclamation would need to be closely considered.

Hazard and risk management: Disaster waste can include numerous environmental and public health hazards, including rotten food, asbestos, faecally contaminated material, treated timber, and household and industrial hazardous materials. These hazards need to be assessed and risks mitigated as soon as possible after an event.

Contractual and operational management: There are many different authorities and industries involved in waste management. It is important that they are all included in the planning and

implementation of the disaster waste management system. Memoranda of Understanding (MOUs) should be considered between regional and local authorities to allow for a collaborative approach, agree how best to ensure recovery objectives are met, coordinate with other activities, allocate shared resources and prioritise works.

For some specific post-disaster activities formal / commercial agreements, such as stand-by contracts for emergency road clearance or urban search and rescue assistance, should be put in place as part of the DWMP process.

Record keeping and monitoring: Development of a standard method of reporting disaster waste composition and quantities would enable future analysis and comparison between events and improve the ability to develop better waste estimation methodologies.

Waste data templates should be developed as part of a DWMP. These should provide a record of all wastes arising, the name and address of the facility used to dispose of or recover the wastes and the waste carrier.

Public communication and engagement: A strong communications plan should be developed as part of any DWMP. Consultation and communication are important issues in post-disaster situations, both inter and intra-organisational.

The community should be involved in risk management decisions, particularly where the operations will be medium to long term.

Local employment in disaster waste management should be promoted by way of sorting, recycling, disposal, deconstruction and recovery of property activities to allow people to remain in an area post-event.

It is strongly recommended that the following organisations are actively encouraged to be involved in the disaster waste management planning process:

- Disaster response and recovery authority representatives
- Waste management operational representatives, both local authority and industry
- Environmental, health & safety, hazardous substances and public health authorities
- Lifeline (critical infrastructure) authorities (particularly with respect to demolition works)
- Marine authorities, for tsunami events and/or events releasing debris into the marine environment
- Transportation authorities
- Heritage building and archaeological authorities
- Non-domestic agencies (e.g. international governmental and non-governmental groups, if any)
- Local cultural groups (iwi)
- Community representatives

Funding: Funding must be available as soon as after a disaster event and must be readily accessible. It is important that those responsible for releasing funds post-disaster are identified as part of the DWMP, including contact details.

The DWMP should also delineate to what extent public funding will be provided for private property clean-up in a disaster response / recovery.

The following funding principles should be considered:

- Funding mechanisms need to be scalable / adjustable to match the disaster context.
- Funding mechanisms / policies need some flexibility to allow for effective and efficient waste management options.
- Funding mechanisms and operational organisational strategies should be designed together to ensure systems can be effectively implemented and there are no funding gaps.
- Immediate funding, as well as long term funding, should be provided for.
- Public funding for waste collection will be necessary where there is a high disruption to road networks.

- Where there is a high number of displaced persons and there is a desire to repopulate an affected area, public funding is likely to be needed to ensure work on private property is completed where owners are absent.
- Where there are significant environmental or human health hazards, a publicly funded approach is desirable.
- Funding mechanisms that directly facilitate waste management works will be more effective at achieving recovery objectives than lump sum or reimbursement delivery mechanisms.
- If private funding approaches are preferred, mechanisms must be in place to ensure there is adequate cover across the community, including for residential and commercial buildings, and infrastructure.
- A single funding source for each property / building is preferable to avoid organisational complexities and improve recovery efficiencies.

Regulations: The following is a list of recommendations for New Zealand disaster law, standards and protocols to facilitate disaster waste management.

- Consider mandating demolition or remediation of disaster-affected properties to facilitate community recovery in the event of resident non-return.
- Establish waste ownership of (or procedures for) recovered materials for government sponsored private property demolition or remediation works.
- Provide greater flexibility in transportation regulations in emergencies
- Provide for delegation of authority to facilitate decision-making across waste management regulatory bodies alongside CDEM recovery coordination structures
- Establish processes for expedient certification of waste handlers and transporters.
- Identify minimum hazardous material handling, transportation, disposal or temporary storage standards
- Establish standards for disposal of asbestos in a disaster situation
- Review the effect of the resource consent process for disaster waste management.
- Pre-identify and enable temporary waste management sites to minimise potential for liabilities
- Pre-identify and enable potential disposal / treatment options which are currently outside standard waste management options (eg. land reclamation and waste incineration).
- Establish payment responsibility for government clean-up works on private property
- Introduce emergency clauses in waste management by-laws and/or the Waste Minimisation Act.

The following policies should also be developed as part of the DWMP:

- A policy on post-disaster waste handling and waste treatment facilities (waste collection centres, temporary storage areas) including: approval criteria and processes, and environmental, health and safety and engineering standards.
- A policy on post-disaster waste disposal (land reclamation) including: approval criteria and process, operational (environmental, health and safety and engineering) standards), ownership and operation, payment, and liability issues.

DWMP review: The DWMP should include a formal procedure for regular review. This should ideally take place annually to ensure that the DWMP remains relevant and all details are up to date.

6 Summary and Conclusion

This project has set out to develop the detail required for a user-friendly and comprehensive tool for dealing with every possible context of disaster waste management planning. The literature has been exhaustively surveyed to obtain best practice examples of disaster waste management planning, both nationally and internationally and the key persons active in this area in a national context have been interviewed and their views included in the report's considerations.

Lessons learned from past events are particularly critical to the iterative process of continually refining and improving the philosophy of and practical approach to planning for waste management following disaster events.

In particular, the learnings inherent in the Canterbury earthquakes response, the Rena grounding and the recent Kaikōura/North Canterbury earthquake event have all been drawn upon in the derivation of this report.

In the international arena, the lessons learned from the Hurricane Katrina response and the 2011 Great Japan earthquake and tsunami have each provided a wealth of detailed and applicable material to support our findings and recommendations.

Ultimately, and as required by the brief for this project, we have prepared a blueprint for the content and delivery of a national tool for disaster waste management planning. The next step in this project is to use the ideas presented to prepare an operative and supported DWMP template-based tool for general use in the future for disaster events in New Zealand.

REFERENCES

Brown, C. (2012) Disaster Waste Management: a systems approach. Thesis in Doctor of Philosophy, Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand

Brown, C., Milke, M., & Seville, E. (2010a). Legislative Implications of Managing Disaster Waste in New Zealand. New Zealand Journal of Environmental Law, 14, 261-308

Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098

Brown C, Milke M., & Seville E (2011) International Journal of Integrated Waste Management, Science and Technology Paper – "Disaster Waste Management: a Literature Review Article", University of Canterbury, Christchurch, New Zealand

Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand

Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and Ministry of Civil Defence and Emergency Management

Brown C., & Milke M (2012) Waste MINZ paper – "Planning for Disaster Debris Management", University of Canterbury, New Zealand

Brown C – Paper - "Waste Management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand

Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand

Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand

Brown C, Milke M., & Seville E (2011) Resilient Organisations Disaster Waste Management Case Study: 2009 Victorian Bushfires, Australia, Research Report 2010/04

Commonwealth of Massachusetts (2013). "Municipal Comprehensive Emergency Management Plan"

Federal Emergency Management Agency, USA (2007). FEMA Guidelines

Integrated Waste Management Board, California (1997). "Integrated Waste Management Disaster Plan – guidance for local government on disaster debris management"

International Recovery Platform (2013). "The Great East Japan Earthquake 2011 – Case Studies – Recovery Status Report"

Johnston D, Dolan L, Saunders W and Glavovic B (2008). – "Disposal of Debris following Urban Earthquakes: Guiding the Development of Comprehensive Pre-event Plans". Joint Centre for Disaster Research, Wellington

Louisiana Department of Environmental Quality (2009). "Comprehensive Plan for Disaster Clean-up and Debris Management"

Luther L, Congressional Research Service (2006). Disaster Debris Removal after Hurricane Katrina: Status and Associated Issues"

Massachusetts Department of Environmental Protection (2014). "Disaster Debris Management Plan"

Ministry for the Environment (2011). "Rena: Long Term Environmental Recovery Plan"

Murdoch S (2013). "Independent Review of Maritime New Zealand's Response to the MV Rena Incident on 5 October 2011"

New Zealand Coastal Society (2014). "Rena: Lessons Learned"

Senate Committee on Environment and Public Works (2007). "Moving Forward After Hurricanes Katrina and Rita – Waste Management of Hurricane Debris"

SLR global environmental solutions (2015). "Disaster Waste Management in New Zealand – Scoping Study".

Solid Waste Association of North America (2005). "Hawaii Disaster Debris Management Plan – Final Draft: Annex VI – Best Management Practices"

Solid Waste Association of North America (2005). "Hurricane Katrina Disaster Debris Management: Lessons Learned from States and Local Governments – Briefing Report"

Swan R C (2004). "Planning for the Temporary Disposal of Disaster Debris – Where are you going to put it?" Solid Waste Association of North America

UNDP (2013). "The Haitian Experience 2010-2012 – Technical Guide for Debris Management"

UNDP (2000). Regional Management Plan for the Rubble in the Marmara Earthquake Region, Turkey – Final Report.

UNEP (2012). "Managing Post-Disaster Debris: the Japan Experience"

United States Government Accountability Office (2008). "Hurricane Katrina: Continuing Debris Removal and Disposal Issues"

UNOCHA (2011). "United Nations Disaster Waste Management Guidelines"

USEPA (2008). "Planning for Natural Disaster Debris" in: Office of Solid Waste and Emergency Response & Office of Solid Waste (eds)

World Bank (2012). "Lessons from the Great East Japan Earthquake"

APPENDICIES

Appendix A: 1st Milestone Report

Disaster Waste Management Planning – 1st Milestone Report – 18 November 2016

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Rev. No.	Date	Description	Prepared By	Reviewed By	Approved By
1	18/11/2016	Milestone Report	Kathryn Halder	Paul Heveldt	
2	05/12/2016	Milestone Report	Kathryn Halder	Paul Heveldt	

1 Introduction

This is the first Milestone Report of work done to date on the project scope, as part of MWH's contracted outputs set out below:

Milestone 1: Project Scope	Activity summary detailing key work undertaken, to include: • Scope of research • Stakeholder consultation • Case studies identified

2 Overview of the scope

The RfP document set out the key elements to be addressed as part of the scope of this project. These can be summarised as:

- Review of existing documents produced by territorial authorities and CDEM groups
- Identify and analyse two selected international DWMP examples with a view to their relevance to and potential at least partial contribution to a New Zealand DWMP template
- Review disaster waste management measures and associated lessons learned from the Christchurch earthquakes and the Rena grounding
- Identify the specific requirements for a New Zealand DWMP template
- Identify key stakeholders
- Recommend the format options and the best platform on which to host a DWMP template.

The ultimate deliverable is a comprehensive report that addresses these key elements in such a manner and in such detail as to facilitate the development of an effective generic DWMP template.

MWH is continuing to progress this project scope accordingly and we have set out a summary of the work completed to date in sections 3 - 5 below.

In brief the review of CDEM plans has shown that these plans have been primarily written to meet Local Authorities' requirements under the The Civil Defence Emergency Management Act (CDEM Act) 2002 and do not contain specific information regarding disaster waste management. Some groups have produced supporting debris management plans but many rely on the information provided by task groups set up following a disaster. MWH is continuing to review existing documents; we are currently seeking copies of any of these debris management plans and will review these further.

A wide variety of papers relating to disaster waste management have been prepared by the University of Canterbury. These provide some clear guidance on what should be considered as part of disaster waste management planning. As part of the project scope MWH intends to draw out the key recommendations from these papers and identify where there are gaps in what is currently provided.

With the recent earthquake near Kaikōura there is also an opportunity to look at whether any of those recommendations set out in University of Canterbury research papers were in place and, if so, how effective were they. This information will be combined with a similar review of the national and international examples set out in section 5.

3 Scope of Research

3.1 Research Papers Produced by C Brown

A wide variety of papers relating to disaster waste management principals, guidelines and lessons learnt have been prepared by Dr Charlotte Brown and Associate Professor Mark Milke from the University of Canterbury. These include but are not limited to:

- Brown, C. (2012) Disaster Waste Management: a systems approach. Thesis in Doctor of Philosophy, Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand.
- Brown, C., Milke, M., & Seville, E. (2010a). Legislative Implications of Managing Disaster Waste in New Zealand. New Zealand Journal of Environmental Law, 14, 261-308.
- Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098.
- Brown C, Milke M., & Seville E (2011) International Journal of Integrated Waste Management, Science and Technology Paper – "Disaster Waste Management: a Literature Review Article", University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand.
- Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and Ministry of Civil Defence and Emergency Management.
- Brown C., & Milke M (2012) Waste MINZ paper – "Planning For Disaster Debris Management", University of Canterbury, New Zealand.
- Brown C – Paper - "Waste management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand.
- Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand.
- Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2011) Resilient Organisations Disaster Waste Management Case Study: 2009 Victorian Bushfires, Australia, Research Report 2010/04

MWH has read through these papers and plans to build upon the extensive work that has already been completed to date by Charlotte and Mark, rather than trying to reinvent the wheel or regurgitate what

has already been written. MWH will draw out the key learnings and identify any gaps, where appropriate, between this work and plans produced by others or lessons learnt that have been obtained since these papers where prepared in (mostly) 2012. MWH has also met with Mark and intends to meet with Charlotte in order to identify any gaps they see in the research completed to date.

3.2 Other Reports

MWH is also keeping in mind other studies such as the 2015 SLR Global Environmental Solutions - Disaster Waste Management in New Zealand Scoping Study and will also draw out the key learnings from these studies as part of this work.

3.3 Local Authority CDEMPs and Recovery Plans

MWH has obtained copies of all of the CDEM Plans and is interrogating each of these plans in order to summarise what they say about waste management in response to emergencies and to identify any gaps.

From a first-cut it is noted that waste management is not mentioned in the majority of the CDEM Plans nor is there any framework to follow after the event of a disaster, specifically in terms of debris or waste management. Instead the plans identify the key risks to each region and set out the framework and structures to be set up and the roles and responsibilities within each centre following a disaster. Those responsible for waste management during non-event periods are then brought onto the Lifeline Utilities Group, or equivalent, to advise the Emergency Coordination Centre (ECC) or National Crisis Management Centre (NCMC) as needed. Hazardous Substances Technical Liaison Committees (HSTLC) are identified in some plans as the agency responsible to provide technical support for emergency management and for warning CDEM and the public if hazardous substances are released as a result of a disaster.

Many of the CDEMPs identify other supporting documents such as the National Civil Defence Emergency Management Plan 2015, CDEM groups Recovery Plans, and Welfare Group Plans which MWH is currently investigating.

A full list of the reviews completed to date is provided in Appendix A

3.4 Other Organisation Emergency Management Plans

Whilst reading through the CDEMPs and other reports MWH has come across reference to other emergency management plans; for example, the Maritime New Zealand National Marine Oil Spill Contingency Plan, the Ministry of Civil Defence & Emergency Management “Focus of Recovery – A holistic framework for recovery in NZ” and Police Emergency Management Plans. Where good direction is provided by others in respect to specific materials MWH will make reference to these so that future disaster waste management plans can direct the user to this guidance, rather than having to cover off every event themselves.

3.5 International Examples of Debris Management Plans and Disaster Waste Management Guidelines

A number of examples of debris management plans and disaster waste management guidelines have been identified and obtained. These have yet to be analysed in any detail but relevant matters will be distilled from these plans and considered in a New Zealand context.

4 Stakeholder Consultation

The project emphasis continues to be on establishing contacts within the key stakeholders, including Councils, CDEM groups, Government Agencies with interests in part of or the whole of the topic, contractor providers of waste management services, etc. In some cases the correct (or best) person to contact is still to be identified as, even within organisations, it is not always clearly understood who holds the ultimate responsibility.

A list of stakeholders is provided in Appendix B.

The interaction with stakeholders in this project is not being viewed as consultation as such but rather as a one-on-one information gathering exercise from individual Council or Stakeholder contacts. If certain stakeholders are not interested in providing information or making other contributions to the project they will be removed from further consideration. It is believed that there will be enough interest to successfully canvass the issues across a broad enough cross-section in number terms of those who are interested.

With the recent earthquake event near Kaikōura MWH staff have been requested to provide assistance to Kaikōura District Council as its infrastructure recovery manager. The activities include:

- understanding the scope of damage
- drafting various commissions for inspection and reporting,
- meeting insurance representatives,
- aggregating the various costs,
- preparing claims
- working with funders, etc.

This work also includes developing standards, considering effects on affected parties, getting approvals from council, liaison with government departments and other agencies, and being part of the overall recovery team. It will also involve developing a solid waste plan of action including provisions for the disposal of material etc. This first-hand experience will be drawn upon (as well as that from others involved in the recovery process in either Kaikōura or Wellington) and used to provide feedback to this project on what worked well and what could have been improved. It is also indented to identify if any of the recommendations set out in University of Canterbury research were in place and, if so, how effective were they.

Given the relevance and importance of their previous work on this subject Mark Milke and Charlotte Brown will also be contacted for a face-to-face meeting in the near future to discuss their views on the issue. Although their collective thinking is well set down in their several papers on the matter, they clearly can provide some valuable specific inputs to aid us in the project.

5 Case Studies

5.1 New Zealand-Based Case Studies

For the New Zealand-based case studies the approach is to discuss and dissect the key elements of each case, including the successful aspects and those DWM elements that were not so successful. It is proposed to focus on the Rena grounding and the Christchurch earthquake as, for both examples, there is a large body of information, review data, reports and other analysis that can be used to draw conclusions about successes, shortcomings, unexpected issues and various other lessons that can be considered and incorporated into better plans and systems for the future, and within the New Zealand regulatory context.

5.2 International Case Studies

5.2.1 Overview

In selecting suitable international case studies about disaster waste management for consideration in this project it was decided that the case studies should firstly be chosen on the basis of reflecting disaster types that were likely to occur in New Zealand. Thus scenarios such as nuclear power plant failures, for example, were not considered.

The selected cases focus respectively on:

- Earthquake (and tsunami)
- Floods / storms

A further key point was that the disaster scale should be such as to generate waste quantities and types that caused significant problems for disposal. It was considered that this in turn would result in reviews, policy adjustments and, particularly, documented improvements in future disaster waste management planning that took account of the shortcomings revealed about the manner in which governments and regulators reacted. Further, the deficiencies in infrastructure and planning for dealing with the quantities of waste needing to be sorted, stockpiled, managed, transported and disposed following a disaster was another issue likely to be considered in detail in subsequent reviews of disaster responses. In short, the case study examples required an extensive body of associated literature that documented and critically analysed the details of the responses, if they were to be of maximum utility to this study.

Accordingly, the Japanese earthquake and tsunami and Hurricane Katrina are the two case studies that have been selected.

5.2.2 Japan earthquake and tsunami, 2011

The Japan earthquake and tsunami of 2011 was chosen as it combines the impacts of both disaster types and was of a globally significant scale. There is a large amount of detailed information analysing the approaches to and failures of post-disaster waste management for the 2011 Japan earthquake event. In addition, the language barrier has not turned out to be an issue as many international agencies have prepared reports on the DWM issues for this event and these reports are in English.

The information obtained to date covers a wide range of DWMP issues and responses. Not all is directly relevant to New Zealand but there is sufficient information to generate a comprehensive case study that includes things that went well in terms of DWM matters and matters that did not (including identified problems to avoid).

