Case Study Report: Hurricane Katrina – Disaster Waste Management

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Executive Summary

Hurricane Katrina hit the states of Louisiana, Mississippi and Alabama, U.S.A., on 29 August 2005. In addition to Hurricane damage, heavy rain led to levee breaches and flooding in some areas. Over 1800 people died and more than 600,000 residential properties were affected resulting in large scale relocation of the affected population.

Approximately 100 million cubic yards (76 million cubic metres) of waste was generated from disaster damage including demolition works. There were some significant hazards in the waste matrix, including: flood water sediment contaminated with heavy metals and poly aromatic hydrocarbons; rotting food / putrescible wastes; and asbestos. There were some 350,000 vehicles to dispose of also.

Due to the scale of the disaster, the Federal Emergency Management Agency (FEMA) elected to pay for all debris removal operations. This included clearing private properties that had been declared a public health risk. Ordinarily FEMA would pay 75% of debris removal from public places and individuals and their insurance company would be responsible for private property waste management.

Many of the local authorities in Louisiana opted for the US Army Corps of Engineers (the Corps) to facilitate the clean-up works. The Corps let four debris removal contacts in the state of Louisiana. Contractors carried out kerbside collection and private property demolitions.

Temporary storage areas were established to sort material collected during kerbside collections. Some recycling was carried out, in particular metals were segregated and sold, and vegetative waste was chipped and used as mulch or for landfill cover. Limited recycling of construction and demolition (C&D) was carried out, particularly not of waste resulting from the private property demolitions. Instead mixed waste was taken to C&D landfills.

To facilitate an expedient clean-up a number of legislative changes and/or regulatory relaxations were enacted. These included:

- Provision for USEPA to waive any law under its jurisdiction.
- Expansion of waste acceptance criteria at C&D landfills.
- Streamlining of asbestos management regulations, including reduced work notification periods and training requirements.
- Streamlining of processes around house condemnation.

Five major factors governed the waste management process:

1. Overall coordination of the waste management process was lacking. Despite well established operational procedures, there was limited linking of the waste management process into other recovery activities, and there was no one monitoring waste management from demolition to collection to disposal. Problems were identified in a reactive rather than proactive way and dealt with in silos.
2. The full funding by FEMA for public and private property clean-up provided a platform for a community wide recovery. The large numbers of uninsured property owners would have left significant numbers of properties uncleared, posing a potential health risk and impacting on community recovery.
3. The organisation of the physical works and letting of large debris removal and demolition contracts had mixed results. Economies of scale were achieved and to a certain extent quality control was simpler. However, there were concerns over mismanagement by some of the large contractors who were not from the area. Limited use of local labour was also cited as a concern for residents. However, given the large scale of the problem and largely displaced population, we conclude that a contract approach was appropriate in this case.
4. There was significant relaxation of some environmental standards to facilitate recovery; in particular, the expansion of waste acceptance criteria at Louisiana Construction and Demolition landfills. The relaxation had the desired effect of allowing expeditious removal of waste; however, there is concern about future environmental remediation costs. In addition this meant there were limited recycling efforts.
5. From a health and safety perspective there was a relaxation in asbestos management guidelines to expedite the clean-up. The relaxation inevitably increased the risk to construction workers and potentially the community.

Contents

Acronyms

ACI	Advanced Contracting Initiative
ACM	Asbestos Containing Material
Al	Alabama
C&D	Construction and Demolition
CCA	Chromated Copper Arsenate
CDC	Centres for Disease Control and Prevention
CEQ	Council of Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CPDCDM	Comprehensive Plan for Disaster Clean-up and Debris Management
DEAO	Declaration of Emergency and Administrative Orders
DMP	Disaster Management Plan
ESF	Emergency Support Function
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office
GCRO	Gulf Coast Recovery Office
Hazmat	Hazardous Materials
HHS	Health and Human Services
La	Louisiana
LDEQ	Louisiana Department of Environmental Quality
LEAN	Louisiana Environmental Action Network
LESHAP	Louisiana Emissions Standards for Hazardous Air Pollutants
LPG	Liquefied Petroleum Gas
Ms	Mississippi
NAA	No Action Assurance
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NRF	National Response Framework
NRP	National Response Plan
OFDA	Office of Foreign Disaster Assistance
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
RACM	Regulated Asbestos Containing Material
RCRA	Resource Conservation and Recovery Act
US	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