The earthquake and tsunami generated approximately 23 million tonnes of debris along the affected coastal area. Shortly after the disaster the Japanese government implemented emergency waste disposal measures; this included time extensions over which waste could be disposed and an allowance for dumping rotting seafood from destroyed storage and processing facilities at sea. This was followed by a law enabling local governments outside the disaster area to accept and manage disaster waste at the national government's expense, thus opening up significant nearby resources for the disposal of disaster debris. The management of debris from the earthquake and tsunami has been further assisted

by the formal development of public-private partnerships to establish tracts of land dedicated to acceptance of waste in large volumes from future disasters.

Particular prefectures have also developed their own disaster waste management plans, for example focusing first on protection of public health by dealing with temporary sewage disposal as a first priority and with this taking precedence over hard debris management. Systems for separating, processing and recycling disaster waste have also been set up, in cooperation with local businesses, so that there is an ultimate economic benefit to the community. Goals setting and timeframes have also been included as key drivers of these plans in various Japanese prefectures. Post-disaster needs assessment has also become a particular focus for changes in disaster management planning, with sharing of information between the public and private sectors considered to be essential to initiatives aimed at swift disaster response and smooth recovery and reconstruction.

5.2.3 Hurricane Katrina, USA, 2005

For the second category of floods/storms there was initial uncertainty as to whether the focus should be on a single event or whether the subject should be covered more generally. There is a vast amount of information on the DWM responses to Hurricane Katrina in the US and this event was therefore chosen as the second case study. Katrina dates back to 2005 but the lessons learned are not time-dependent and may be actually the better for having been considered over time. There are still literature papers being published 10 or more years after the event about the response to Katrina; in other words, the analysis has not stopped and is seemingly being refined all the time.

One of the most significant identified shortcomings in the response to waste management with respect to Hurricane Katrina was the lack of effective debris waste management capability and planning. This resulted in ad hoc disposal (some of which generated significant and long-lasting environmental impacts), inappropriate disposal endpoints for certain waste types (e.g. infectious wastes improperly disposed) and various other problems all stemming from the lack of a coherent and coordinated debris disposal approach.

The upshot has been a strong emphasis on disaster management planning. The lessons of Hurricane Katrina in this regard do seem to have had a significant degree of uptake by other US states and/or city jurisdictions. Consequently there is a considerable volume of information to be analysed, both for the Hurricane Katrina response itself and the impact of that disaster on debris management planning elsewhere in the United States.

6 Next Steps

Milestone 2: Interim Report	Report which details the findings so far, and; • Identifies any gaps, • Identifies learnings, • Preliminary indication of what a tool might look like. • Strategic direction for completing the Final Report

APPENDIX A CDEM Reviews

NATIONAL CDEM STRATEGY VISION and GOALS

Resilient New Zealand - Communities Understanding and Managing Their Hazards and Risks

Goal One:
- Increasing community awareness, understanding, preparedness and participation in Civil Defence emergency management.

Goal Two:
- Reducing the risks from hazards to New Zealand.

Goal Three:
- Enhancing New Zealand's capability to manage Civil Defence emergencies.

Goal Four:
- Enhancing New Zealand's capability to recover from Civil Defence emergencies.

Name of CDEMP	Marlborough MCDEM Plan 2011 – 2016
Date written	30 August 2011 Effective from 3 June 2011 Currently being revised
Local Authority Areas	Marlborough District Council
Website	http://www.marlborough.govt.nz/Services/Emergency-Management/Civil-Defence.aspx

Vision for the Plan

"Improve the resilience of the region to all foreseeable emergencies through the active engagement of communities and the effective integration of support agencies."

Goals
- Goal 1 - to co-ordinate efforts to reduce the risks posed by hazards that threaten the life, wellbeing, infrastructure, economic fabric and ecological systems that support the lifestyle of the area.
- Goal 2 - to promote an awareness of the remaining risks faced by residents and visitors to the region in order to be better prepared for the risks of known hazards.
- Goal 3 - to enhance the efficiency and effectiveness of all agencies and the community in their response to an emergency through integrated and co-ordinated effort.
- Goal 4 - improve the process of recovery after an event in order to return to normal life as quickly as possible with a minimum of loss and disruption.

Summary

Marlborough recognises there are issues surrounding the disposal of waste following electrical power failures, earthquake, epidemics and other natural hazards. They have highlighted the need to develop resilient infrastructure particularly from 'wet' processing as well as developing strategies to deal with the large costs associated with the repair and clean-up of sewage effluent. The impacts of dealing with the disposal and treatment of large amounts of general waste, chemical waste and rubbish following a tsunami, storm or flooding event have also been documented.

Civil Defence Emergency Management Groups have the responsibility for disposal of carcasses (if deemed necessary). However there are no frameworks or legislative processes to follow after the event of a disaster regarding waste disposal/waste management.

Risks Identified

The following hazards were considered.

1. Earthquake - A large earthquake was considered the greatest threat to the region
2. Biological pests and organisms - The biological threats were assessed as the next greatest risk and subdivided between human pandemic and the emergence of virulent disease or alien pest species in the non-human environment.
3. Tsunami - The threat of tsunami was included in the risk assessment for earthquake
4. Flooding - Climate change will manifest itself as more extreme weather that will also increase the occurrence of flood, drought and fire events.
5. Animal Disease Epidemics
6. Drought
7. Rural Wildfires
8. Strong Winds - wind gusts over 180 km/h can be expected at least once every 50 years over most of the Wairau Valley and Marlborough Sounds.
9. Coastal Erosion
10. Human Disease Epidemic
11. Electrical Power Failures - most power is imported into the Marlborough region through two routes only
12. Telecommunication Failure
13. Marine Transport Accident
14. Rail Transport Accident
15. Air Transport Accident
16. Wastewater System Failure
17. Municipal Water Supply Failure
18. Urban Fire
19. Hazardous Substance Spillage
20. Civil Unrest

Reference made to disaster waste management	Page Number
Concerns about forest and horticultural responses to earthquake, could incur large-scale problems of disposal of infected material.	88
The impacts of dealing with the disposal and treatment of large amounts of general waste, chemical waste and rubbish following a tsunami, storm or flooding event.	91 + 93
Environmental concerns following an animal disease epidemic. Disposal of large amounts of meat and/or milk	94
Council operates wastewater treatment and disposal systems to protect both the health of the community and the physical environment	107
Civil Defence Emergency Management Groups responsibility for disposal of carcasses (if deemed necessary)	Page 13 - Appendix 5

This plan is currently under review and a draft Marlborough CDEM Group Plan 2017 – 2022 has been produced. Waste management is not directly mentioned in the new 2017-2022 Draft Marlborough CDEM Group Plan

Reference made to disaster waste management	Page Number
Hazard Consequence: Trade waste discharges. Wastewater has only been addressed in the plan.	94

Name of CDEMP	Bay of Plenty CDEM Group Plan 2012-2017
Date written	Adopted by CDEM groups August 2012. Revised May 2013
Local Authority Areas	Bay of Plenty Regional Council Kawerau District Council Opotiki District Council Rotorua District Council Tauranga City Council Western Bay of Plenty District Council Whakatane District Council
Website	http://bopcivildefence.govt.nz/

Vision for the Plan

"A resilient Bay of Plenty: communities understanding and managing their risks."

Goals:

- Goal 1: Reducing risk from hazards in the Bay of Plenty to acceptable levels
- Goal 2: Increasing community awareness, understanding, preparedness and participation in Civil Defence Emergency Management.
- Goal 3: Ensuring an effective response capability
- Goal 4: Ensuring an effective recovery capability
- Goal 5: Robust monitoring and evaluation

Summary:

The Bay of Plenty CDEM Group Plan has highlighted the importance of dealing with potential hazardous chemical emergencies because of the presence of large-scale industrial sites (I.e. the Port of Tauranga, Kawerau mill). There is however, no mention of how waste could be disposed of and/or managed in the current plan. Those responsible for the disposal of waste are also not mentioned. The BOP Regional Council has acknowledged the benefit of clear and concise guidance documents to assist those involved in emergency response scenarios (i.e. Rena).

Risks Identified

The following Higher priority hazards where considered.

1. Flooding, Rangitaiki R. (Whakatāne & Opotiki)
2. Coastal Storm
3. Animal disease epidemic
4. Volcanic eruption – local
5. Human disease –pandemic
6. Biological pests & new organisms
7. Wildfire/rural fire
8. Tsunami – local & distant
9. Major air accident – Rotorua
10. Earthquake

Moderate priority hazards included:

1. Coastal erosion
2. Heavy rainfall
3. Electrical failure
4. Civil unrest/terrorism

Lower priority hazards included:

1. Hazardous substance release
2. Telecommunications failure
3. Geothermal
4. Volcanic eruption distal – ashfall
5. Oil tanker fire at berth
6. Marine accident - cruise liner

Reference made to disaster waste management	Page Number
Regional infrastructure includes waste disposal as part of the 2.2 > Built Environment > Infrastructure Business. “The management of these regional resources is spread across a number of utility operators, local authorities and Crown agencies.”	8

Name of CDEMP	Canterbury CDEM Group Plan 2014
Date written	June 2014
Local Authority Areas	Christchurch City Council Environment Canterbury Ashburton District Council Hurunui District Council Kaikoura District Council MacKenzie District Council Selwyn District Council Timaru District Council Waimakariri District Council Waimate District Council
Website	http://cdemcanterbury.govt.nz/

Vision for the Plan

A resilient Canterbury — Waitaha Tukaha - A resilient Canterbury will exist when communities have reduced their risks, increased their readiness, and are ready to respond to and recover from any emergency.

Goals:

Collaboration

- Community leaders demonstrate their commitment to collaboratively build and maintain resilience.
- Everybody accepts their responsibility for reducing risks to acceptable levels.
- Decisions about how best to manage risks are made in a way that contributes to the overall sustainable development of communities.
- Emergency management planning is integrated into everyday decision making.
- Responses to emergencies are timely, well-coordinated and effective.
- Emergency recovery capabilities are well developed, resourced and delivered.

Community

- Communities recognise the need to invest time and resources in building and maintaining resilience.
- There is a strong community spirit, where communities work together to ensure their safety and resilience.
- The risks we face are well understood within all communities and organisations.
- Businesses have well-rehearsed business continuity capabilities that safeguard their people, the services they provide, and their business income
- Residents and visitors know how to help each other in the event of an emergency.
- The critical role that emergency management plays in ensuring community safety and prosperity is recognised.

Summary:

Waste pollution is identified under the Natural Environment Task Group. The definition of lifeline utilities in Canterbury has been broadened to include other essential services such as fast-moving consumer goods and solid waste. There is national support for solid waste to become a formally adopted lifeline utility, but this is yet to occur.

It is also noted that "*All the designated lifeline utilities organisations listed are invited to be involved in the Canterbury Lifeline Utilities Group and its activities. Because membership is voluntary not all listed organisations are currently active in this group. Other organisations, including contractors, consultants and emergency services involved or interested in lifelines resilience and response are encouraged to participate in the Lifeline Utilities Group.*"

There is no detail within the CDEMP on how waste or debris are to be managed following a disaster.

Risks Identified

High-Priority Hazards identified include:

1. Earthquake
2. Tsunami (local or regional source)
3. Human disease pandemic
4. Flooding (including dam failure)
5. Electricity failure
6. Disruption to fuel supply
7. Telecommunications failure
8. Offshore marine/port incident
9. Drought

Medium priority hazards include:

1. Animal disease epidemic
2. Biological pests and new organisms
3. Fire at the rural/urban interface
4. Water supply failure
5. Wastewater failure
6. Large urban fire
7. Heavy snow and ice
8. High winds
9. Electrical storms
10. Land instability
11. Hail
12. Volcanic eruption ash fall or disruption to air travel

Lower priority hazards include:

1. Hazardous substance release
2. Major road accident
3. Major rail accident

Reference made to disaster waste management	Page Number
Lifeline Utilities: There is national support for solid waste to become a formally adopted lifeline utility, but this is yet to occur.	92
Designated Lifeline Solid Waste Utilities have been identified as; • Transwaste Canterbury (operator of Kate Valley landfill), • Kaikoura landfill, • Redruth landfill, Timaru, • Transpacific Waste Management and • Living Earth Ltd (operators of the organics processing plant in Christchurch) • A range of kerbside collection and other contractors operating solid waste activites for council	92 & 93

Name of CDEMP	Gisborne CDEMP
Date written	December 2009
Local Authority Areas	Gisborne District Council
Website	http://www.gdc.govt.nz/civil-defence/

Vision for the Plan

"Resilient Tāirawhiti - Communities understanding and managing their hazards and risks"

Goals:

- Promoting robust reduction activities that reduce the risks from hazards to Tāirawhiti.
- Communities that understand, are prepared and participate in Civil Defence emergency management.
- Enhancing the CDEM Group's ability to manage emergencies in Tāirawhiti.
- Enhancing the CDEM Group's ability to recover from emergencies in Tāirawhiti.

Summary:

It is stated that it is the responsibility of Territorial Authorities to oversee the management of disaster waste. However there is currently no specific local level management plan noted.

The Co-ordinating Executive Group (CEG) has been created in fulfilment of the Civil Defence Emergency Management (CDEM) Group's obligations under section 20 of the Civil Defence Emergency Management Act 2002 (the Act); it is responsible for the recovery phase following disaster. The following organisations are members of the Coordinating Executive Group: NZ Fire Service, Gisborne District Council, NZ Police and Tāirawhiti District Health Board ((Hauora Tāirawhiti).

It is stated that the CEG should ensure the development of processes, including the issuing of consents, for identified functions, e.g. disposal of 'waste' and carcasses following a disaster. It does not however say how they will do this.

Risks Identified

- **Tsunami -** The entire coastline of the Gisborne District is subject to tsunami from a distant or local source.
- **Drought -** The present region's climate trends towards seasonal droughts rather than long-term conditions that cause severe problems.
- **Flooding/Ponding -** The East Cape has a history of "hits" from decaying tropical cyclones causing widespread disruption and flooding. There are also other events that are more localised and result from weather systems dumping large volumes of rain over a small area.
- **Volcanic Activity -** Ash fallout has the potential to be the most disruptive disaster in the District.
- **Earthquake** - The Gisborne District is in close proximity to a major tectonic plate boundary. This boundary runs parallel to the coast about 60 to 90 kilometres offshore.
- **Erosion** - The Gisborne District is geologically unstable and, apart from earthquake impacts, intensive rainfall can cause landslip and deep-seated erosion.
- **Biosecurity** - Pest organisms arriving in the region may impact on economic, environmental, socio–cultural and human health values.
- **Human Pandemic**
- **Information Systems Failure and power loss**
- **Financial Crisis** - Recent global events suggest there is still potential for a financial crisis to occur.

Reference made to disaster waste management	Page Number
Hazards identify the potential for: Large volumes of debris contribute sediment to watercourses and inundation of valuable alluvial flats downstream.	25 & 26
Gisborne District Council - Has primary responsibility for managing a declared state of local emergency, all rural fires that occur in its area, tier 2 marine oil spills and specified hazardous substance incidents. It also has major co-ordination roles in non-declared events (see Adverse Event Plan), rural fires "owned" by other authorities, tier 1 and 3 marine oil spills and hazardous substance incidents it is not responsible for. The Fire Service is also responsible for making accident sites safe from fire or dealing with the risk to life from hazardous chemicals, prior to any other response requirements.	52
The CEG should, pre-event, ensure that the following measures are in place: • The development of processes, including the issuing of consents, for identified functions, e.g. disposal of 'waste' and carcasses.	61
In the plan it is stated that while a state of emergency is in force in its area, a Civil Defence Emergency Management Group may carry out or require to be carried out all or any of the following: i. works: ii. clearing roads and other public places: iii. removing or disposing of, or securing or otherwise making safe, dangerous structures and materials [wherever they may be]: iv. Undertake emergency measures for the disposal of [the dead] [dead persons or animals] if it is satisfied that the measures are urgently necessary in the interests of public health.	76
Hazardous Substance Incident Co-ordinator	85 - 90

Name of CDEMP	Hawkes Bay CDEM Group Plan 2015
Date written	March 2015
Local Authority Areas	Hawkes Bay Regional Council Napier City Council Central Hawkes Bay District Council Hastings District Council Wairoa District Council
Website	www.hbemergency.govt.nz

Vision for the Plan

"A Resilient Hawke's Bay Community - He Aumangea Hapori ki Te Matau a Māui"

Goals:

- **Reduction**- Local communities work together to reduce the risk of hazards.
- **Readiness** - People and communities provide for their own safety and well-being.
- **Recovery** - Communities and organisations are capable of recovering from an emergency in an effective and efficient manner.
- **Response** - Response agencies prepared to provide a timely, well-coordinated and effective response to an emergency.

Summary:

Waste management is not directly mentioned in the Hawkes Bay CDEM Group Plan nor are there any frameworks or legislative processes to follow in the event of a disaster.

Hawke's Bay has a number of active groups/ committees which are supported by the CDEM Group including: Welfare Coordination Group (WCG), Emergency Services Coordinating Committee (ESCC), Hazardous Substances Technical Liaison Committee (HSTLC), and the Intercom Group. The Hawke's Bay Engineering Lifelines Group has recently been re-established. The HBELG is made up of Lifeline Utility Operators as defined under the CDEM Act 2002 (e.g. power, water, sewerage, roads, communications and gas providers) and operating in the Hawke's Bay. The purpose of this Group is to plan and coordinate the restoration of key infrastructure as soon as possible during and after an event.

Risks Identified

Top 10 hazards in Hawke's Bay have been identified as:

1. Earthquake
2. Tsunami
3. Volcanic (ashfall)
4. Human Pandemic
5. Flood/Storm Event
6. Animal Epidemic, Plant & Animal Pests
7. Urban Fire (Multiple)
8. Lifeline Failure
9. Rural Fire
10. Hazardous Substances Event

Reference made to disaster waste management	Page Number
The HSTLC was established by the NZ Fire Service to develop and maintain key relationships, and provide technical advice during a hazardous substances emergency.	76

Name of CDEMP	Manawatu – Wanganui Region CDEM Group Plan 2016 -2021
Date written	June 2016
Local Authority Areas	Horizons Regional Council Palmerston North City Council Horowhenua District Council Manawatu District Council Rangitikei District Council Ruapehu District Council Tararua District Council Whanganui District Council
Website	http://www.horizons.govt.nz/flood-emergency-management

Vision for the Plan

"A Resilient Regional Community"

Goals:

- Strategic Goal 1: Where possible, reducing the risks from hazards to acceptable levels.
- Strategic Goal 2: Our communities are aware of their hazard scape, are prepared and empowered to respond to and recover from an emergency.
- Strategic Goal 3: Agencies are aligned, prepared and able to provide an effective response to an emergency.
- Strategic Goal 4: Communities and agencies can effectively recover from an emergency

Summary:

The management of disaster wastes or debris is not directly mentioned in the CDEMP nor is it included in the Horizons One Plan – Manawatu – Wanganui Region.

Waste pollution is included within the Natural Environment task group and Lifeline Utilities within the Built Environment task group. The role of the Task Groups at all levels is to act as advocates for and provide support to specific sectors (such as welfare services as a part of the social environment), and advice to recovery offices. Task Groups also play an important role in ensuring co-ordination of activities at local, group and national levels.

Risks Identified

The following Hazards have been identified for the Manawatu-Wanganui Region.

Natural hazards	Human-made hazards	Biological Hazards
• Earthquake • River flooding • Volcanic • Tsunami • Landslides • Coastal flooding and erosion • Droughts • Severe winds	• Lifeline utilities failure • Electricity failure • Transportation failure • Civil services failure • Dams – water supply and flood detention • Rural fire • Urban fire	• Human disease • Animal disease • Plant/Pest disease

• Severe storms	• Hazardous chemical incidents • Transportation accidents • Civil unrest • Terrorism	

With the Top 10 hazards identified as:

1. Severe Earthquake
2. River flooding
3. Tsunami
4. Human Pandemic
5. Drought
6. Animal Epidemic (Foot & Mouth)
7. Landslide - Widespread hill country
8. Volcanic Activity (Ruapehu)
9. Landslide - Manawatu Gorge
10. Rural Fire (Wildfire)

Reference made to disaster waste management	Page Number
Waste pollution is included within the Natural Environment task group and Lifeline Utilities within the built environment	66
Hazardous chemical incidents - Significant quantities of hazardous materials are transported within and through the Region by road and rail; however the occurrence of hazardous chemical incidents within the region is low. Significant land-based spills have the potential to impact upon human life and safety, contamination of the environment, disruption to land transport and community activities and evacuation.	28

Name of CDEMP	Auckland Council CDEM Group Plan 2011-2016
Date written	30 June 2011 to be reviewed in 2016
Local Authority Areas	Auckland City Council
Website	http://www.aucklandcivildefence.org.nz/

Vision for the Plan

A Resilient Auckland - A resilient Auckland will be able to quickly adapt and continue to function at the highest possible level during extraordinary events.

Goals:

- Goal 1 - Reducing risk to acceptable levels
- Goal 2 - Increasing community awareness, understanding, preparedness and participation in civil defence emergency management
- Goal 3 - Ensuring an effective response capability
- Goal 4 - Ensuring an effective recovery capability

Summary:

Waste management is not directly mentioned in the Auckland Council CDEM Plan nor are there any frameworks or legislative processes to follow after the event of a disaster.

In an emergency, the Emergency Coordination Centre (ECC) works closely with the National Crisis Management Centre (NCMC) reporting and coordinating activities with central Government through this facility. The Hazardous Substances Technical Liaison Committee (HSTLC) is identified in the plan as the agency responsible for providing technical support for emergency management and warning CDEM and the public if hazardous substances are released as a result of a disaster.

Risks Identified

Hazards Requiring Auckland CDEM Group Management

Natural Hazards

- Animal disease/epidemic
- Cyclone
- Drought: agricultural or water supply
- Earthquake
- Erosion: coastal cliff, landslide or land instability
- Flooding: river/rainfall, storm surge, tsunami (distant or local)
- Human epidemic
- Introduced species/pests
- Tornado
- Volcanic eruption: Auckland volcanic field or distant source

Technological Hazards

- Crash: aircraft, marine, rail, road
- Criminal acts: civil unrest/riot or terrorism
- Dam failure
- Fire: rural or urban
- Hazardous substance spill

- Lifeline utility failure: airport, communications, electricity, fuel, gas, port, roading, wastewater or water supply

Reference made to disaster waste management	Page Number
Lifeline Utility Failure: Wastewater and fuel - Likelihood: Possible, Consequence: Moderate, Risk Rating (Risk x Consequence): Moderate	20
Hazardous Substance Spill – Considered High Hazard Prioritization	21
Hazardous Substances Technical Liaison Committee (HSTLC) - is the agency which provides technical support for emergency management and is responsible for warning CDEM and public	32 + 39
There is currently no mention of waste management/who is responsible in the Response phase in the Auckland Council CDEM Group Plan.	41-42
Emergency Coordination Centre (ECC): In an emergency, the ECC works closely with the National Crisis Management Centre (NCMC) reporting and coordinating activities with central Government through this facility.	42-42

Name of CDEMP	Wellington Region Civil Defence Emergency Management Group Plan
Date written	1 July 2013
Local Authority Areas	Greater Wellington Wellington City Council Hutt City Council Porirua City Council Upper Hutt City Council Carterton District Council Kapiti Coast District Council Masterton District Council South Wairarapa District Council
Website	http://www.getprepared.org.nz/

Vision for the Plan

"A resilient community, ready and capable" - Resilient communities are ready for emergencies and have the knowledge, skills, resources and relationships to respond to and recover from an emergency event.

Goals:

- Goal 1: Our communities are prepared, empowered, connected and able to respond and recover from an emergency.
- Goal 2: CDEM activities are integrated and coordinated across each of the 4 R's
- Goal 3: Risk management is conducted collaboratively across the region
- Goal 4: A flexible and principle-based approach is applied to recovery

Summary:

Waste and pollution is included within the Natural Environment task group and Lifeline Utilities within the Built Environment task group. The CDEMP refers to Debris Disposal Guidelines for the region as a supporting document to this plan.

Risks Identified

Hazards identified as requiring CDEM Group management

- Earthquake
- Flooding (rivers)
- Tsunami (distant, regional and local)
- Storm (e.g. high winds, storm surges)
- Landslide
- Drought
- Volcanic eruption
- Human pandemic
- Animal pandemic
- Lifelines utility failure
- Hazardous substances incident (including
- radioactive substances)
- Transport accident
- Terrorism

- Fire

Reference made to disaster waste management	Page Number
Man-made hazards are a result of human activities such as infrastructure failures and hazardous substances.	10
Goal #2: CDEM activities are integrated and coordinated across each of the 4 R's (3.3) To actively monitor, evaluate and address gaps in current and future planning. (3.3.3) Develop plans to address existing gaps in capability e.g. debris disposal.	35
Appendix 3: Supporting Plans - Debris Disposal Guideline	60

Name of CDEMP	Nelson Tasman Civil Defence Emergency Management Group Plan
Date written	2012
Local Authority Areas	Nelson City Council Tasman District Council
Website	http://nelsontasmancivildefence.co.nz/

Vision for the Plan

"A resilient Nelson Tasman Community"

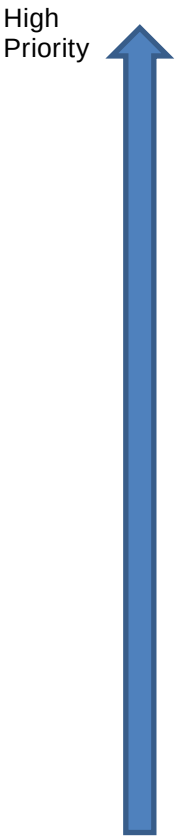
Goals:

1. Reduced Impact from Hazards
2. Individual and Community Self Reliance
3. Effective Response and Recovery Capability

Summary:
Generally sets out roles and responsibilities following a disaster rather than providing specific detail. Waste pollution is included within the Natural Environment task group and Lifeline Utilities within the Built Environment task group. The Task Groups will be comprised of advisors and liaison personnel from lifeline utilities, government departments, community groups, the insurance industry, health agencies and any other appropriate organisations to assist the Recovery Manager and provide multi-agency input into management decisions.

Risks Identified

- Earthquake - Alpine Fault
- Earthquake - Regional (e.g. White Creek Fault Murchison)
- Earthquake – Waimea / Flaxmore Fault
- Human Pandemic
- Local tsunami
- Electricity - infrastructure failure
- Fuel supply - infrastructure failure
- Plant & Animal Pests / disease
- Dam break
- High winds
- Slope Failure - Large scale
- Drought
- Communications / Information systems - infrastructure failure
- Large catchment flooding
- Coastal inundation (storm surge / tidal effects)
- Wastewater - infrastructure failure
- Snow
- Rural Fire
- Slope Failure - Small scale
- Urban Fire
- Water supply - infrastructure failure
- Civil Unrest / Criminal activities / terrorist attack
- Distant tsunami
- Coastal erosion
- Air Transport Accident
- Roading Transport Accident
- Small catchment flooding
- Surface ponding (localised flooding)



Reference made to disaster waste management	Page Number
Has identified the main hazards for the region but does not refer specifically to solid waste management or debris management. Refers to other plans and documents that may contain this detail.	
• In 2009 the NTEL group completed a report entitled “Limiting the Impact” which provided a comprehensive assessment of natural hazards risks to the region’s infrastructure.	24
• The Nelson Tasman CDEM Group Welfare Plan gives more details about how Welfare will be delivered during the response and recovery phases (available at www.nelsontasmancivildefence.co.nz).	26
• Nelson Tasman CDEM Group Recovery Plan	53 & 58
• In many rural areas and smaller centres, readiness and response at the local level is supported by Community Response Plans (CRP’s).	59

Name of CDEMP	Taranaki Civil Defence Emergency Management Group
Date written	11 September 2012, to take effect on 22 September 2012
Local Authority Areas	Taranaki Regional Council New Plymouth District Council South Taranaki District Council Stratford District Council
Website	https://cdemtaranaki.govt.nz/

Vision for the Plan

'A resilient Taranaki,'

Goals:

- **Goal 1:** *To increase community awareness and understanding of, and preparation and readiness for emergencies*; through public education, engagement, and community led CDEM planning.
- **Goal 2***: To reduce the risks from hazards in Taranaki;* by improving understanding of hazards, and by developing and monitoring a Group wide risk reduction programme which demonstrates how individual agency initiatives contribute to overall regional risk reduction.
- **Goal 3:** *To enhance Taranaki's ability to respond to emergencies;* through continued focus on response plans, professional development and exercises
- **Goal 4:** *To* enhance *Taranaki's ability to recover from emergencies;* through a continued focus on community recovery planning, management and training.

Summary:

Existing solid waste infrastructure is identified under Taranaki's risk profile and reference to Taranaki CDEM Group plans and procedures includes an Emergency Debris Management Plan 2012 for the group. It also refers to contingency plans for specific hazards, e.g. Flood response plans.

The *Lifelines Advisory Group (LAG)* has the responsibility of providing technical advice to the CDEM Group on lifeline issues, providing a lifelines forum to address integrated CDEM planning and preparedness, and participation in the development of the Group Plan.

Risks Identified

Significant hazards for Taranaki are identified as:

- Seismic event (local fault)
- Volcanic eruption – tephra (ash fall); lahars/associated flooding; slope instability
- Flooding – lower Waitara river
- Damaging winds or tornado
- Hazardous substance spill, industrial – widespread; or major oil spill
- Lifeline utility failure: Major urban water supply failure or contamination
- Lifeline utility failure: Information and Communication Technology failure (ICT)
- Significant structure failure
- Infectious human disease/pandemic
- Biosecurity incursion

A summary of risk analysis and hazard prioritisation identifying significant hazards is also provided.

Reference made to disaster waste management	Page Number
Solid and hazardous waste facilities The New Plymouth and South Taranaki District Council each have a dedicated store for the storage of hazardous waste at a transfer station in their districts. Stratford District Council has a facility at its transfer station for the temporary storage of hazardous wastes, which are then transferred to the New Plymouth District Council. Major industries using hazardous substances also have appropriate storage facilities with contingency plans in place to deal with onsite incidents. Taranaki has one regional landfill located in New Plymouth (Colson Road) and this has an estimated 5-7 years capacity left at current filling rates. A new regional site south of Eltham has all the necessary resource consents in place. No final decision on the use of this site will be made during the term of this plan.	16
The Taranaki Lifelines Advisory Group (LAG) shall be an advisory group to the Taranaki Civil Defence Emergency Management Group, through the Co-ordinating Executive Group to provide a forum for discussion and planning for issues relevant to infrastructure services in an emergency.	86
Emergency Debris Management Plan 2012	93

APPENDIX B Stakeholders

- CDEM groups
    - Northland Region Civil Defence Emergency Management (CDEM) Group
    - Wellington Region Emergency Management Office
    - Canterbury Civil Defence Emergency Management Group
    - Gisborne Emergency Management Group
    - Auckland Civil Defence Emergency Management (CDEM) Group
    - Nelson Tasman Civil Defence Emergency Management Group
    - Taranaki Civil Defence Emergency Management Group
    - Waikato Region Emergency Management Group
    - Marlborough Civil Defence Emergency Management Group
    - West Coast Civil Defence Emergency Management Group
    - Hawke's Bay Civil Defence Emergency Management Group
    - Bay of Plenty Civil Defence Emergency Management Group
    - Manawatu-Wanganui Civil Defence Emergency Management Group
    - Otago Civil Defence Emergency Management Group
    - Emergency Management Southland
- New Zealand Civil Defence and Emergency Management
- Ministry of Health & District Health Boards
- Ministry of Primary Industries (MPI)
- Maritime New Zealand
- Public Hospitals
    - Christchurch Hospital
    - Wellington Hospital
- New Zealand Police
- University of Canterbury
- Waste MINZ
- Waste Management Companies
    - Waste Management
    - Enviro NZ
    - Smart Environmental
- New Zealand Fire Service
- NZ Defence Force
- Insurance Sector
- Those involved following the earthquake near Kaikōura
    - Kaikōura District Council (TBC)
    - MWH (Don Young)
    - ECan (Rowan Latham)
    - Nelson Environment Centre (Karen Driver)
    - Wellington City Council (Mike Mendonca)
- Other Stakeholders identified in CDEMP's
    - St John

- Iwi
- Government Social Services Welfare and Community Services
- Professional Associations
- Volunteer Groups
- Industry and Commerce
- Government Agencies
- Media Agencies
- Scientific / Technical Associations and Advisors
- Works and Services Providers
- Private Health Care Sector

Appendix B: 2nd Milestone Report

Disaster Waste Management Planning Project – 2nd Milestone Report – 1 February 2017

This report has been prepared for the benefit of Environment Canterbury. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

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Rev. No.	Date	Description	Prepared By	Reviewed By	Approved By
1	1/2/2017	2nd Milestone Report	Paul Heveldt	Kathryn Halder	

Introduction

This is the second Milestone Report of work done to date on the project scope, as part of MWH's contracted outputs set out below:

Milestone 2: Interim Report	Report which details the findings so far, and; • Identifies any gaps, • Identifies learnings, • Preliminary indication of what a tool might look like. • Strategic direction for completing the Final Report

Identification of Gaps and Learnings and Summary of Recent Research

The key elements to be addressed in this project can be summarised as:

- Review of existing documents produced by territorial authorities and CDEM groups
- Identification and analysis of selected international DWMP examples with a view to their relevance to and potential for contributing to a New Zealand DWMP template
- Review of disaster waste management measures and associated lessons learned from local and recent disaster events such as the Christchurch earthquakes and the Rena grounding
- Identification of the specific requirements for a New Zealand DWMP template
- Identification of key stakeholders
- Recommendations on the format options and the best platform on which to host a DWMP template.

MWH is continuing to progress this project scope accordingly and a summary of the work completed since the 1st Milestone Report is provided in the following sections. We have also noted areas of current research for the project which are still under action.

Research Papers Produced by C Brown and/or M Milke

Papers relating to disaster waste management principles, guidelines and lessons learnt that have been prepared by Dr Charlotte Brown and Associate Professor Mark Milke from the University of Canterbury have been scrutinised. These include, but are not limited to:

- Brown, C. (2012) Disaster Waste Management: a systems approach. Thesis in Doctor of Philosophy, Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand.
- Brown, C., Milke, M., & Seville, E. (2010a). Legislative Implications of Managing Disaster Waste in New Zealand. New Zealand Journal of Environmental Law, 14, 261-308.
- Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098.
- Brown C, Milke M., & Seville E (2011) International Journal of Integrated Waste Management, Science and Technology Paper – "Disaster Waste Management: a Literature Review Article", University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand.
- Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and Ministry of Civil Defence and Emergency Management.
- Brown C., & Milke M (2012) Waste MINZ paper – "Planning for Disaster Debris Management", University of Canterbury, New Zealand.
- Brown C – Paper - "Waste management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand.
- Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand.
- Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2011) Resilient Organisations Disaster Waste Management Case Study: 2009 Victorian Bushfires, Australia, Research Report 2010/04

MWH has now carried out a detailed summary of these papers and this is attached as Appendix A to this 2nd Milestone Report. We intend to build upon the extensive work that has already been completed to date by Brown and Milke, rather than trying to reinvent the wheel. In this regard MWH will draw out the key learnings and identify any gaps, as and where identified, between this work and plans produced by others or lessons learnt that have been obtained since these papers where prepared in (mostly) 2012. MWH has also met with Mark Milke and intends to meet with Charlotte Brown in order to identify any gaps they see in the research completed to date.

In brief the Brown / Milke papers contents include:

1. ***Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand.***

This paper includes reviews of the response to the Rena Oil Spill (2011), a landfill collapse event in New Plymouth (2007), Auckland tornado (2011) and floods (2012), Central Hawkes Bay flooding (2011), Gisborne earthquake (2007), Ruapehu eruption (1996) and New Plymouth tornadoes (2007 & 2011). Key findings were:

- Consideration of strategic management requirements and operational roles/responsibilities in a disaster event are critical.
- Industry should be consulted and included in planning for disaster management.
- Formal commercial agreements and contracts can be put in place as part of planning.
- Temporary storage sites for waste should be identified.

- Consultation and communication are necessary post-disaster but need to be planned for prior to any disaster.
- A need to consider to what extent public funding might be needed for private property clean-up.
- Limitations of existing waste collection infrastructure need to be understood.

2. ***Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and Ministry of Civil Defence and Emergency Management.***

Pre-event tasks for disaster waste management planning are identified in this paper; these tasks include:

- Preparation of a plan
- Attend to organisational structures
- Provide training for all stakeholders that will be involved in dealing with disaster waste
- Establishment of pre-event contracts
- Develop regulatory controls and policies
- Gather information and keep and maintain records

This report also provides thorough templates for disaster waste management planning.

3. ***Brown C (11 April 2012) – Disaster Demolition and Debris Management Policy Recommendations, University of Canterbury, Christchurch, New Zealand.***

New principles of risk management are deemed to be required for managing disaster waste, including:

- Acceptance of higher risks
- Retention of a skilled work force for high-risk work
- Avoid giving any permit exemptions
- Consideration of the requirements of long term risk management
- Involving the community in decision making
- Application of consistent standards

This paper also makes extensive suggestions about what needs to be covered in disaster waste management laws.

4. ***Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand.***

Disaster waste management is considered to sit in a “grey area” between an immediate hazard and a longer term threat to economic, social and environmental recovery. Any disaster waste management law will need to allow for flexibility in adaptation to any situation, have sufficient boundaries to provide support and confidence to decision-makers, be effectively communicated to the public both pre- and post-disaster and provide streamlining of waste management organisational structures. This paper includes an extensive list of specific recommendations for inclusion in any disaster waste management law for New Zealand.

5. ***Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098.***

This review analyses eight key aspects of disaster waste management and provides a summary in each case of what current literature covers for each of these, as follows;

- Planning
- Waste – including waste composition, quantities, and management phases
- Waste treatment options
- Environment
- Economics
- Social considerations
- Organisational aspects

- Legal frameworks
- Funding

Appendix A provides further information.