1 Introduction

1.1 Disaster Waste Management

Disasters can create large volumes of inert and hazardous debris. The amount and composition of the waste depends on their type, the severity of the disaster, and the nature of the built environment. Recent natural disasters such as the 2010 Haiti earthquake (Booth, 2010; Johnson and Correa, 2010; Kahn, 2010), Victorian Bushfires 2009 (Brown et al., 2010a), and the 2004 Indian Ocean tsunami (Basnayake et al., 2005; Petersen, 2006) have all generated volumes of waste which overwhelmed existing solid waste capacities and required extraordinary management approaches.

Disaster debris can impede rescuers and emergency services reaching survivors; inhibit provision of lifeline support; pose a public and environmental health hazard; and hinder the social and economic recovery of the affected area. Poor management of a clean-up effort can result in a slow and costly recovery which is potentially risky to public and environmental health in both the short and long term.

The first and most comprehensive national guidance on disaster debris management was the USEPA's "Planning for Disaster Debris" (USEPA, 1995) which was updated in 2008 (USEPA, 2008). Most US local government authorities now have plans due to recovery cost incentives provided by the Federal Emergency Management Agency (USEPA, 2008). Outside the US, understanding of the need to plan for debris management is growing (Johnston et al., 2009; JEU, 2010).

The majority of reports of waste management following hurricanes/cyclones are from the US: Hurricane Ivan and the Seminole Hurricane Season 2004 (USEPA, 2008); Hurricanes Frances and Jeanne (Solid Waste Authority, 2004); Hurricanes Opal, Frances and Georges (Reinhart and McCreanor, 1999); Hurricane Iniki and Hugo (USEPA, 1995); and Hurricane Andrew (Tansel et al., 1994; Meganck, 1995; USEPA, 1995; Jones, 1996; Luther, 2008). Due to the wind and rain action, hurricane debris is usually highly mixed, relatively light weight and with a large amount of vegetative debris. Flood damage (normally due to storm surge) can cause flood damage including siltation (USEPA, 2008). As most of the literature is US based, the management approaches to waste management used in these cases were in line with Federal Emergency Management Agency (FEMA) debris management guidelines (FEMA, 2007a). The guidelines dictate the overall management and funding approach for disaster debris management. The responses to each hurricane varied due to the technical approaches selected, such as use of incineration, level of recycling, kerbside collection, disposal solutions, etc.

Establishing a solid waste management system in 'peace' time is a complex challenge – balancing stakeholder desires, community needs, environmental factors and political will. Adding a disaster to the challenge adds another level

of complexity by introducing extremely large volumes of debris, time pressures and a shocked community.

1.2 **Hurricane Katrina**

Hurricane Katrina was a Category 5 (downgraded to Category 4 on landfall) storm that hit the States of Louisiana, Mississippi and Alabama, United States (US) on 29 August 2005. The Hurricane alone caused widespread wind and rain damage. Storm surges and heavy rain resulting from the hurricane led to several breaches in the flood levees surrounding the predominantly below sea level metropolitan of New Orleans. 80% of New Orleans was inundated by 3 – 12 feet of floodwaters (Cook, 2009). The total area of destruction has been estimated at 90,000 square miles (233,000 square kilometres) (Esworthy et al., 2006).

Over 1800 people died (HHS.gov, accessed 2010). Over 600,000 residential structures were affected – 77% were totally destroyed (Roper, 2008). The disaster resulted in mass voluntary and involuntary evacuations. Four years after Hurricane Katrina some Parishes have still not returned to pre-Katrina population levels (51% for St Bernard and 76% for Orleans) (Brookings Institute, 2009).