6. ***Brown C – Paper - "Waste Management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand.***

This paper recommends that plans should cover the following key headings:

- Waste composition and quantities to be expected
- Waste collection mechanisms
- Waste handling and treatment
- Waste disposal
- Hazard management
- Waste transportation
- Strategic and operational management
- Record keeping and monitoring
- Public communication and engagement
- Funding
- Regulations

7. ***Brown C., & Milke M (2012) Waste MINZ paper – "Planning for Disaster Debris Management", University of Canterbury, New Zealand.***

Depending on their nature and severity, disasters can create large volumes of debris. In some cases the equivalent of many years' worth of waste can be generated in a single event, often overwhelming existing solid waste management facilities and personnel. With the capacities of existing solid waste management facilities likely to be far exceeded in a large scale event some pre-planning and forethought as to potential debris management options needs to be carried out by:

- Considering alternative disposal options
- Assessing possible environmental impacts and risks
- Investigating recycling options
- Establishing MOU's between localities and contractors
- Establishing operational roles and responsibilities with civil defence, ministry groups and local authorities
- Sensitising the community and preparing post-event communication strategies
- Investigating funding mechanisms and capacities.

8. ***Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand (Ph D Thesis).***

This is Charlotte Brown's Ph D thesis. It is an extensive document and contains valuable information about the theory and practice of disaster waste management, both in the local (New Zealand) context and as derived from international examples and associated literature. A fuller summary is provided in Appendix A but the major chapter headings within this thesis are:

- Strategic management
- Funding mechanisms
- Funding sources (private and public)
- Funding delivery mechanisms
- Funding policies
- Operational organisation
- Procurement approach
- Human resourcing
- Recycling feasibility
- Recycling mode – on-site or off-site
- Recycling policies
- Environmental and human health risk management
- Legislation and regulation
  - Strategic management

- Funding mechanisms
- Operational management
- Environmental and human health risk management

Local Authority CDEMPs and Recovery Plans

MWH has obtained copies of all of the CDEM Plans prepared by local authorities in New Zealand and has interrogated each of these plans in order to summarise what they say about waste management in response to emergencies and to identify any gaps. A summary of each of these plans was provided within the 1st Milestone Report.

In general, waste management is not mentioned in the majority of the CDEM Plans, nor is there any framework to adhere to after a disaster, specifically in terms of debris or waste management. Typically the plans identify the key risks to each region and set out the framework and structures to be set up and the roles and responsibilities within each centre following a disaster.

The responsibilities for waste management during non-event periods are then brought onto the Lifeline Utilities Group, or equivalent, to advise the Emergency Coordination Centre (ECC) or National Crisis Management Centre (NCMC) as needed. Hazardous Substances Technical Liaison Committees (HSTLC) are identified in some plans as the agency responsible to provide technical support for emergency management and for warning CDEM and the public if hazardous substances are released as a result of a disaster.

MWH has also contacted each of the CDEM groups directly, requesting a copy of any disaster waste management or debris management plans prepared for each region or details of any policies or procedures in place to specifically manage solid waste after an event. A summary of responses received to date is attached in Appendix B to this 2nd Milestone Report.

Emergency Management Plans of Other Organisations

Whilst reading through the CDEMPs and other reports MWH has identified references to other emergency management plans; for example, the Maritime New Zealand National Marine Oil Spill Contingency Plan, the Ministry of Civil Defence & Emergency Management “Focus of Recovery – A holistic framework for recovery in NZ” and Police Emergency Management Plans. Where good direction is provided by others in respect to specific information and guidance MWH will make reference to these so that future disaster waste management plans can direct the user to this guidance, rather than having to cover off every event themselves.

National and International Examples of Debris Management Plans and Disaster Waste Management Guidelines

In 2008, the Wellington Region Civil Defence and Emergency Group prepared the first debris disposal guidelines in the country for Greater Wellington (WRCDEMG 2008). Also, the Joint Centre for Disaster Research has recently lead a small EQC-funded report on issues specific to urban earthquake debris management in Wellington (Johnston, Dolan et al. 2009).

A number of examples of international debris management plans and disaster waste management guidelines have also been identified and obtained, including:

- United Nations Disaster Waste Management Guidelines (March 2013)
- Louisiana Department of Environmental Quality Comprehensive Plan for Disaster Clean-up and Debris Management
- Municipal Comprehensive Emergency Management Plan (CEMP) and Disaster Debris Management Plan published by the Massachusetts Department of Environmental Protection (MassDEP),
- Integrated Waste Management Board, California - Integrated Waste Management Disaster Plan

- United States EPA – Planning for Natural Disaster Debris - Guidance for local government on disaster debris management (March 2008).

These are currently being analysed and relevant matters will be distilled from these plans and considered in a New Zealand context.

As an example, the key elements identified in the USEPA's "Planning for Disaster Debris" (EPA 2008) for pre-event planning are:

1. Pre-planning activities
2. Ancillary activities
   - Identify likely debris types and forecast amounts
   - List applicable federal, state, and local environmental regulations
   - Inventory current capacity for debris management and determine debris
   - tracking mechanisms
   - Pre-select temporary debris storage sites
   - Identify equipment and administrative needs (including pre-negotiated
   - contracts)
   - Develop communication plan
   - Create a disaster debris prevention strategy
3. Create a debris removal strategy
4. Harmful materials identification and handling recommendations
5. Recycling options
6. Waste-to-energy options
7. Disposal options
8. Open burning options

These items are essentially a reflection of the material covered in considerable detail in the Brown and Milke papers.

Summary of Gaps and Learnings Identified

A review of CDEM plans has shown that these plans have primarily been written to meet Local Authorities' requirements under the Civil Defence Emergency Management Act (CDEM Act) 2002 and do not contain specific information regarding disaster waste management. Some groups have made a commitment to debris management plans in the future but most rely on the information provided by 'task' or 'lifeline' groups set up following a disaster.

A wide variety of papers relating to disaster waste management have been prepared by the University of Canterbury. These provide some clear guidance on what should be considered as part of disaster waste management planning. Initial discussions with Mark Milke have identified the following gaps in this research:

- Need to further liaise with the Insurance Council particularly regarding the approval for demolition processes and timeframes following an event
- To make provisions for segregating special wastes, in particular considering dedicating a site for monofills for these materials following an event
- Getting the demolition and waste management contractors engaged as early as possible.

With the recent earthquake near Kaikōura there is also an opportunity to look at whether any of the recommendations set out in University of Canterbury research papers were in place and, if so, how effective they were. Lessons learnt from some of those directly involved at Kaikōura will be included in the 3rd Milestone Report. It is our intention that this will including input from Rowan Latham in terms of a Regional Council point of view of the event and Karen Diver (Nelson Environment Centre Waste Minimisation Manager) who helped with formulating a disaster waste management response with some of Kaikōura NGO's. This work is currently out of scope of the project brief.

Stakeholder Consultation

According to the Disaster Demolition and Debris Management Guidelines it is important that the following organisations are involved, to varying degrees, in the disaster waste management planning process:

- Disaster response and recovery authority representatives
- Waste management operational representatives (likely local authority but it is important to include industry where applicable)
- Waste management industry representatives
- Environmental authorities
- Health and safety authorities
- Public health authorities
- Hazardous substance authorities and industry
- Lifeline (critical infrastructure) authorities (particularly with respect to demolition works)
- Marine authorities (for tsunami events and/or events releasing debris in the marine environment)
- Transportation authorities
- Heritage building and archaeological authorities
- Non-domestic agencies (e.g. international governmental and non-governmental groups, if any)
- Local cultural groups (Iwi)
- Community representatives

The interaction with stakeholders in this project has not been viewed as consultation as such but rather as a one-on-one information gathering exercise from individual Council or Stakeholder contacts. The project emphasis has been focussed on establishing contacts with key stakeholders for future use as the project develops rather than contacting all stakeholders now.

As noted in section 2 MWH has contacted each of the CDEM groups directly requesting a copy of any disaster waste management or debris management plans prepared for each region or details of any policies or procedures in place to specifically manage solid waste after an event. A summary of responses received to date is attached as Appendix B to this 2nd Milestone Report.

First-hand experience from the Kaikōura earthquake will also be drawn upon for this project and will be used to provide feedback on what worked well and what could have been improved as part of the 3rd Milestone Report. It is also intended to identify if any of the recommendations set out in the University of Canterbury research were in place and, if so, how effective they have proven.

Given the relevance and importance of their previous work on this subject we have met with Mark Milke to discuss his views on the issue but because of the holiday season we have not been able to arrange a joint meeting with Mark and Charlotte Brown to date. We will summarise the discussions that duly take place in the 3rd Milestone Report.

Waste Management Issues and Proposed Solutions from Recent Disaster Events

New Zealand-Based Case Studies

For the New Zealand-based case studies the approach is to discuss and dissect the key elements of each case, including the successful aspects and those DWM elements that were not so successful. It is proposed to focus on the Rena grounding and the Christchurch earthquake as, for both examples, there is a large body of information, review data, reports and other analysis that can be used to draw conclusions about successes, shortcomings, unexpected issues and various other lessons that can be considered and incorporated into better plans and systems for the future, and within the New Zealand regulatory context. This research is ongoing and will be summarised in the 3rd Milestone Report.

6.1.1 Kaikōura Learnings

This will be summarised in the 3rd Milestone Report.

6.2 International Case Studies

6.2.1 Overview

The selected cases focus respectively on:

- Earthquake (and tsunami)
- Floods / storms

Accordingly, the Japanese earthquake and tsunami and Hurricane Katrina are the two case studies that have been selected.

6.2.2 Japan earthquake and tsunami, 2011 – key findings from post-disaster reviews

The Japan earthquake and tsunami of 2011 generated approximately 23 million tonnes of debris along the affected coastal area. Shortly after the disaster the Japanese government implemented emergency waste disposal measures; this included time extensions over which waste could be disposed and an allowance for the dumping at sea of rotting seafood from destroyed storage and processing facilities. This was followed by a law enabling local governments outside the disaster area to accept and manage disaster waste at the national government's expense, thus opening up significant nearby resources, including areas of land, for the disposal of disaster debris. The management of debris from the earthquake and tsunami was further assisted by the formal development of public-private partnerships to establish tracts of land dedicated to acceptance of waste in large volumes from future disasters.

Particular prefectures also developed their own disaster waste management plans, for example focusing first on protection of public health by dealing with temporary sewage disposal as a first priority and with this taking precedence over hard debris management. Systems for separating, processing and recycling disaster waste were set up, in cooperation with local businesses, to ensure an ultimate economic benefit to the community. Goals setting and timeframes were typically included as key drivers of these plans in various Japanese prefectures. Post-disaster needs assessment became a particular focus for changes in disaster management planning. Sharing of information between the public and private sectors was viewed as essential to initiatives aimed at swift disaster response and smooth recovery and reconstruction.

Japan has now formulated a basic policy for the disposal of earthquake waste and the associated minimisation of environmental impacts, with essential points as follows:

- Waste to be treated and disposed as promptly as possible;
- Temporary waste storage sites to be designated and created;
- Recycling to have the highest priority for waste management; and
- Local employment and wide-area cooperation must be facilitated in disaster waste recycling.

A classification scheme for disaster waste has also been formulated; this identifies the following categories:

- Waste consumer electrical appliances and electronics, and various household effects;
- Waste wood, concrete, tiles, rubble, etc.;
- Trees, shrubs, plants and other natural materials;
- Large structural items, etc.;
- Deposits such as liquefaction silt;
- Wrecked vehicles and boats;
- Hazardous wastes (asbestos, pesticides, PCBs, general chemicals, etc.)
- Infectious wastes and animal carcasses.

The appropriate treatment and disposal methods for each waste type still need to be determined on a case-by-case basis, while keeping in mind the possibilities and opportunities for recycling.

Based on Japan's experience from the 2011 earthquake/tsunami event a set of essential recommendations for application in other jurisdictions has been published; this is said to be framed to assist "developing countries" but the blueprint is universally applicable. The major elements are:

- Preparation of a disaster waste management plan in advance, with the major focusses on classification of disaster waste types, securing the necessary equipment and temporary storage sites for disaster waste, having sufficient individual modules in the plan for disasters of different scales, and allowing for periodic review of disaster waste management plans to continually incorporate the lessons learned from other international disasters.

- Building of cooperative structures and connections with relevant organisations and institutions to assist with the smooth management of disaster waste. Effective management of the sheer volume of waste generated in large-scale disasters is greatly aided by strong relationships with local authorities in the immediate vicinity of the stricken area. This includes collaboration in the handling, transportation, recycling and disposal of waste of waste.

Each of these fundamental precepts has clear relevance and applicability to the New Zealand context although it must be said that the work of Brown and Milke has already identified these same fundamentals. We intend to expand on these issues further in the final report for this project.

6.2.3 Hurricane Katrina, USA, 2005 – key findings from post-disaster reviews

One of the most significant identified shortcomings in the response to waste management with respect to Hurricane Katrina was the lack of effective debris waste management capability and planning. This resulted in ad hoc disposal (some of which generated significant and long-lasting environmental impacts), inappropriate disposal endpoints for certain waste types (e.g. infectious wastes improperly disposed) and various other problems all stemming from the lack of a coherent and coordinated debris disposal approach.

The upshot has been a strong emphasis on disaster management planning. The lessons of Hurricane Katrina in this regard have had a significant degree of uptake by other US states and/or city jurisdictions and there are many literature examples available for scrutiny and derivation of best practice concepts, most of which are directly applicable to a New Zealand context.

Federal directions (via a Senate Committee) that arose from detailed scrutiny of the responses to disaster waste management with respect to Hurricane Katrina included:

- A critical need for waste stream characterisation and proper disposal avenues to have been developed in proactive manner. To ensure this happens the Senate Committee recommended that it be made mandatory for waste stream characterisation to enable proper sorting of waste into pre-ordained streams with subsequent disposal based on waste characteristics.
- Debris management parameters and siting of facilities to be used for disaster waste disposal. Facility siting is required to take into account natural hazards, protection of water and air resources, and with a critical and fundamental focus on protection of human health and the environment
- Preparation of regionally-based waste management plans that include sufficient disposal options, with an emphasis on the protection of the environment and vulnerable communities. Disposal capacity was specifically identified as a critical matter.

As an example of the instigation of disaster waste management plan development activity in the aftermath of Hurricane Katrina, the state of Hawaii prepared its own specific plan, incorporating lessons learned from the Katrina response (particularly the shortcomings). This plan focusses on the identification of individual debris types and the related preparation of specific management blueprints for each of these waste types. The Hawaii DWMP contains these "best management practices" as detailed sheets that set out the definition of the type of waste (to aid effective categorisation), the objective(s) inherent in management of the waste type, what should be carried out in the "response phase" and the "recovery phase", a succinct tabulation of the applicable management techniques (usually three or four of these), the general feasibility of each management technique, the broad extent of cost, the extent of

debris volume reduction, environmental "friendliness", health and safety, availability of resources and recyclables markets, and an assessment of public acceptability.

The choices that can be made are several for each parameter and for each waste type but the approach does allow a significant extent of flexibility, depending on the circumstances of each type of disaster, the geographic area where it occurs, and a variety of other factors. This approach has a useful degree of general applicability in the New Zealand context but, more importantly, it also represents an example of the finer detail that would back up the more general concepts and requirements of a more overarching disaster waste management plan template.

Format of a Disaster Waste Management Tool

MWH's thinking on the most suitable format for a tool to assist the implementation of effective disaster waste management following a catastrophic event was originally that a web-based tool would work best, with the format aligned on a series of prompts that would, in turn, bring up certain sections or elements of an overall plan necessary for effective disaster waste management, depending on the degree of their relevance to the particular circumstances (e.g. type of disaster, geographic extent, probable waste types, logistical issues, etc.).

This view has been altered somewhat by the Kaikōura earthquake event for which the immediate features of relevance were the loss of the internet and electricity, both of which were slow to fully recover. These issues would render the proposed web-based tool temporarily useless, at least for delivery via the initially proposed platform.

On the basis of that experience it seems that a dual approach may be necessary, this being a web-based tool allowing the selection of modules and management parameters for waste but with this backed up by a hard-copy system covering the same factors but that is independent of the infrastructural loss of electric power and/or the Internet. Such a hard copy approach would effectively fill the necessary elements of a disaster waste management planning gap until the internet and electricity supply were each reliably up and running again.

We will continue to develop these ideas as the project moves towards its conclusion.

Strategic Direction for Summarising the Information Obtained and Finalising the Report

For the final phase of researching, preparing and ultimately delivering the project report we will be focusing on completing, as much as is possible, the information gathering that we have seen as essential to the success of the project outcomes and researching case studies and the work of key researchers in this field, most particularly Charlotte Brown and Mark Milke.

A meeting with these two key researchers has yet to be arranged for a mutually suitable time so this is a priority in the final phase of MWH's work.

We still await the full results of consultation with key stakeholders (as discussed in the Milestone 1 report); various items of information and proposals on waste management issues have been promised by several sources but are yet to be received. Once obtained, the information within those documents will be assessed for relevance and any key points will be distilled to inform our final project outputs.

We intend to assemble all information obtained in the course of the project, summarise this (much has already been done) and include these summaries in the report. Key working papers will be appended to the final report as supplementary material. A full list of references will be an important inclusion for the report and will form a resource base for the next phase of this project.

Next Steps

Milestone 3: Research Summary	Activity summary detailing key work undertaken, to include: • All research completed • All consultation with stakeholders • Summary of all information to form the Final Report

APPENDIX A Summary of University of Canterbury Research

Introduction

A wide variety of papers relating to disaster waste management principals, guidelines and lessons learnt have been prepared by Dr Charlotte Brown and Associate Professor Mark Milke from the University of Canterbury. These include but are not limited to:

- Brown, C. (2012) Disaster Waste Management: a systems approach. Thesis in Doctor of Philosophy, Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand.
- Brown, C., Milke, M., & Seville, E. (2010a). Legislative Implications of Managing Disaster Waste in New Zealand. New Zealand Journal of Environmental Law, 14, 261-308.
- Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098.
- Brown C, Milke M., & Seville E (2011) International Journal of Integrated Waste Management, Science and Technology Paper – "Disaster Waste Management: a Literature Review Article", University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand.
- Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and Ministry of Civil Defence and Emergency Management.
- Brown C., & Milke M (2012) Waste MINZ paper – "Planning For Disaster Debris Management", University of Canterbury, New Zealand.
- Brown C – Paper - "Waste management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand.
- Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand.
- Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand.
- Brown C, Milke M., & Seville E (2011) Resilient Organisations Disaster Waste Management Case Study: 2009 Victorian Bushfires, Australia, Research Report 2010/04

The following is a summary of the key learnings from this work and in most places has been quoted directly from each of the reports.

Paper	Key Learnings
Brown C (2012) EQC Project 10/U608 - "Disaster Waste Management: New Zealand Experiences and Future Planning, University of Canterbury, Christchurch, New Zealand.	Two of the many examples reviewed in this paper included: **2011 Rena Oil spill** One of the 'advantages' of an oil spill over other disaster events is that there is a lead-in time before the oil reaches the shore and modeling also gives an approximate location where the oil will land and resources can be deployed to that site. The advantage in this case, however, was slightly reduced because the lead-in time fell on a Sunday and the logistics of organising extra equipment and PPE was difficult because business telephone numbers on record were not being answered or were answered overseas. Defining lines of communications and firmly establishing responsibilities were identified as potential areas for improvement. Generally the waste contractors had a single point of contact at ICC (for the oily waste) and this worked very well. The difference in responsibility between the container waste and the oily waste caused some confusion where container waste and containers washed up onshore. Communication between Maritime New Zealand and the container/ debris recovery contractor and with the public could have been better coordinated. One option proposed was to include contractors in the daily ICC briefings. At the clean-up sites there was often not a clear command which was difficult for waste contractors as they did not have an obvious and authoritative point of contact. Personal phone numbers were also used (rather than site phones) and this caused some frustration. One specific preparedness measure that has been developed since the Rena was the construction of portable decontamination units which are now held in storage along with the other response equipment at Maritime New Zealand's Maritime Pollution Response Service HQ at Te Atatu to be used in the event of a spill in the future. Maritime New Zealand has an established oil response operations plan, title the 'National Marine Oil Spill Contingency Plan'. **Landfill collapse, New Plymouth** In 2007 there was a landfill collapse at the New Plymouth District Council Landfill. Municipal waste management contingencies are already well developed. The water and waste team have an incident response plan which was first issued in 2004 and is updated yearly. Every year the plan is tested in a simulated emergency exercise and the document is refined based on lessons learned from the yearly exercises. The plan has a section devoted to solid waste issues. The section mainly includes contingencies for managing disruption to the municipal solid waste collection and disposal services. A plan for large scale disaster debris management is currently being prepared by Taranaki Regional Council. This will link with the New Plymouth District Council Incident Response Plan. As part of the plan a number of temporary storage sites have been identified such as old landfill sites, cleanfills and quarries. Consideration has also gone into possible skip bin set-down areas for community waste collection operations. The Taranaki lifelines group is currently considering whether waste should be included in their lifeline utility planning. Other examples reviewed include: • Auckland tornado and floods • Central Hawkes Bay flooding

Paper	Key Learnings
	• Gisborne 2007 earthquake • Ruapehu eruption • New Plymouth Tornadoes The following is a summary of the key findings from these examples. **Key Findings** As part of planning, authorities need to consider strategic management and operational roles and responsibilities for disaster waste management. Organisational processes need to be stream-lined, where possible, to avoid potential organisational inefficiencies or confusion over responsibilities. There is also significant value in assigning these roles pre-event so that organisations and individuals can start to develop working relationships which would be called on in a disaster event. It is beneficial to include industry in planning for disaster waste management. Private industry can provide a number of practical insights during the planning stage. However, care must be taken to ensure that industry remains impartial during this process. For some specific post-disaster activities formal / commercial agreements, such as stand-by contracts for emergency road clearance or urban search and rescue assistance, can be put in place during planning. However, it is important to appreciate that the exact disaster impact, location and nature are not known. Contracts must allow for circumstances where other entities may be better placed to provide services than those contracted. Identification of temporary storage sites should also be considered; however, it is important to note that where the proposed location is privately owned formal identification of land may affect the future land use and value of the land. Consultation and communication were consistently identified as issues in post-disaster situations: both inter and intra-organisational. Failure to adequately communicate and consult with the public and Iwi can lead to disruption in the recovery process. Local authorities need to consider, in more detail, to what extent public funding will be provided for private property clean-up in a disaster response / recovery. As a general principle, high risk waste management activities should be managed through low risk funds. Many of the above disaster events led to the local authority providing a detritus material collection service (generally via skip bins) to affected communities. If this is to be a regular post-disaster service then funding policies and adverse event budgets (whether local or national) need to be set to include this service. 'When designing waste management systems in peace time it is important to consider their capability in a disaster (minimise coupling, that is, maximise redundancy and flexibility). Waste managers need to consider limitations of existing waste collection infrastructure such as maximum truck travel distance or dependence on specialised trucks and equipment such as the hooklift bins.
Brown C (2012) – Disaster Demolition and Debris Management Guidelines and Policy Recommendations, Environment Canterbury and	Throughout the guidelines a number of pre-event tasks have been identified for local, regional and national authorities to consider to facilitate effective disaster responses. These are summarised below. **Plan** • Prepare a plan. Identify the likely hazards (and subsequent impacts) and design for the likely range of scenarios. Prepare the plan collaboratively with all relevant agencies. Ensure the plan is written for roles and not individuals and that new staff are familiar with the plan. Review the plan every year.

Paper	Key Learnings
Ministry of Civil Defence and Emergency Management.	**Organisational Structures** • Assign responsibility for disaster waste oversight to an organisation(s); and, subsequently a role within that organisation(s). The position needs to be assigned to a role not a person (in the event of loss of life). • Develop a cross-organisational coordination structure. Ensure the structure is scalable for larger disasters and/or disasters involving different agencies. **Training** • Include demolition and construction contractors in urban search and rescue and civil defence training sessions. **Pre-event Contracts** • Establish stand-by contract for coordination of contracting resources to assist Urban Search and Rescue. • Establish stand-by contract for contracting resources to assist Urban Search and Rescue (including demolition, construction and vehicle removal). • Identify potential temporary waste handling and treatment areas (including for areas to store material liked to fatalities and heritage material). Where possible establish: operational management arrangements (e.g. stand-by contract) operational protocols (e.g. environmental and human health standards, payment mechanisms), environmental baseline measurements, and land use arrangements (lease and land-use consents where necessary). • Develop contract templates for post-disaster demolition. **Regulation** • Develop a policy on post-disaster waste handling facilities (waste collection centres, temporary storage areas) including: approval criteria and process, and operational (environmental, health and safety and engineering) standards. • Develop a policy on post-disaster waste treatment (combustion, onsite processing, temporary staging areas) including: approval criteria and process, and operational (environmental, health and safety and engineering) standards. • Develop a policy on post-disaster waste disposal (land reclamation) including: approval criteria and process, operational (environmental, health and safety and engineering) standards), ownership and operation, payment, and liability issues. • Determine funding responsibilities pre event. Whether private or public funding, disaster waste authorities must be aware of potential funding gaps. **Information/Records** • Collect building data, including building dimensions, building material, hazardous materials (asbestos, LPG, etc.), building use (to identify problematic waste sources e.g. putrescible waste), owner and tenant details. • Prepare an inventory of existing demolition contracting services, waste handling facilities, resources and personnel (including for hazardous material). Identify existing databases / resources e.g. the Christchurch recycling directory • Consider some form of accreditation or pre-approval system for contractors and waste handling facilities. Carry out a risk assessment on existing facilities and understand it vulnerabilities in a disaster. • Establish reporting systems (including data collection and synthesis) with existing waste handling facilities. Regulatory mechanisms may be required to enable this. There are also templates provided within this report for Disaster waste management planning.
Brown C (11 April 2012) – Disaster Demolition and Debris Management	Peace-time approaches to management may be too cumbersome or generally unfeasible post-disaster when balancing all the environmental, economic and social factors. Specific legislation / regulation and new risk management approaches may be required. It is important that appropriate risk management techniques are

Paper	Key Learnings
Policy Recommendations, University of Canterbury, Christchurch, New Zealand.	adopted as part of any legislative / regulatory change. The following principles should be considered: • Accept higher risks: Due to large scale of works, the likely speed of management and the likely lower skilled workforce (due to the resource demand post disaster) it is inevitable that the quality of the works (intentionally or unintentionally) will be lower. Therefore, regardless of the desired standards, mitigation measures need to be in place to protect people and the environment against potential negative effects. • Maintain a skilled workforce for high risk work: Where there is a demand for resources / to carry out skilled / technical work more expediently, authorities can either a) reduce the standards required to be met (e.g. removing the requirement to seal buildings with asbestos during asbestos removal) or b) To increase the workforce (e.g. by reducing worker certification requirements). Generally it is better to maintain a skilled workforce as these personnel have a vested interest in long term quality of their work and should be able to identify and act where additional mitigation measures are required. • Avoid permitting (consenting) exemptions: When a consenting process is deemed to be too cumbersome in a post-disaster situation authorities can either expedite the process or permit the activity (i.e. not require a consent). Generally permit exemptions should be avoided. Going through some form of consenting process will enable site specific assessments to be made. It also ensures that authorities know the activity is taking place and can maintain visibility, monitoring of activities and can intervene in emergent risks if necessary. • Consider long term risk management: When changing environmental and human health standards post-disaster, authorities must consider who owns the risk in the short and long term. Entities are more likely to act responsibility where they have long term ownership of the risk. • Involve community in decision-making: It is important to involve community in risk management decisions as much as possible and particularly where the operations will be medium to long term operations. However, as mentioned previously, consultation requirements may need to be stream-lined to allow for efficient and effective decision-making. • Apply consistent standards: To improve public perception and trust in a risk management approach, consistent standards should be applied across the recovery effort. In general, disaster waste management laws need to: allow for flexibility for adaptation to any situation; be bounded enough to provide support and confidence in outcomes for decision-makers; allow for timely decision-making and action; be collaborative; and focus on responsibility, not accountability. • Emergency laws are not always applicable to recovery. Recovery specific legislation is recommended and a clear distinction between decisions made to enable emergency response and to enable recovery. • Recovery legislation and regulation changes need to be clearly delineated from 'peace-time' laws. • Clear disaster waste management decisions making processes (not just outcomes) need to be officially established, such as establishment of minimum acceptable standards, or transparent risk / decision assessment processes. The process should include environmental, economic, social and recovery objectives. • Liability for long term adverse effects resulting from emergency provisions needs to be considered.

Paper	Key Learnings
	• Liability protection within recovery legislation may empower decision-makers to make timely decisions. • If alteration of interpretation of peace-time standards is practiced, liability implications should be considered. • Changes to legislation or regulation during response and recovery should be minimised and a realistic duration for changes should be assigned (such that waste managers can develop long term strategic plans with certainty). • Disaster waste management requirements should be considered when developing peace-time waste strategies and regulations such that disaster waste managers are restricted by strict peace-time regulations. • Legal implications on, and conflicts with, peace-time legislation and regulation needs to be considered when developing recovery legislation (regulation at local, regional and national level). • Flexibility around notification periods allow for necessary programme flexibility. Short notification periods are desirable. • Consultation periods / requirements should be designed to balance consultation and timely decision-making (e.g. time limited, targeted consultation with existing representative groups rather than community wide)
Brown C, Milke M., & Seville E (2012) New Zealand Journal of Environmental Law paper - Disaster Waste Law - An Analysis of the Implications of Existing Legislation on Disaster Waste Management in New Zealand, University Of Canterbury, New Zealand.	In the recovery following a disaster, disaster waste managers are restricted by existing legislation. In many cases, emergency legislation is available to waive peace-time requirements to reduce threats to life, property and the environment. But disaster waste management sits in a grey area between an immediate hazard and a longer term threat to the economic, social and environmental recovery of a disaster struck area. Emergency laws are not often written with disaster recovery in mind. In general, disaster waste management laws needs to: allow for flexibility for adaptation to any situation; be bounded enough to provide support and confidence in outcomes for decision-makers; be effectively communicated with the public both pre and post disaster; and provide stream-lining of waste management organisational structures including decision-making authority. The following is a list of recommendations for NZ disaster law, standards and protocols to facilitate disaster waste management resulting from this paper. • Consider mandating property demolition or remediation of disaster affected properties to facilitate community recovery in the event of resident non-return. Note it is unclear which existing legislation (if any) this would be included in. • Establish waste ownership of (or procedures for) recovered materials for government sponsored private property demolition or remediation works. • Provide greater flexibility in transportation regulations in emergency (i.e. in situations that do not threaten life and/or property as is currently provided for). • Organisational stream-lining and/or delegation of authority to facilitate decision-making across waste management regulatory bodies alongside CDEM recovery coordination structures (including delegation of authority within authorities in the event of personal harm or injury). • Establish processes for expedient certification of waste handlers (hazardous goods etc) and transporters. • Identify minimum hazardous material handling, transportation, disposal or temporary storage standards in a large scale disaster including the possibility of emergency arrangements under the Basel Convention for ‘export’ of waste products. • Establish standards for handling and disposal of asbestos in a disaster situation. • Review the effect of the resource consent process for medium to long term emergency / recovery activities such as disaster waste management. • Pre-identify and regulate temporary waste management sites to minimise liability potential.

Paper	Key Learnings
	• Pre-identify and regulate potential disposal / treatment options which are currently outside our standard waste management options (eg land reclamation and waste incineration). • Establish payment responsibility for government clean-up works on private property (for cases where there is not a centrally sponsored clean-up process but works are necessary to remove public health threat or danger resulting from the disaster event). • Establish liability for long term adverse effects resulting from emergency provisions. • Introduce emergency clauses in waste management by-laws and/or the Waste Minimisation Act. • Establish assessment criteria (for environmental, economic and social impacts) under the RMA for post-disaster situations.
Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098. January 2011	The review analyses eight key aspects of disaster waste management: • Planning • Waste – including waste composition, quantities, and management phases • Waste treatment options • Environment • Economics • Social considerations • Organisational aspects • Legal frameworks • Funding And provides a summary of what current literature does or doesn't say about each aspect. The following is some of the key points identified. **Planning** In general plans give little guidance on decision-making and option consideration in different disaster situations. The documents also do not consider the effectiveness of various organisational, financial and legal structures in different disaster events. Rather than producing a prescriptive operational style plan, a plan based around key decisions could be a more effective approach to allow for the large variability in disaster events and impacts that may affect a region. **Waste** To plan a disaster waste management system, waste compositions and quantities must be estimated. The current barrier to this analysis being carried out is the availability and consistency of post-disaster waste data. Development of a standard method of reporting disaster waste composition and quantities would enable future analysis between events and improve our ability to develop better waste estimation methodologies. The waste streams generated by disasters are: • vegetative debris or greenwaste • sediment / soil and rock • household hazardous waste (refrigerant, oils, pesticides, etc.) • construction and demolition debris from damaged buildings and infrastructure (such as roads, pipe networks and other services) • industrial and toxic chemicals (including fuel products • putrescible wastes (such as rotting food) • vehicles and vessels • recyclables (plastics, metals etc.) • electronic and white goods • waste from disaster-disturbed pre-disaster disposal sites

Paper	Key Learnings
	• human and animal corpses The largest component of urban disaster waste would meet the peace-time classification of construction and demolition (C&D) waste. Some components of this waste stream pose a potential health risk in peace-time which could be exacerbated post-disaster where volumes are significantly increased. These include; asbestos, arsenic treated woods, gypsum leaching and organic pollutants In addition to disaster generated waste, other waste streams that can be indirectly generated post-event, including: excessive unwanted donations, large amounts of health care wastes, rotten food from power outages and emergency relief food packaging. Municipal waste must also be managed if the disaster affected community is still living in the area. Municipal waste collections should be considered when planning and/or implementing a disaster waste system **Waste management phases** Typically management of disaster waste (and disaster management in general) is described in the literature in three phases • Emergency response (debris management to facilitate preservation of life, provision of emergency services, removing immediate public health and safety hazards such as unstable buildings, etc.) • Recovery (debris management as part of restoring lifeline restoration and building demolition) • Rebuild (debris management of wastes generated from and used in re-construction). The phases are not distinct and the duration of each phase varies significantly between disasters **Waste treatment options** A more comprehensive understanding of post-disaster recycling is required. Factors such as: the effect of surplus materials on existing recycling markets; the need for establishment of post-disaster markets (e.g. environmental land remediation, land reclamation, waste to energy and housing reconstruction applications); the logistics involved; space requirements and associated land-use issues; and the economics of post-disaster recycling, all require further analysis in order to aid our future disaster planning and response. Temporary staging sites are a common tool used in the management of disaster waste. Factors requiring consideration include space requirement, environmental factors, noise and dust, pre-disaster site identification, land-use planning issues and cost. The choice of disaster waste treatment options should not only include costs but also environmental and engineering risks. Guidance on the circumstances under which open burning should be used would assist disaster waste managers to assess and implement appropriate treatment programmes. **Environment** Environmental standards, such as the level of recycling, the use of open burning, and disposal regulations are often reduced to expedite recovery. However, the risks or effects of changes in environmental standards do not appear to be well understood by disaster waste managers. Post-disaster analyses of cases where environmental standards have been reduced – addressing why the decision was

Paper	Key Learnings
	made, what information the decision was based on and what the impacts of the option was – is needed. **Economics** There is little guidance available for disaster managers on cost assessments. Development of an approach to assess the likely direct costs of various waste management options (recycling, waste to energy, landfill disposal, land reclamation, etc.) and indirect costs of those options (slower debris removal, long term environmental degradation, etc.) would greatly enhance disaster waste managers' abilities to respond appropriately to disasters in the future. **Social considerations** Overall, there is limited understanding of the impact of disaster waste management on community recovery and/or the impact of a post-disaster communities' behaviour on waste management programmes. • An assessment should consider the public health hazards from the waste matrix, waste management options and from handling the waste. • It would also be beneficial to better understand the psychosocial implications of the speed of debris removal process. For example the desire the recover personal belongings and the emotional attachment owners often have with their properties. Understanding these factors will enable better planning of disaster waste systems. • Waste managers need to recognise that communities can be changed by a disaster – their expectations, risk tolerance and needs will likely have changed significantly-- and so the social relations with the community must also change. **Organisation** Organisational structures for the coordination of disaster waste management programmes are likely to be context specific and will need to fit within existing governance structures. However, there would be value in further investigations into how organisational (intra-organisation) structures influence the effectiveness of waste management programmes (for example human and equipment resourcing, subcontract management, work scheduling); and how best to integrate waste management into the overall disaster recovery operation (inter-organisation) (such as coordination with rebuilding activities; allocation of shared resources, works prioritisation). **Legal frameworks** The literature includes a number of examples where legislative frameworks were a hindrance to expedient disaster waste management. As noted by Kobayahsi (1995), the greater progress we make toward recycling and advanced waste treatment methods, the more our ability to cope with disaster decreases. Complex treatment and disposal processes with strict environmental standards are not designed for large acute influxes of materials. **Funding** Funding, like organisational and legal structures is very context specific.
Brown C – Paper - "Waste management following Earthquake Disaster", Christchurch Polytechnic Institute	Debris volumes generated from past earthquake (and tsunami) events can not only overwhelm existing solid waste management facilities and personnel, it can also affect both the response and long term recovery of an earthquake affected area. Immediately after an earthquake, debris can block roads, which in turn impedes rescuers and emergency services reaching survivors. In the longer term, poor management of debris can result in a slow and costly recovery. Rebuilding