The storm caused severe power cuts, crippling damage to water supply and sewage networks and facilities which took many months to reinstate (Esworthy et al., 2006).

There were significant numbers and volumes of oil spill events due to the number of oil and chemical industries in the area (Esworthy et al., 2006).

Hurricane Katrina generated the most disaster-related debris in the history of the US – more than twice the previous record generated by Hurricane Andrew in 1992. It is estimated that when the demolition of affected properties is complete, approximately 100 million cubic yards (76 million cubic metres) of debris would have been generated and disposed of in the three affected states, with 64 million cubic yards (49 million cubic metres) in the State of Louisiana alone (Luther, 2008).

While cost estimates from Hurricane Katrina waste management are yet unknown, the management of disaster debris in the US over the last five years has been estimated at approximately 27% of total recovery costs (FEMA, 2007a) so it is likely Hurricane Katrina's waste management will be in this order.

1.3 **Report Scope**

This report includes: a brief overview of the response and the initial stages of the recovery from the Hurricane Katrina; and details of the disaster waste recovery process – including demolition works, collection and disposal. The final section of the report is an analysis of the strengths and weaknesses of the key waste management decisions. The report focuses on the city of New

Orleans, Louisiana. Not that a comparison between the efforts in Mississippi and Louisiana might be worthwhile investigating.

The report forms a case study of a modern disaster waste management system. It will be used, by the authors, as part of a wider study on disaster waste management systems and will in time be compared with other case studies to try and develop a strategic and integrated approach to planning for and responding to disaster waste.

It should be noted that the focus of the report is on the recovery phase, therefore waste management during the emergency phase is commented on but not analysed in any detail.

The definition of waste here includes all waste types except for animal and human remains and wastewater.

2 Methodology

2.1 Literature review

This case study is developed from both pre-disaster contextual information and post-disaster reporting. Documents cited for contextual information include websites, laws and statutes, design guidelines, reports – all mainly government produced. Post disaster literature included government status reports, websites, and public information brochures. Some newspaper articles have also been cited.

2.2 Professional interviews

Due to time constraints and constraints on access to appropriate personnel, only two telephone interviews with persons involved in the debris management process were carried out. The interviews were unstructured and were primarily to fill in the gaps in information identified in the literature.

2.3 Limitations

There are a number of limitations with forming the case study purely from published documents. These include:

- Potentially moderated accounts
- Aggregated organisational perspectives rather than individual ones.
- Generally only the final decision or outcome is presented rather than the process taken to reach that decision
- Predominantly government sourced document and perspectives, and few contractor or private company perspectives
- Second hand community impact data
- Possible misinterpretation by authors with no chance for clarification
- Information gaps

The interviews carried out assisted in closing some of the gaps in the information and gaining individual accounts on various aspects of the waste management and demolition process.

3 Hurricane Katrina waste management

3.1 Waste

3.1.1 General composition and nature

Esworthy et al (2006) classify the hurricane waste into the following categories.

- Municipal solid waste — general household trash.
- Construction and demolition (C&D) debris — building materials (which may include asbestos-containing materials), drywall, lumber, carpet, furniture, mattresses, plumbing.
- Vegetative debris — trees, branches, shrubs, and logs.
- Household hazardous waste — oil, pesticides, paints, cleaning agents.
- White goods — refrigerators, freezers, washers, dryers, stoves, water heaters, dishwashers, air conditioners.
- Electronic waste — computers, televisions, printers, stereos, DVD, players, telephones.

Tyres, (potentially toxic) flood sediment, industrial wastes, spoiled food etc. (Luther, 2008) and surplus and/or weather damaged donations have been identified as significant additional components of the waste stream.

Estimation of debris volumes was extremely difficult. The USACE had some techniques to estimate waste, such as using population and land use, but found them difficult. Hotels and rental properties along the coast, particularly, made it difficult to estimate waste volumes. Satellite imagery was also used to count homes damaged for waste estimation. LDEQ estimated that each house demolition generated 300-350 cubic yards (229-267 cubic metres) of debris (LDEQ, 2006b).