Paper	Key Learnings
of Technology, New Zealand.	and repair cannot be carried out before the waste is removed. It is also a public indicator of the speed of recovery. If managed effectively, debris can become a valuable resource in the recovery and rebuilding process and can have a positive effect on social and economic recovery (Brown et al. 2011). This paper recommends that plans should cover the following: **Waste composition and quantity:** Earthquake waste predominantly consists of construction and demolition waste. The composition and quantity of the waste will depend on the nature of the built environment and the severity of the earthquake. There are three quantity estimation approaches: Unit: $\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n N_n}$ Volume: $Total\ waste\ (tonnes) = 1/3\ Building\ volume\ (m^3)$ Area estimates: $\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n A_n}$ **Waste collection:** The majority of earthquake waste is collected by demolition and building contractors carrying out demolitions and repairs. If there is a lot of small debris, kerbside collection services or debris drop-off centres can be useful. **Waste handling and treatment:** Waste handling facilities are often required to separate waste into recyclable and non-recyclable material and to create a buffer to ease the pressure on existing waste facilities. These are called temporary staging areas. As an approximation, the space required for a temporary staging area is 50 hectares per 1,000,000 cubic metre of debris. After waste has been sorted, it can be treated in a number of ways including recycling, incineration, or used as land reclamation and engineering fill. If the waste is contaminated with hazardous materials or is wet, recycling or reuse may not be feasible. **Waste disposal:** Ultimately some or all of the waste has to be permanently disposed of in a landfill. Shortage of space in existing landfills may be a problem so alternative disposal sites may need to be considered. **Hazard management:** Earthquake waste generally includes numerous environmental and public health hazards, including rotten food, asbestos, faecal contaminated material, treated timber, household and industrial hazardous materials. These hazards need to be assessed and risks mitigated as soon as possible. **Waste transportation:** Waste needs to be transported throughout the management process. Trucks not usually used for waste management will often be needed. Authorities need to consider and manage any potential risks associated with transportation. Measures need to be considered such as

Paper	Key Learnings	
		dust suppression (either by water or dust covers), wheel washes, truck weight limits, dedicated truck routes (for example to avoid dangerous roads), truck travel hour limits and waste tracking.
	Strategic and operational management:	There are many different authorities and industries involved in waste management. It is important that they are all included in the planning and implementation of the waste management system. Ideally one organisation should be given responsibility to oversee the waste management process. In terms or operations, contractors are typically engaged on a lump sum or time and cost basis. Contract templates should be drafted pre-event.
	Record keeping and monitoring	Information and monitoring are invaluable when planning and operating a waste management system. Information will enable the bottlenecks and potential risks and hazards to be identified and monitoring acts as a deterrent to illegal or improper practices. Record keeping is also important for managing contracts and billing.
	Public communication and engagement	Public information and communication is essential to all aspects of disaster response and recovery and this includes waste management. Negative public reaction to waste management efforts can lead to delays and disruptions. Where possible, information should be prepared pre-disaster for ready dissemination when an earthquake strikes. There also needs to be good communication between regulatory authorities and the waste management industry.
	Funding:	Funding for management of earthquake waste may come from a range of private and public sources. It is important to consider funding when designing the waste management system.
	Regulations:	Regulations govern many parts of earthquake waste management: environmental, public health, building and waste ownership regulations. Legal waivers have and can be used to expedite disaster responses and recovery but this must be done with caution.
Brown C., & Milke M (2012) Waste MINZ paper – "Planning For Disaster Debris Management", University of Canterbury, New Zealand.	There is real social, economic and environmental value in planning for the management of disaster debris. It is not just a logistical exercise – it is an integral part of the disaster recovery process. Typically disaster debris management is described in 2 or 3 phases 1. Emergency response (preservation of life, provision of emergency services, stabilising buildings, clearing roads etc.) 2. Recovery (restoring lifelines, debris removal, building demolition) 3. Rebuild (construction of major structures and houses).	

Paper	Key Learnings
	Depending on their nature and severity, disasters can create large volumes of debris. In some cases the equivalent of many years' worth of waste can be generated in a single event often overwhelming existing solid waste management facilities and personnel. With existing solid waste management facilities likely to be far exceeded in a large scale event some pre-planning and fore-thought into potential debris management options needs to be carried out by: • considering alternate disposal options • assessing possible environmental impacts and risks • investigating recycling options • establishing MOU's between localities and contractors • establishing operational roles and responsibilities with civil defence, ministry groups and local authorities • sensitising the community and preparing post-event communication strategies • Investigating funding mechanisms and capacities. Current funding mechanisms only consider direct costs and do not consider the longer term, indirect costs, of certain debris management options, such as reduction in landfill space use, environmental impact remediation resulting from inappropriate and/or illegal dumping, limited resource recovery, etc. In some cases, however, environmental legislation waivers have led to community disaffection and potential environmental degradation.
Brown C, Milke M., & Seville E (2011) International Journal of Integrated Waste Management, Science and Technology Paper – "Disaster Waste Management: a Literature Review Article", University of Canterbury, Christchurch, New Zealand.	Similar to Brown, C., Milke, M., & Seville, E. (2011). Disaster Waste Management: a Review Article. Waste Management, 31, 1085-1098. January 2011
Brown C (2012) Paper - "Disaster Waste Management Principles", University of Canterbury, Christchurch, New Zealand.	**Disaster Waste Management Principles** The following is a summary of the key principles for management disaster waste, as developed in: Brown, C., 2012. Disaster Waste Management: a systems approach. Thesis in Doctor of Philosophy, Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand. **Strategic Management** 1. A strategic management approach, distinct from peace-time structures is generally required to ensure recovery objectives are met. 2. An entity must be given the responsibility and mandate to lead disaster waste management activities toward community-wide recovery goals. 3. If there is an urgency to clean-up, responsibility for strategic management should be delegated to the recovery authority.

Paper	Key Learnings
	4. It is vital that the strategic management structure has strong links with those with vested interest and long-term responsibility for waste management facilities and operations. 5. If peace-time waste authorities are responsible for strategic management of disaster waste, appropriate authority and mandate must be given to the organisation for the purposes of the recovery. 6. Waste activities should be managed under the recovery organisation where waste management activities have a strong interconnectedness with other recovery activities. This is particularly relevant where there are a high number of displaced persons, high disruption to the road network and high human health impacts. 7. The disaster scale (and resultant economic and social impact extent) will inevitably determine what level of government strategic management should occur. 8. Strategic management organisational structures should be tiered and modular such that they can be adapted to different disaster scales. 9. Strategic management personnel must have the capacity to think strategically and objectively (outside their peace-time roles and avoiding silo mentality), therefore, regional and national authorities may be more appropriate than local authorities. 10. The geographic extent of the waste should generally determine the level of government response (i.e. strategic management should, at a minimum, correspond to the physical extent of damage). 11. The geographic extent of waste will trigger involvement of different organisations, in particular where waste extends into different environments (terrestrial, marine, wetland etc.). 12. Strategic managers must provide operational guidelines to ensure waste is handled appropriately. 13. Strategic management structures must prioritise resources to meet recovery objectives. 14. Strategic managers must anticipate and mitigate potential problems. 15. Strategic management structures must assign responsibility for, and oversee, post-disaster environmental and human health risk management. 16. Strategic managers must ensure appropriate monitoring systems are in place to enable effective strategic management and planning. 17. Strategic waste management structures need to include protocol for cross-organisational coordination and collaboration across both waste and recovery functions. 18. Organisational relationships may need to be streamlined to meet the needs of the recovery. 19. Strategic management structures for waste need to bridge between emergency and recovery structures as far as possible while recognising that each structure needs a different approach. 20. Organisational structures and protocols in plans need to account for a range of potentially untrained persons needing to be involved. 21. Strategic waste managers must become a focal point for all communications. 22. Communications personnel should be embedded within the disaster waste management team. 23. Strategic waste managers should develop a proactive public communications strategy.

Paper	Key Learnings
	Funding mechanisms **Funding source (private or public)** 1. Public funding mechanisms generally enable more effective strategic management. 2. Public funding, in general, more readily allows for a macro (community wide) rather than micro (individual property) level approach to demolition and waste management. 3. If private funding approaches are preferred, mechanisms must be in place to ensure there is adequate cover across the community, including for residential, commercial and infrastructure. 4. Where there is a high number of displaced persons and there is a desire to repopulate the affected area, public funding may be needed to ensure work on private property is completed where owners are absent. 5. Where there are significant human health hazards in the waste matrix, a publicly funded approach is preferable. 6. Where there are significant environmental health hazards, a publicly funded approach may be desirable. 7. Communities susceptible to hazards that can cause trans-boundary movement of wastes should consider public funding mechanisms for debris management. 8. Public funding for waste collection will be necessary where there is a high disruption to road networks. **Funding delivery mechanisms (direct facilitation, reimbursement, lump sum)** 9. Funding mechanisms that directly facilitate the waste management works are more effective at achieving recovery objectives than lump sum or reimbursement delivery mechanisms. 10. Where there is a significant human health hazard or environmental health standards, direct facilitation of the works is beneficial. 11. Direct facilitation reflects the actual costs post-disaster and therefore offers greater quality control. Reimbursement and lump sum offer less and the least quality control, respectively. 12. Direct facilitation reduces the uncertainty in operating waste handling facilities and consequently reduces the potential for environmental legacy issues. **Funding policies** 13. Funding mechanisms need to be scalable / adjustable to match the disaster scale. 14. Disaster funding mechanisms, public or private, must routinely include allowances for demolition and debris management, preferably as an item separate from rebuilding. Estimates for post-disaster demolition and debris management costs need to: a. Be updated regularly b. Be priced to match the local market c. Include a post-disaster premium (due to time and/or resource constraints and recycling market changes)

Paper	Key Learnings
	15. Funding sources that determine funding amounts post-disaster need to establish these as soon after the disaster as possible. 16. Funding mechanism policies need some flexibility to allow for effective and efficient waste management options. 17. Funding policies should not only consider direct costs, but also environmental, social and economic effects (and must avoid perverse outcomes). 18. Funding policies should include provision for data collection. 19. Where possible, policy exclusions which may affect implementation, or have significant environmental and human health effects, should be avoided (e.g. asbestos). 20. If funding scope is limited, efforts need to be made to provide education, assistance and incentives for individuals to appropriately deal with that waste. 21. Where multiple funding sources are relied upon, efforts must be made to ensure there are no funding gaps, or overlaps. 22. Funding mechanisms and operational organisational strategies should be designed together to ensure systems can be effectively implemented and there are no funding gaps. 23. A single funding source for each property / building is preferable to avoid organisational complexities and improve recovery efficiencies. 24. Funding providers need to consider the potential for liability due to adverse effects resulting from the disaster response. 25. Funding mechanisms for large scale disasters needs to include a strategic waste management function. **Operational Management** **Operational organisation** 1. Operational strategies need to consider how project risks should best be managed including: consequences of poor risk management; ownership of risk; incentives for risky behaviour; and appropriate mechanisms to mitigate risks. 2. If well managed, centralised management offers opportunities to ensure recovery objectives are met by prioritising resources and works. 3. If well managed, centralised management offers opportunities to monitor and control the timeliness of the works. 4. Centralised management reduces the demands on the affected community and is easy (for communities) to understand. 5. Centralised management can disempower the community. 6. Central management potentially improves the quality control of the works. 7. Macro (community level) cost control can be better achieved through centralised recovery works. 8. Centralised works allow for waste management systems to be designed on a macro (community) scale. 9. Risks associated with establishing post-disaster waste handling facilities can be mitigated by linking them with front-end (collection and demolition) centralised waste management processes. 10. Individual / private operational management approaches allow for ‘cradle to grave’ waste management at a micro (site level) scale.

Paper	Key Learnings
	11. Centralised management methods facilitate information gathering, which enables planning and monitoring. 12. Operational management strategies must include mechanisms for information gathering (to enable strategic planning). 13. Operational management strategies need to, where possible, reduce the number and complexity of organisational interfaces. 14. Funding mechanisms must be designed with the desired operational strategy (or strategies) in mind. 15. If a centrally managed operations programme is desired, public funding mechanisms can significantly reduce administrative demands and can improve operational efficiencies. 16. When central management systems are imposed in a privately funded disaster recovery environment (by an entity other than the funder), consideration into cost recovery mechanisms is important. 17. Public funding for central management overhead costs should be considered. 18. For a large disaster scale, centralised management is likely to be highly beneficial. 19. Where there are significant environmental and human health hazards, a centrally managed clean-up is preferable. 20. A centralised approach may be necessary where there has been a significant trans-boundary movement of waste during the hazard event. 21. A high number of displaced persons may indicate a need for a centrally managed approach. 22. Centralised management will be beneficial where there is high disruption to road network (by controlling and rationalising vehicle movements). **Procurement approach (for centralised operational approaches)** 23. Cost reimbursement contracts reduce incentives for contractors to adopt risky behaviour (environmental or human health), particularly in cases where there is a high human and environmental health hazard in the waste. 24. Cost reimbursement contracts may reduce contractor incentives to independently develop new waste management options, including recycling markets. 25. Contracts conditions can be written to mitigate risks associated with cost reimbursement contracts. 26. Waste ownership needs to be appropriately incorporated into contracts. Waste ownership will be different depending on contract type. 27. Transparent post-disaster procurement policies need to be established. 28. Where possible, contracts let during the emergency phase should be time limited to allow for full procurement procedures to be followed for long term operations. 29. Regardless of the procurement strategy (and funding mechanism) contractor cash-flow must be facilitated to ensure recovery works can continue. 30. Cost reimbursement contracts can simplify payment chains as service providers can directly charge the Principal (rather than the subcontractor). 31. The work force is likely to be less skilled and operational strategies which increase control of operations (such as centralised management and cost reimbursement contracts) are beneficial.

Paper	Key Learnings
	Human resourcing 32. Where there are significant human health hazards, public participation should not be called on. 33. When waste is difficult to handle and when specialist waste handling equipment is required public participation cannot be relied upon. 34. Reliance on private property owners to manage waste should be avoided when there are a high number of displaced persons or where it is anticipated that there is not a strong desire to participate. **Post-disaster reuse and recycling** **Recycling feasibility** 1. As the volume of waste increases, the need to recycle will generally increase. 2. As the volume of waste increases, the economic viability of recycling will likely decrease. 3. As the volume of waste increases, resource shortages (primarily labour) are likely to limit recycling capacities. 4. As the geographical extent of damage increases, the feasibility of recycling likely decreases. 5. Geographical isolation will decrease likelihood of post-disaster recycling being feasible. 6. As the human health hazard increases, the feasibility of recycling decreases. 7. The more mixed the waste is (the more difficult it is to handle), the less feasible recycling is. 8. Recycling, as in peace-time, is dependent on the availability and relative costs of alternative waste management options. 9. Funding mechanism policies need to consider indirect costs (as environmentally beneficial options such as recycling are not always the least expensive option). 10. Public perception towards recycling should be assessed and considered during the decision-making process. **Recycling mode: on or offsite** 11. Offsite separation reduces the time required onsite to demolish structures. 12. Offsite separation increases the direct costs but likely reduces the indirect costs. 13. Offsite separation costs can be comparable to onsite separation costs where the recovery facility (facilities) is close to the affected area and economies of scale can be realised. 14. Offsite separation is dependent on access to a suitable waste handling facility, relatively close to the affected area. 15. Site separation is more feasible when there are more demolition resources available. 16. Offsite separation may create resource bottlenecks due to the fast demolition, such as: contractor availability, truck availability and waste handling facility capacity. 17. Generally, the more mixed the waste (difficulty in handling), the less likely site separation is feasible. 18. Offsite separation is appropriate where (physical) human health hazards exist.

Paper	Key Learnings
	19. Human and environmental health hazards can be better managed by off-site waste separation. 20. The ability to rely on public participation for site separation (on residential properties), decreases as the number of displaced persons increases. 21. The ability for contractors to site separate waste (on residential properties) increases as the number of displaced persons increases. 22. Separation offsite will allow for greater consolidation of truck movements if there is significant disruption to the road network. **Recycling policies** 23. Environmental risks around both onsite and offsite separation need to be considered. 24. Strategic management strategies need to include recycling policies and corresponding institutional support systems. 25. Recycling operations (particularly in terms of timeliness) are better effected under a centrally managed approach. 26. Contract types and terms need to include for recycling. **Environmental and human health risk management** 1. Environmental and human health risk decisions need to be made (1) in the context of the wider community recovery and (2) as transparently as possible. 2. Risk managers must maintain oversight of operations to ensure emergent risks are identified and managed effectively. Centralisation of operational activities may reduce likelihood of emergent risks. 3. In the absence of data and a full understanding of the risk, accept a higher level of uncertainty and mitigate against the potential effects as far as possible. 4. When considering permitting exemptions in a post-disaster situation, cost implications and opportunities for misuse need to be considered. 5. Basic notification or reporting should be required for any risky activity to assist authorities in planning and monitoring. 6. An expedited assessment approach is more suitable where risks vary significantly between sites. 7. Central management can reduce the demands on resource constrained regulatory authorities. 8. It is preferable to maintain a skilled workforce for high risk work, particularly if a reduction in peace-time management procedures has been made. 9. Involve community in risk management decisions as far as practical and in particular for activities that will be operational medium to long term. 10. To improve public perception and trust in a risk management approach, consistent standards across the recovery effort are important. 11. Short and long term risk ownership should rest with the same entity, where possible. **Legislation and regulation** **Strategic management**

Paper	Key Learnings
	1. Overall authority and clear responsibility for management of disaster waste should be incorporated into legal frameworks for recovery. 2. Strategic managers should aim to anticipate necessary legislative changes to: minimise the number of legislative changes and avoid unnecessary legislative changes. 3. Strategic management authorities should have legislated mandate to enable decision-making. 4. If regional or national strategic waste planning is desired, approaches adopted must account for local legislation. 5. Consultation requirements may need to be adapted to the disaster situation, to facilitate timely decision-making. 6. Where possible, regulations should ensure that basic data are collected to aid risk monitoring and strategic planning. **Funding mechanisms** 7. Where funding mechanisms are private, legislative powers will be required to ensure funds can be directed strategically toward the recovery objectives. 8. Where central management is desired in a privately funded environment, legislative provisions need to include for cost recovery. 9. Review the impact of any proposed legislative changes on funding eligibility. **Operational management** 10. If a waste classification system exists, a disaster waste category is necessary which reflects the nature of the waste and ownership of the waste. 11. Classifying the mixed disaster waste as a single waste product may simplify regulatory or legal requirements. 12. Legislative provisions are needed to allow private property entry in a disaster recovery situation where the threat is not just immediate but may affect the community recovery. 13. Laws need to clearly assign waste ownership and liability for loss of valuables. 14. Demolition and debris management contracts need to include waste ownership clauses. Waste must be delineated into personal property and building materials. 15. Waste ownership laws need to be considered where there is movement of waste during the hazard event (particularly across jurisdictional boundaries). 16. Legislative structures need to allow for the desired operational systems to be implemented. 17. Flexibility around notification periods are useful to allow for necessary programme flexibility. Short notification periods are desirable. 18. Legislation or regulations may need to be altered to increase the available labour resources. 19. Liability implications of volunteer or community participation need to be considered. 20. Legislative provisions need to consider procurement requirements for contracts which commence in the emergency period and endure through the recovery phase. 21. Procurement regulations during the recovery phase need to account for the uncertainty likely in the recovery works.