The hurricane and flooding combined meant that wastes were often mixed beyond the point where separation was practical (Esworthy et al., 2006). The wind and flood damage also meant that a lot of property was moved from the original property site to neighbouring properties. Some houses were lifted off their foundations and carried blocks away. This made property identification in some cases difficult to determine.

In the areas worst affected by floods, debris removal could not have commence until any earlier than October / November due to the presence of the floodwaters and difficulty in draining the area.

3.1.2 Specific waste related hazards

In general hazardous materials (hazmat) included tanks (propane, BBQ cylinders, above-ground storage), batteries, paint, flammable material, corrosives (acids), chlorine (pool chemicals), pesticides, waste oil, household chemicals and ammunition (FEMA, 2006).

In addition to these general household waste hazards there were some specific hazards identified as being particularly hazardous post Hurricane Katrina:

Sediments

The storm surge, subsequent levee breach and pumping of floodwaters into Lake Pontchartrain resulted in large volumes of sediments being transported and deposited in large areas of New Orleans. There were initial and ongoing concerns over the potential public safety and environmental hazards associated with the sediments – particularly as the flood waters derived from pre-historic petro-chemical sites and the overflow of wastewater facilities (Esworthy et al., 2006).

The United States Environmental Protection Agency (USEPA), commenced sampling of the floodwater sediments in New Orleans on 10 September 2005. It was generally found that some metals, petroleum hydrocarbons and pesticides were detected but they were generally below levels of health concern. Levels of arsenic, poly aromatic hydrocarbons, diesel and oil that exceeded the USEPA's 30-year exposure criteria were found in isolated areas. However, the USEPA did not believe there was a significant risk for short term exposure if the public and workers adhered to good health and safety practices. Some bacteria (including E. Coli) were also detected in the soils for which USEPA did not have any existing guidelines on exposure to, so USEPA could only issue general advice on limiting contact with the sediment (Esworthy et al., 2006).

Some studies have shown iron and lead levels in the soil in excess of USEPA acceptable levels for chronic exposure and, in the case of lead, exceeding levels which require prioritised remediation (Presley et al., 2005). However, Esworthy et al noted that some of the sites were contaminated pre-Katrina and elevated levels of lead in particular have already been documented (Esworthy et al., 2006).

Dust

Dust from dried contaminated sediment (including contamination from chemical spills, petro-chemical residues, pathogens) was identified as an inhalation hazard. Air quality testing began on August 30 to test damage from the storm and to monitor the impact of clean-up and restoration activities. Initial sampling indicated that air-borne pollutants were below health standards and health concerns would only arise after a year or more of exposure (Esworthy et al., 2006).

Mould

The floodwaters from Hurricane Katrina introduced the health risk associated with mould, mildew and fungi arising from the warm, wet conditions.

Potential health effects include respiratory effects, infections, allergic reactions and toxic effects. However, the Centres for Disease Control and Prevention (CDC) had no established guidelines on exposure to these hazards (type, concentration) and could only offer generic advice to beware of the hazard (Esworthy et al., 2006). It is unknown whether there were real effects from mould. This is an area worth further investigation.

Arsenic
Arsenic, commonly used in the form of Chromated Copper Arsenate (CCA) to treat timber used in construction, has been identified as a significant hazardous component of the waste matrix. A study at the University of Florida estimated that out of the total 72 million cubic metres of waste generated from the event, there was 12 million cubic metres of treated wood - which equates to 1740 metric tonnes of arsenic (Dubey et al., 2007).

Arsenic has adverse health effects when inhaled or ingested (USEPA, 2000).

Vectors
Disease carrying rodents and insects were highlighted as a concern due to the presence of putrescible waste and increased areas of standing water. The problem was aggravated by the evacuation of vector control personnel and the damaging of equipment. Some spraying was carried out for mosquito control, however, this was limited by the health concerns to recovery personnel (Esworthy et al., 2006).