Paper	Key Learnings
	22. Peace-time recycling mandates should have disaster clauses. 23. Legislative allowances may be necessary to facilitate higher volumes of truck movements (truck weight, operation hours, location etc.) and increase the available truck fleet. **Environmental and human health risk management** 24. Emergency legislation should allow for waste facilities to action immediate repair following a disaster. 25. Legislative provisions to expedite hazardous waste handling procedures may be necessary. 26. Legislative authority to prevent contractors (and public) engaging in risky behaviour (such as entering unsafe buildings) may be necessary. 27. Environmental legislative flexibility is required to enable existing and new facilities to cope with the disaster waste. 28. Regulations should be prepared for all possible disaster waste management options. 29. Liability for adverse effects from relaxation of environmental and public health standards needs to be addressed. 30. Emergency laws are not always applicable to recovery. Recovery specific legislation is recommended for large scale events. 31. A clear distinction between emergency and recovery activities needs to be made and allowance needs to be made for activities which transition between the two phases (and legislative frameworks). 32. Legislative authority needs to reside with recovery authorities in collaboration with other relevant authorities. 33. Recovery legislation and regulation changes need to be clearly delineated from peace-time laws. 34. Clear disaster waste management decision-making processes need to be officially established, such as establishment of minimum acceptable standards, or transparent risk / decision assessment processes. 35. Where possible, a legislative framework for recovery should be prepared pre-disaster. 36. Recovery legislative provision must include appropriate delegation authority to empower operational personnel to make operational decisions. 37. Liability protection within recovery legislation may empower decision-makers to make timely decisions. 38. If alteration of peace-time standards is practiced, liability implications should be considered. 39. The impact on liability needs to be considered for legislative or regulatory changes to existing facilities with existing approvals and licences. 40. The number of changes to legislation or regulation should be minimised and a realistic duration should be assigned. 41. Consider disaster waste management requirements when developing peace-time waste strategies and regulations. 42. When preparing recovery legislation legal implications on peace-time legislation and regulation needs to be considered.

Other Papers

<table>
<tr><th>Paper</th><th>Key Learnings</th></tr>
<tr><td>Reported waste quantities from previous disasters</td><td>
<table>
<tr><th>Year</th><th>Event</th><th>Estimated waste Quantities</th><th>Data Source</th></tr>
<tr><td>2011</td><td>Tohoku earthquake and tsunami</td><td>over 23 million tonnes</td><td>(UNEP 2012)</td></tr>
<tr><td>2011</td><td>Christchurch earthquakes</td><td>8 million tonnes</td><td>(Brown 2012)</td></tr>
<tr><td>2010</td><td>Haiti earthquake</td><td>23 - 60 million tonnes</td><td>(Booth 2010)</td></tr>
<tr><td>2009</td><td>L’Aquila earthquake, Italy</td><td>1.5-3 million tonnes</td><td>(Di.Coma.C accessed 2010)</td></tr>
<tr><td>2008</td><td>Sichuan earthquake, China</td><td>20 million tonnes</td><td>(Taylor 2008)</td></tr>
<tr><td>2005</td><td>Hurricane Katrina, USA</td><td>76 mill cubic metres</td><td>(Luther 2008)</td></tr>
<tr><td>2004</td><td>Indian Ocean earthquake and tsunami</td><td>10 million cubic metres (Indonesia alone)</td><td>(UNOCHA 2011)</td></tr>
<tr><td>2004</td><td>Hurricanes Frances and Jeanne, Florida, US</td><td>3 million cubic metres</td><td>(Solid Waste Authority, 2004)</td></tr>
<tr><td>2004</td><td>Hurricane Charley, USA</td><td>2 mill cubic metres</td><td>(MSW 2006)</td></tr>
<tr><td>1999</td><td>Marmara Earthquake, Turkey</td><td>13 million tonnes</td><td>(Baycan 2004)</td></tr>
<tr><td>1995</td><td>Great Hanshin-Awaji Earthquake, Kobe, Japan</td><td>15 million tonnes</td><td>(Hirayama et al. 2009)</td></tr>
</table>
</td></tr>
<tr><td>USEPA’s “Planning for Disaster Debris”</td><td>The key elements identified in the USEPA’s “Planning for Disaster Debris” (EPA 2008) for pre-event planning are:
1. Pre-planning activities
2. Ancillary activities
• Identify likely debris types and forecast amounts
• List applicable federal, state, and local environmental regulations
• Inventory current capacity for debris management and determine debris
• tracking mechanisms
• Pre-select temporary debris storage sites
• Identify equipment and administrative needs (including pre-negotiated
• contracts)
• Develop communication plan
• Create a disaster debris prevention strategy
3. Create a debris removal strategy
4. Harmful materials identification and handling recommendations
5. Recycling options
6. Waste-to-energy options
7. Disposal options
8. Open burning options</td></tr>
</table>

Appendix C: 3rd Milestone Report

Disaster Waste Management Planning Project – 3rd Milestone Report – 10 March 2017

This report has been prepared for the benefit of Environment Canterbury. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

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Rev. No.	Date	Description	Prepared By	Reviewed By	Approved By
1	3/10/2017	3rd Milestone Report	Kathryn Halder	Paul Heveldt	

Introduction

This is the third Milestone Report of work done to date on the project scope, as part of MWH's contracted outputs set out below:

Milestone 3: Research Summary	Activity summary detailing key work undertaken, to include: • All research completed • All consultation with stakeholders • Summary of all information to form the Final Report

MWH is continuing to progress this project scope towards combining all the information gathered to date into a final report. A summary of the work completed since the 2nd Milestone Report is provided in the following sections. The information provided below builds upon that provided in previous milestone reports and should be read in conjunction with those other reports.

Further Research Completed

Additional Notes – Hurricane Katrina Lessons Learned

The Federal Emergency Management Agency (FEMA) Guidelines of 2007 provide a range of technical and management options for disaster waste. Specific disaster waste management plans should be the responsibility of individual municipalities; i.e. devolved down from the federal level. Much of this guidance stems from an analysis of the responses to Hurricane Katrina.

FEMA has introduced an incentive programme, by way of a promised increased cost share from the federal government for any future disaster debris management responses, to thus encourage municipalities to prepare their own specific plans (USEPA, 2008: "Planning for Natural Disaster Debris" in: Office of Solid Waste and Emergency Response & Office of Solid Waste (eds)).

Waste managers were challenged in their response to Hurricane Katrina by the mixture of hurricane- and flood-generated debris, each of which was different in character and in disposal requirements. Different fundamental management approaches were in fact required for each of these waste types.

The experience of Hurricane Katrina demonstrated that disaster debris management planning is aided by pre-disaster waste quantity estimations. Such estimates are also useful for post-disaster response planning and management and can be effectively carried out using GIS / hazard maps.

Waste-to-energy was a management option used on a small scale in dealing with a limited portion of the waste from Hurricane Katrina. There would be scope for considering this option in a New Zealand context but only if a suitable nearby facility was available (and undamaged).

The aftermath of Hurricane Katrina saw a significant quantity of disaster waste being disposed directly into unlined landfills. The ensuing environmental impacts of this disposal are currently under investigation and definitive results are not yet available. The issue is a concerning one however and must be considered in the identification of any potential disposal sites in pre-disaster planning for New Zealand.

6.3 Additional Notes – Great Japan Earthquake/Tsunami Lessons Learned

Further lessons from the Japan experience which can help inform disaster preparedness and post-disaster response efforts for the management of debris are as follows:

Waste volume estimations: Estimating the volume of disaster debris is an important technical challenge facing any authority in the wake of a disaster. In order to scope the damage and calibrate the response, it is important that a reasonable estimate of the disaster debris is available to decision makers as quickly as possible.

Waste transport: It is best to keep the extent of transportation of disaster debris and number of times the debris is handled to a minimum.

Land reclamation and landfilling: Land reclamation and landfilling are waste management options which have the potential to rapidly reduce the total volume of debris to be handled.

Handling tsunami sediments: The decision to recover, move and dispose of the deposited soil should be based on an analysis of the physical and chemical properties of the sediments and an analysis of how the residual soil may adversely impact future land use at selected disposal sites.

Management of hazardous materials: Set up a single, shared Integrated Hazardous Waste Management area for the treatment and safe disposal of (tsunami-related) hazardous waste.

Local employment generation: While in principle there was guidance to promote local employment in disaster waste management by way of downstream sorting, recycling and disposal activities this was not systematically followed through.

Process optimisation: There is scope for reviewing the process pipeline at existing waste processing centres and any new centres, to optimise the throughput by avoiding bottlenecks in the interim steps in the process.

The importance of being prepared: Japan has decades of experience in planning for, and responding to, disasters. The major municipalities have documented plans for disaster debris. This was extremely beneficial as it allowed the government authorities to move swiftly into “emergency mode” after the disaster.

Swiftness of response: Japan’s Ministry of the Environment had a clear guideline for the local municipalities on how to deal with the disaster debris. This included a guidance note on segregation, storage and treatment. This enabled the municipalities to have a consistent framework to deal with the debris. Individual municipalities trying to decide on a sorting strategy would have created different waste streams in different municipalities, thus making any final consolidation difficult.

Technical backstopping: Dealing with disaster debris is a specialised technical task, something which local municipalities, at least the smaller ones, generally lack the technical capability to implement. Thus providing them only with a guidance note would have been inadequate. The decision by the Ministry of the Environment to deploy staff from the national government at the prefecture and local level was a welcome initiative which provided important technical support to the local experts.

Central financial support: The disaster produced such vast quantities of debris that the local municipalities would never have been able to handle the clean-up burden on their own, even during a normal period. However, the disaster debris had to be handled at a time when their revenues had dropped sharply due to the reduction in economic activity and the relocation of local populations. The national government's decision to fully underwrite the costs associated with the disaster debris management has been the core factor behind the success of the disaster debris management operation in Japan, following the earthquake and tsunami.

Stakeholder Consultation

As part of our research and consultation we have been keen to obtain first-hand experience from the Kaikōura earthquake on what worked well and what could have been improved. MWH have therefore met with Karen Driver to look at it from a community group-run waste management perspective and the notes from this discussion are detailed below. We have also sought the views of Rowan Latham of Environment Canterbury who has also been closely involved in both immediate and ongoing waste management issues associated with the Kaikōura earthquake event; notes of that discussion are included in section 3.2 below.

Notes on Discussion with Karen Driver, Nelson Environment Centre and CRN Member

Karen Diver (Nelson Environment Centre Waste Minimisation Manager) provided assistance to Rob Roche, Innovate Waste Kaikōura (IWK), immediately after the Kaikōura earthquake. Rob is the manager of IWK and one of the Trustees of the Community Recycling Network (CRN).

IWK is a community enterprise that aims to help Kaikōura to achieve zero waste to landfill. It came into existence in 2000, as a joint venture between Kaikōura District Council and Wastebusters Trust Kaikōura. With the hard work of Kaikōura's community IWK was achieving 75% diversion from landfill prior to the earthquake and over the years there has been a shift in community attitudes and behaviour around waste.

Since the earthquake struck IWK have been working hard to deal with their town's earthquake-related waste while sticking to their zero waste principles. Karen contacted IWK immediately after the earthquake to see how the wider CRN network could best help. Rob noted that he just needed people like Karen on the ground, who knew the business and what was involved, in order to provide relief for his team. Many of the team had houses and family affected by the earthquake that they needed to provide support to but they had been committed to working round the clock to serve the community.

No immediate funding was available to allow for Karen and others to go to Kaikōura and so the CRN set up a 'Give a Little Fund', with funds raised going to IWK to assist them to pay the costs of getting experienced waste diversion people in to support their staff, to modify their centre to cope with damaged plant and to cope with the huge volumes of waste. Karen suggested that, in the future, national funding was needed immediately after an event to allow trained people like her to reach a site and provide assistance to local staff much in the same way that central government funds search and rescue and other specialists to quickly get to an affected area.

Karen commented on the positive partnership that already existed between Council and IWK and the clear understanding from both parties that they wanted to adhere to their zero waste principles throughout the process and in finding solutions. Karen noted that her role was definitely not to make changes, 'be the expert' or to 'take over' but instead to come alongside the people, culture and process already in place and provide experienced help and support where needed. She also recommended that anyone coming into an area straight after an event should look to do the same, as every location is different and a solution that works for one place may not be the best solution for another.

Karen also noted the emotional impact an event has on people, the emotional value people place on their property and the effect that having everything taken away or demolished can have on people for years to come. She noted that this has not been clearly understood in the past and was one of the lessons following the Christchurch earthquake that the team in Kaikōura wanted to learn from. As part of the recovery plan it was agreed that there should be deconstruction of buildings where possible, rather

than an approach of demolishing everything. By salvaging as much as possible and allowing the community to have as much control and involvement in what happens to their houses there are opportunities to meet this emotional need. This would also allow for less contamination and better opportunities to separate and reuse items. There is also a desire in Kaikōura to up-skill local people and provide opportunities for people to stay and work in the area while it recovers and tourism returns, rather than people being forced to leave an area in search of work in order to support their families.

To set out how this could be achieved Karen, along with others from the CRN, IWK, Kaikōura District Council and ECan, helped to formulate a disaster waste management response plan for the area. The plan provides details on how to up-skill people and how to revamp or reorganise the existing infrastructure to cope with the additional waste material. The plan also looks at equipment needs and innovative temporary storage solutions that do not take up a lot of space or cost large sums of money. They also worked with iwi, businesses, homeowners, insurance companies, EQC and local builders and demolition companies to get 'buy in'. There was also thinking around how to handle hazardous material such as asbestos, and workshops with homeowners to ensure that there was clear communication on the options available.

For example, WorkSafe New Zealand is holding a free event for the Kaikōura construction industry, residents of the properties affected by the earthquakes and other interested parties, to provide helpful Information on:

- risks related to demolition/deconstruction/repairs of buildings
- asbestos and current requirements when handling this material
- health risks around demolition and asbestos
- what you can do to protect yourself and your workers

Careful consideration of the requirements of Te Rūnanga o Kaikōura was also given as a number of Tapu sites were damaged during the earthquake and special quiet areas are required to allow the recovery of these sites to be undertaken respectfully. Karen commented that consultation upfront with the local iwi is important to understand what additional sites are potentially needed post-event.

One passing comment of note was that the IWK site is on elevated ground and many from the community came to the site after the earthquake in case of a tsunami. They broke into the site and reuse shop to get warm clothes, as many had left their homes with very little. The reuse store was a great resource in this event and with better communication, especially to tourists visiting an area, immediate needs for high ground, shelter and warmth can be identified up front, well publicised and where possible people assigned to provide rapid access.

Notes on Discussion with Rowan Latham, Senior Hazardous Substances and Wastes Officer, Environment Canterbury

Rowan has been involved in the Kaikōura/Hurunui (North Canterbury) earthquake in an initial capacity through the Canterbury Civil Defence response, as an intelligence manager at the Emergency Coordination Centre (ECC) and subsequently through his role as Senior Hazardous Substances and Waste Officer at Environment Canterbury.

During his initial involvement with the ECC, Rowan was actively involved in discussions with the solid waste managers and waste contractors and, as a particular example, helped to organise the collection and out-of-district disposal of hospital wastes. This latter issue had to be dealt with as very much a primary priority because protection of public health in this sort of emergency is of paramount importance. It was very helpful, and a pointer to the nature of a general response to this matter that will affect all districts, that a local waste management contractor made available one of their specialised vehicles to transport the medical waste over a very difficult temporary access road to the out-of-district disposal point.

Since this initial first response phase Rowan's role has shifted to supporting the recovery process, assisting the development of an appropriate approach and ensuring necessary concerns were included and addressed. The complexities of the recovery process included roles and responsibilities, drawing together of a clear direction and incorporating those invaluable learnings from the Christchurch earthquake. An important lesson from this in Rowan's view is that a clear direction is needed to delineate the operational activities and associated priorities that need to kick in in the immediate recovery phase after an event.

The above process delayed answering affected peoples' key question of "what happens next?" To manage immediate concerns, Environment Canterbury provided communications around the potential risks associated with handling wastes generated. However as funding and associated disposal options were as yet unknown, only limited direction regarding disposal could be provided. It is clearly important, in Rowan's view, that a disposal strategy is formed so that advice is available to people as soon as possible after an event. A strong communications plan is one area that must be included in any planning template.

Hurunui district has prepared a response plan following the North Canterbury earthquake event and so has Kaikōura district. Environment Canterbury supported these plans by hosting a workshop to develop the necessary recovery strategy; attendees included recovery managers, planners, technical advisors and Worksafe. The outcome of this workshop was the development of a more comprehensive recovery document which addressed the various areas of concern.

In fact, as a critical aspect of the process, a plan is needed that can be activated effectively and more or less immediately on Day 1 of an event. This plan must cover off issues such as:

- Capacity issues for waste management
- Waste types and (approximate) expected quantities
- Logistics and transport matters
- Available disposal sites and the assignment of temporary storage sites for sorting, etc.
- Expected special wastes and an outline plan of how they will be dealt with (e.g. medical waste)

The overarching critical issue that is essential in determining effective disaster waste management is funding. This must be available immediately (or at least guaranteed) and must be accessible. Central government is a key provider of funding.

In this case the Territorial Authorities and Environment Canterbury have made an application to the Ministry for the Environment for funding identified in the recovery workshop. Key inclusions in the application are the appointment of a project manager and two case managers to coordinate the project, noting that the additional workload associated with a project of this scale is likely to be outside the capacity of existing staffing. Repairs to transfer station infrastructure is also provided for in both districts. Provision is included for the active management of hazardous materials, including collection, transportation and disposal. Asbestos surveys are a further essential element of ongoing waste management in the two districts.

A Memorandum of Understanding has been developed between Environment Canterbury, Hurunui and Kaikōura District Councils. The project will utilise a collaborative approach, with Environment Canterbury acting as the project administrator.

It is the intention of all parties, in particular ECan and the MfE, to allow Kaikōura to continue the implementation of its zero waste strategy (which was in place before the earthquake event) and to carry on with the current approach of deconstruction of buildings (see notes on the discussion with Karen Driver).

Notes on Discussion with Charlotte Brown, Senior Research Consultant, Resilient Organisations

Given the relevance and importance of her previous work on this subject we have met with Charlotte Brown to discuss her views on the issue and her experiences during the Christchurch Earthquake. The following paragraphs provides a summary of these discussions.

Charlotte Brown has now moved her personal focus away from research in disaster waste management and is now active in consulting on resilience in organisations and planned responses to events requiring reinstatement of utilities, facilities and services. She has a particular interest in regulatory requirements for resilience. Nevertheless she still monitors research and issues associated with disaster waste management and has many connections to individuals and groups active in this area.

While her papers and thesis identify a wide range of issues that are pertinent to effective disaster waste management she has a strong belief that the two most critical factors are those of funding availability and also having pro forma contracts already in place with various preferred waste management providers.

On the issue of funding Charlotte's view is that funding for the management of disaster waste can come from a range of both public and private sources. However funding arrangements are probably the most critical consideration when designing the waste management system that will kick in post an event. It needs to be in place in a pro forma sense and immediately operative as soon as it is needed. Public funding is the preferred approach because a community-wide focus is best for demolition and waste management.

Waste management contracts appropriate to deal with the expected quantum of waste potentially resulting from a disaster (particularly for an earthquake) must be in place "now". This includes temporary storage area provisions and the availability of waste sorting areas, including an allowance for segregation of particular waste types. The ability of a contractor to handle particular special waste types needs to be taken into account and a clear idea is also needed of recycling and ultimate disposal options that are available via each contractor. Space availability is also an important matter when establishing pro forma contracts as part of disaster waste planning.

Waste transportation capability, including machinery inventory and location, is yet another essential matter that needs pre-planning and contractual consideration between contractors and persons responsible for disaster waste planning.