Asbestos
Asbestos is typically present in buildings built prior to 1975.(USEPA, 2005b) and so was present in large numbers of affected properties.

3.2 Organisation

3.2.1 Overall coordination
Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act a governor can request the President to issue a major disaster declaration. This declaration invokes emergency assistance from federal authorities which is administered by the Federal Emergency Management Agency (FEMA) (a branch of the Department of Homeland Security). Federal disaster assistance is carried out in accordance with the National Response Plan (NRP) (now superseded by the National Response Framework 2008). The intention of the plan is to maintain primary disaster management jurisdiction at state and local level but for federal assistance to be provided when capacities are overwhelmed (Esworthy et al., 2006).

The NRP has 15 Emergency Support Functions (ESFs). Each ESF outlines lead agencies, roles and responsibilities, planning requirements, and resources etc. When an emergency is declared, FEMA assigns missions to various ESFs and priorities are determined under each ESF jointly among state, tribal, and/or local officials (FEMA, accessed 2010). For waste management issues there are primarily two ESFs:

- ESF#3 – Public Works and Engineering – coordinated by the US Army Corps of Engineers (USACE or the Corps) and with FEMA as another primary agency.
- ESF #10 – Oil and Hazardous Material Response – is coordinated by USEPA with The US Coast Guard as another primary agency.

However, while the majority of waste management activities are carried in the ESF #3 and #10, a review of the ESF shows that a number of other ESF involve aspects of waste management. Certain waste activities are also carried out in ESF #'s 4, 6, 8, 11, and 14. In addition waste activities are impacted by ESF #'s 1, 2, 5, 7, 11, 12, and 13 and in turn impact activities in ESF 1, 7, 9, 11, 13, and 14. Appendix A shows a summary of the ESF and relevant support agency activities. In all there are about 19 government departments involved in or affected by waste management activities.

In addition to the pre-established NRP roles, a Gulf Coast Recovery Office (GCRO) was established to oversee and coordinate FEMA's recovery activities across the affected states. It is unknown exactly what role the GCRO played in waste management activities.

Establishment and monitoring of environmental standards etc. were the responsibility of the state environmental department – Louisiana Department of Environmental Quality (LDEQ). USEPA was responsible for ensuring federal environmental regulations were met and providing technical advice where necessary. The majority of the standards and procedures for handling and disposal of disaster waste were established by LDEQ. Any contractors engaged by the Corps of local authorities had to adhere to these guidelines.

3.2.2 Physical works

Local authorities can choose to either facilitate debris management works and be reimbursed by FEMA or the Corps can be authorised to facilitate the works directly. In the latter case the Corps typically contract the work out to private contractors and the Corps monitor and provide technical assistance for removal and disposal of waste on publically owned property (Esworthy et al., 2006). Under the USACE Advanced Contracting Initiative (ACI) there are existing contracts in place to respond in disaster situations. However, the scope of the works following Hurricane Katrina exceeded the cost limit on these contracts. The Corps let three contracts to manage the debris from Louisiana alone – two for New Orleans and one for the rest of Louisiana. The contracts totalled US$1.5 billion (Cook, 2009). Some pre-existing contracts for immediate disaster debris response in New Orleans were activated prior to these new contracts being let (Jackson, 2008).

Initially, waste management efforts concentrated on clearing public property and rights of ways (Esworthy et al., 2006). Under normal circumstances private property owners are responsible for clearing waste on their own property. However, it became apparent that many private properties were not being cleared due to the large numbers of people displaced from the region and this posed a public health hazard. As a result local authorities stepped in

to remove wastes. Initially local authorities attempted to manage this process but in March 2006, the state of Louisiana requested FEMA assistance in management of this process (FEMA, 2007b).

FEMA was only responsible for clearance of private properties where property owner consent had been obtained. FEMA did not have authority, however, to carry out works on properties where property owners could not be contacted or consent could not be gained. Local authorities were responsible for facilitating these 'condemned' (recognised as a public health threat) property clean-ups.