Charlotte has contributed a great deal in a short time to New Zealand's strategic thinking and planning for disaster responses in general, and disaster waste management in particular. While her personal focus has shifted into the resilience space, as outlined earlier, she remains keenly interested in this subject and, for example, is currently a part-supervisor of a PhD student at Canterbury University who is researching the specific problem of volcanic eruption and ensuing waste disposal, with a focus on Auckland's currently dormant, but not extinct, vulcanism.

6.4 Notes on Discussion with Louise Bennett, CDEM Manager for Tāirawhiti District

Louise first came into a civil defence role in 2002 at the time of the Jody F Millennium grounding in Poverty Bay. She is currently the CDEM Manager for the Tāirawhiti (Gisborne) district and has a role at the Gisborne District Council in the waste unit managing compliance issues. Through her experience gained in the Jody F Millennium incident she was considered an ideal person to be seconded to manage the waste issues arising out of the Rena grounding in October 2011.

Her role in the Rena incident response started on the day of the event itself – she was made responsible for the management of all wastes arising from the ship, including the hardware of the ship itself and the cargo units. However oil was not one of her responsibilities and that remained the domain of Maritime New Zealand. She was however responsible for "oily waste". In broad terms she dealt with oily solid waste, oily liquid waste, general refuse and recycling opportunities for solid waste. She also dealt with the food waste from the containers but this appears to have been somewhat of a grey area in that the salvors also had an interest in the contents of containers since, under maritime law, once a salvor is formally appointed, that entity can realise any value of the cargo; i.e. can sell it or otherwise dispose of it.

At an early stage in the recovery process two contracts were set up; the first was with Waste Management Ltd under an adapted contract and the second was with Enviro Waste under a specific contract. The salvors also had a specific contract with Enviro Waste to deal with container contents, etc. Enviro Waste constructed a purpose-built landfill to deal with the salvor-sourced wastes.

Enviro Waste (local manager is Des McLeary) had a good relationship with the Council (Louise Bennett). The Tauranga Transfer Station was the initial reception point for waste sorting, etc and appropriate wastes were then sent to Enviro Waste's landfill "in the Waikato" subsequent to the sorting process. However, even though Enviro Waste did the sorting and disposal, Louise's staff still had to ensure compliance with landfill acceptance criteria for all solid waste.

Liquid wastes had to be analysed before a decision could be made on whether disposal to the Tauranga City trade waste sewer could be allowed. If a liquid waste did not comply it was sent to Auckland for speciality disposal. Any liquid waste containing oil and/or detergent / dispersant had to be particularly carefully monitored. The local landfill was used for disposal of some oily liquid waste that did not meet Council trade waste acceptance criteria.

A key point made by Louise Bennett was that relationships with waste disposal contractors have to be in place before an incident. While it is obviously not possible to predict the occurrence of an incident in temporal terms, any coastal region in New Zealand can potentially be faced with a ship grounding and / or an oil spill event. If suitable relationships (even to the extent of pro forma contracts) are already in place this makes the mechanisms for dealing with the waste from an actual incident much smoother and more effective.

Format of a Disaster Waste Management Tool

MWH's thinking on the most suitable format for a tool to assist the implementation of effective disaster waste management following a catastrophic event has identified that a dual approach may be necessary, this being a web-based tool allowing the selection of modules and management parameters for waste but with this backed up by a hard-copy system covering the same factors but that is independent of the infrastructural loss of electric power and/or the Internet. The web-based tool format would be aligned on a series of prompts that would, in turn, bring up certain sections or elements of an overall plan necessary for effective disaster waste management, depending on the degree of their relevance to the particular circumstances (e.g. type of disaster, geographic extent, probable waste types, logistical issues, etc.). A hard copy approach would then effectively fill the necessary elements of a disaster waste management planning gap in the event that power and internet are disrupted until these are reliably up and running again.

The following table details the information that should be considered both pre-disaster event and post-disaster as part of the disaster waste management planning tool. This is based on the research completed to date and set out in earlier milestone reports and in Charlotte Brown's papers, "Disaster Demolition and Debris Management Guidelines and Policy Recommendations"[4] and "Waste Management following Earthquake Disaster"[5]. We will continue to develop these ideas as the project moves towards its conclusion.

Pre-Disaster Waste Management Plan

AREA TO BE CONSIDERED	DESCRIPTION
Roles and Responsibilities	Planning for disasters is extremely beneficial as it allows those responsible for responding to an event to move swiftly into "emergency mode" after the disaster. A disaster waste management plan (DWMP) should be written for roles and not individuals and new staff should be made familiar with the plan. It should clearly state where it fits within the CDEMP and structure, and where authority for decision making lies. Organisational processes need to be streamlined, where possible, to avoid potential organisational inefficiencies or confusion over responsibilities. A DWMP also needs to develop a cross-organisational coordination structure ensuring that it is scalable for larger disasters and disasters involving different agencies. It should also be written collaboratively with all relevant agencies. It is recommended that a DWMP should be reviewed every year to ensure that it remains relevant and contact details are up to date.
Identify likely hazards and impacts	It is important to clearly understand the types of hazards for a specific area and what each type of disaster would mean for the generation of waste. Most CDEMPs already identify the likely hazards for their area and the DWMP should expand on the work

[4] Brown C (2012) – "Disaster Demolition and Debris Management Guidelines and Policy Recommendations", Environment Canterbury and Ministry of Civil Defence and Emergency Management.

[5] Brown C – Paper - "Waste Management following Earthquake Disaster", Christchurch Polytechnic Institute of Technology, New Zealand.

AREA TO BE CONSIDERED	DESCRIPTION
	already completed to identify the potential areas affected by each e.g. flooding around rivers and flood plain only, tsunamis around coastal areas only. Maps could be developed as part of the tool showing high risk areas following certain events. These would then be used to calculate the potential and type of properties likely to be affected, and the amount of waste generated.
Identifying existing waste systems and capacity	All territorial authorities will have identified existing waste infrastructure and services (especially those that are Council-owned or undertaken on behalf of Council) as part of their waste assessments and waste minimisation and management plans. The DWMP should expand on this information by detailing the acceptance criteria and consent conditions, operational capacity, total capacity and contact details for all: • Recycling / sorting facilities • Waste handling facilities • Waste treatment facilities (including for hazardous wastes) • Final disposal facilities / end use (including cleanfills) • Demolition contractors • Hazardous waste contractors • Current waste transportation operators • Other transport operators or equipment supplies that could provide assistance in an emergency. This aspect needs to include all private operators, as well as Council owned facilities and services.
Waste composition and quantity:	Estimating the volume of debris is a technical challenge facing any authority in the wake of a disaster. It is important that a reasonable estimate of the disaster debris quantum is available to decision makers as quickly as possible and pre-estimates should even be prepared as part of the DWMP. Understanding the typical waste streams that could be associated with each disaster type is key to planning on how to manage these wastes. The following table produced by Charlotte Brown provides an example of this. *Example: Source Brown Thesis*

		Typical Waste Streams								
		Vegetative	Construction and Demolition (C&D)	Personal Property / Household Items	Hazardous Waste	Household Hazardous Waste (HHW)	White Goods	Soil, Mud and Sand	Vehicles and Vessels	Putrescent
Types of Disasters	Hurricanes/ Typhoons	X	X	X	X	X	X	X	X	X
	Tsunamis	X	X	X	X	X	X	X	X	X
	Tornadoes	X	X	X	X	X	X		X	X
	Floods	X	X	X	X	X	X	X	X	X
	Earthquakes		X	X	X	X	X	X	X	X
	Wildfires	X	X	X	X	X	X	X	X	
	Ice storms	X				X				
	Volcanic eruption	X	X	X	X	X	X	X	X	X

AREA TO BE CONSIDERED	DESCRIPTION

	Pandemic				X	X					
	Industrial disaster	X	X	X	X	X	X	X	X		

Estimating the quantities of waste that could arise with each disaster type allows for evaluating the effectiveness of existing infrastructure to meet the demand, or the potential need for additional or temporary sites.

The actual composition and quantity of the waste will however depend on the nature of the built environment and the severity of the disaster and therefore will need to be refined post-disaster. There are three quantity estimation approaches recommended in the Brown and Milke papers that would allow for high level calculations to be made pre-event. These are shown below.

Unit: $\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n N_n}$

Volume: $Total\ waste\ (tonnes) = 1/3\ Building\ volume\ (m^3)$

Area estimates. $\boldsymbol{Total\ waste} = \sum_{i=0}^{n} \boldsymbol{W_n A_n}$

The electronic template or tool should provide for easy calculation of potential waste arisings online and allow this to be refined post-disaster. After an event the template should also be able to classify the quantities of waste for each of the following phases:

- Emergency response (preservation of life, provision of emergency services, stabilising buildings, clearing roads etc.)
- Recovery (restoring lifelines, debris removal, building demolition)
- Rebuild (construction of major structures and houses).

Each phase has different requirements and time pressures associated with them.

Waste collection & transportation:

It is best to keep the extent of transportation of disaster waste and the number of times the material is handled to a minimum.

A DWMP needs to consider limitations of existing waste collection infrastructure, such as a maximum truck travel distance or dependence on specialised trucks and equipment (e.g. hook lift bins) and the capacity of the local fleet. Trucks not usually used for waste management will also often be needed.

The DWMP needs to consider and manage any potential risks associated with transportation. Measures need to be considered such as dust suppression (either by water application or dust covers), wheel washes, truck weight limits, dedicated truck routes (for example, to avoid dangerous roads), truck travel hour limits and waste tracking.

The procurement of additional services and equipment needs to happen as quickly as possible, if necessary. This can be done by establishing MOUs between local authorities and contractors pre-event or by including disaster waste management provisions within existing collection contracts. It is recommended that the tool provides templates for such agreements. This should also consider provisions for reporting and waste tracking post-event, as discussed later.

Any event can affect multiple networks across an area, and access to properties and facilities. It is recommended that the electronic tool should identify all collection routes and routes to facilities and have the capability to assess these immediately after a disaster. Any damaged routes should be identified quickly to allow for alternatives to be found or priority given to reopening certain routes as rapidly as possible. This can be coordinated with other lifeline groups' requirements.

AREA TO BE CONSIDERED	DESCRIPTION
Temporary waste handling and treatment:	Existing solid waste management facilities are likely to be far exceeded in capacity in a large scale event. Therefore some pre-planning needs to be carried out around: • considering all alternative disposal options • considering temporary storage sites • assessing possible environmental impacts and risks with using each site • investigating alternative recycling or reuse options • Identifying potential capacities of each facility or site, and • establishing MOUs between local authorities and contractors where appropriate Temporary waste handling facilities or temporary staging areas are often required to separate waste into recyclable and non-recyclable material and to create a buffer to ease the pressure on existing waste facilities. As an approximation, the space required for a temporary staging area is 50 hectares per 1,000,000 cubic metre of debris. After the waste has been sorted, it can be treated in a number of ways including recycling, reuse, composting, or used as land reclamation and engineering fill. If the waste is contaminated with hazardous materials or is wet, recycling or reuse may not be feasible. Identifying potential sites as part of a DWMP through a clear site selection process allows for the possible environmental impacts and risks with using each site to be considered upfront. It is important to note that where the proposed location is privately owned, formal identification of land as having a possible future role for waste storage or disposal may affect the land use and value of the land. Other factors requiring consideration include space requirements, environmental factors, noise and dust, pre-disaster site identification, land-use planning issues and cost.
Recycling, recovery and treatment options	A more comprehensive understanding of post-disaster recycling is required. Factors such as: the effect of surplus materials on existing recycling markets; the need for establishment of post-disaster markets (e.g. environmental land remediation, land reclamation, waste-to-energy and housing reconstruction applications); the logistics involved; space requirements and associated land-use issues; and the economics of post-disaster recycling, all require further analysis in order to aid future disaster planning and response. The choice of disaster waste treatment options should be considered as part of a DWMP and should not only include costs but also environmental and engineering risks.
Waste disposal:	Ultimately some or all of the waste has to be permanently disposed in a landfill. Shortage of space in existing landfills may be a problem, or a site may be damaged and therefore alternative disposal sites should be considered as part of a DWMP. This should include both for municipal waste, hazardous materials and cleanfill material. Identifying these sites pre-event through a clear site selection process allows for the possible environmental impacts and risks with using each site to be considered upfront. As for temporary staging areas, it is important to note that where the proposed location is privately owned, formal identification of land may affect the future land use and value of that land. Other factors requiring consideration include space requirements, traffic impacts, noise and dust, land-use planning issues, waste acceptance criteria, engineering design and cost. The decision to recover, move and dispose of deposited soil following an event should be based on an analysis of the physical and chemical properties of the sediments and an analysis of how the residual soil may adversely impact future land uses. Land reclamation has the potential to rapidly reduce the total volume of debris to be handled but the long term environmental effects of using an area for land reclamation need to be closely considered.

AREA TO BE CONSIDERED	DESCRIPTION
Hazard management:	Disaster waste can include numerous environmental and public health hazards, including rotten food, asbestos, faecally contaminated material, treated timber, and household and industrial hazardous materials. These hazards need to be assessed and risks mitigated as soon as possible after an event. It is recommended that consideration is given to each of these specific materials as part of the DWMP and sites or processes identified for the treatment and safe disposal of hazardous waste. Procedures should also be developed as part of the DWMP that can be easily distributed to those affected post-disaster.
Strategic and operational management:	There are many different authorities and industries involved in waste management. It is important that they are all included in the planning and implementation of the disaster waste management system. Contractors are typically engaged on a lump sum or time and cost basis. Cost reimbursement contracts have the potential to reduce incentives for contractors to adopt risky behaviour (environmental or human health), particularly in cases where there is a high human and environmental health hazard in the waste. It also reduces contractor incentives to independently develop new waste management options, including recycling markets. Waste ownership needs to be appropriately incorporated into contracts. Waste ownership will be different depending on contract type. Where possible, contracts let during the emergency phase should be time-limited to allow for full procurement procedures to be followed for long term operations. Regardless of the procurement strategy (and funding mechanism) contractor cash-flow must be facilitated to ensure recovery works can continue. It is recommended that the following contract templates be drafted as part of the DWMP. • Stand-by contract for coordination of contracting resources to assist Urban Search and Rescue • Stand-by contract for contracting resources to assist with waste collection and transportation • Where possible establish operational arrangements (e.g. stand-by contracts) operational protocols (e.g. environmental and human health standards, payment mechanisms), environmental baseline measurements, and land use arrangements (lease and land-use consents where necessary). • Develop contract templates for post-disaster demolition • Review existing waste collection contracts and allow provisions for handling additional material after an event.
Record keeping and monitoring	Information and monitoring are invaluable when planning and operating a waste management system. Record keeping is also important for managing contracts and billing and monitoring often acts as a deterrent to illegal or improper practices. It is recommended that templates are developed as part of a DWMP that can be quickly rolled out post-event or form part of pre-agreed contracts mentioned above. This should provide a record of all wastes arising, the name and address of the facility used to dispose of or recover the wastes and the waste carrier.
Public communication and engagement	Public information and communication is essential to all aspects of disaster response and recovery. Failure to adequately communicate and consult can lead to disruption in the recovery process. Negative public reaction to waste management efforts can also lead to delays and disruptions. Where possible, information should be prepared pre-disaster for ready dissemination when a disaster strikes. A clear communication plan should also be developed as part of the DWMP. Waste managers need to consider the emotional impact on people post-event and recognise that communities can be changed by a disaster. Their expectations, risk

AREA TO BE CONSIDERED	DESCRIPTION
	tolerance and needs will likely have changed significantly and thus the social relations with the community must also change. Consideration should also be given to promoting local employment in disaster waste management by way of sorting, recycling, disposal, deconstruction and recovery of property activities to allow people to remain in an area post-event.
Funding:	Funding for management of disaster waste may come from a range of private and public sources. It is important to consider funding as part of the DWMP. It is recommended that those responsible for releasing funds post-disaster are identified as part of the DWMP and these entities are consulted with. Funding mechanisms need to be scalable / adjustable to match the disaster scale. Funding mechanism policies also need some flexibility to allow for effective and efficient waste management options and should include provision for data collection. They should also consider providing immediate funding to bring relief staff into an area to assist with waste management aspects of the emergency response, as well as long term funding.
Regulations:	Regulations govern many parts of waste management by way of environmental, public health, building and waste ownership regulations. Legal waivers have and can be used to expedite disaster responses and recovery but this must be done with caution. Environmental standards, such as the level of recycling, approval criteria and processes, operational (environmental, health and safety and engineering) standards, and disposal regulations are often reduced to expedite recovery. However, the risks or effects of changes in environmental standards are not always well understood. The DWMP should consider developing draft policies on waste facilities (waste collection, waste disposal, land reclamation, waste treatment etc.) to be implemented post-disaster including, • Establishing approval criteria, processes and standards for handling and disposal of waste (including hazardous materials) in a disaster situation • Introducing emergency clauses in waste management by-laws and/or the Waste Minimisation Act • Establishing assessment criteria (for environmental, economic and social impacts) under the RMA for post-disaster situations • Clearly establishing ownership and operational payment and liability issues

6.5 Post Event

After an event there is a need to review the pre-event DWMP and provide some more event-specific details. There is a need to understand the event, clearly define the scale of the disaster and refine the actual impact of the disaster including:

- Disaster scale
- Number of displaced persons
- Geographical extent – affected routes
- Duration of hazard
- Volume of waste
- Human health risks
- Movement of waste
- Waste handling difficulties

This could be provided as an online tool to allow quick calculations to be made for an area by defining the scale of the tasks involved. Maps could be produced showing areas affected, routes open or closed, locations of facilities to be used and with these distributed to collection contractors immediately after an

event. It should be noted that in the situation where there is no power or internet service the tool needs to reproducible off line (i.e. in a hard copy format).

There is also a need to confirm which sites identified pre-event will be used, initiate any contracts or legislative changes needed and provide good communication to all affected. Having most of the thinking around each of these already in place pre a disaster event will allow recovery to happen more rapidly. Monitoring and record keeping will also be important post-event.

Finalising the Report

For the final phase of delivering the project report we intend to assemble all information obtained in the course of the project, summarise this (much has already been done) and include these summaries within the text of the Final Report under a series of headings. These headings will broadly reflect the "Areas to be Covered" column in the table of section 4.1 above. Our research findings will thus be used to supplement, as and where relevant, the table section headings and in this way the Final Report will draw on the literature findings of our work and the outcomes of our national and international case studies.

The Final Report will be a standalone document which provides the necessary technical information to inform the development of the Disaster Waste Management Plan template/tool. The description and recommendations accompanying the template/tool will include a full description of how it will look, what it covers, and how all of the necessary elements to enable an effective and user-friendly tool have been incorporated.

We originally intended to append the three Milestone Reports to the Final Report but, after discussion, it has been decided that these (effectively progress) reports have achieved their purpose of keeping the client working group informed of the project's findings and the shape of our thinking regarding a tool to deliver a generic Disaster Waste Management Plan. They will thus remain as background papers associated with the project's progress.

A full list of references will be an important inclusion for the report and will form a resource base for the next phase of this project.

Next Step

Milestone 4: Final Report	A published final report which addresses all deliverables identified in the RFP and is in the format described above.

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