3.2.3 Disaster debris management plans

The USEPA and FEMA both have guides for planning for disaster debris management which were operational before and were updated following Hurricane Katrina (USEPA, 1995; FEMA, 2007a; USEPA, 2008). State and/or local authorities are responsible for preparing detailed operational disaster debris management plans. FEMA has also recently given incentives, by way of increased federal contributions for clean-up activities, for local governments that establish pre-event plans (USEPA, 2008)

Both Louisiana and Mississippi had disaster debris management plans prior to the event. Both, however, were required to update the plans to reflect requirements, emergency laws, procedures and protocols specific to Hurricane Katrina including hazardous material handling, disposal site selection etc. (Esworthy et al., 2006). On September 28, 2005, LDEQ issued a Hurricane Katrina Debris Management Plan (DMP), which was later revised on October 14, 2005 (LDEQ, 2005c). In July 2006, Louisiana also issued a Comprehensive Plan for Disaster Clean-up and Debris Management (CPDCDM) (LDEQ, 2006a) for management of future disaster debris. The CPDCDM was a directive of the 2006 Louisiana Legislature Senate Bill 583, Act 662. The plan is consistent with state and federal law but does not supersede any local ordinances. The plan states that it may be superseded by any Declarations of Emergency.

The CPDCDM plan outlines debris management goals, priorities, options and allows LDEQ regulatory flexibility to waive or modify regulatory requirements if necessary for 'rapid and environmentally sound waste management'. The goal for disaster clean-up outlined in the comprehensive plan is 'to facilitate a reasonable, efficient and prompt recovery from such disasters and be protective of human health and the environment' (as directed by the Senate Bill 583). While at the same time the plan states that 'the primary objective of the plan is to conserve landfill capacity and to protect natural resources to the maximum extent practicable'. The priority of debris management options are: *"to the extent that they are appropriate, practical, efficient, timely and have available funding: recycling and composting; weight reduction; volume reduction; incineration or co-generation; and land disposal"* (LDEQ, 2006a).

When an ESF function has been activated and federal agencies are managing debris removal operations it is the responsibility of USACE to prepare a debris management plan. Following Hurricane Katrina, there was some initial

confusion over the responsibility to do this. USEPA and USACE subsequently worked together to prepare a plan.

3.3 **Legislation**

3.3.1 Federal waste and emergency laws

Waste management activities are carried out predominantly in accordance with the federal Resource Conservation and Recovery Act (RCRA) (management of solid and hazardous waste) and the Clean Air Act. States are authorised by the USEPA to implement these federal laws. RCRA includes provisions such as landfill standards and hazardous waste management. The Clean Air Act requires the establishment of National Emissions Standards for Hazardous Air Pollutants (NESHAP) for management of air pollutants and hazards such as asbestos. Louisiana implement their own version of NESHAP (Louisiana Emissions Standards for Hazardous Air Pollutants – LESHAP) (Esworthy et al., 2006). Other federal legislation related to disaster debris management are outlined in FEMA's Debris Management Guide (FEMA, 2007a).

In a state of emergency, USEPA and other regulatory agencies have powers (including waiving regulatory requirements or invoking enforcement discretion) under several statutes. The Robert T. Stafford Disaster Relief and Emergency Assistance Act, for example provides waiver authority to USEPA to waive administrative conditions to enable federal agency assistance following a disaster (McCarthy and Copeland, 2006).

The Stafford Act also waives certain requirements under the National Environmental Policy Act (NEPA)(42 U.S.C. 5159). The NEPA is a procedural act which requires an environmental impact statement to be prepared for any major federal action affecting the environment. Under the Stafford Act, NEPA regulations are specifically exempted for debris removal from public or private land after a major disaster (See 42 U.S.C. § 5173.). It is interesting to note that for longer-term recovery / reconstruction activities the provisions of the Stafford Act do not apply. Congress may, however, exempt some NEPA regulations to facilitate recovery efforts. In this case "The Louisiana Katrina Reconstruction Act" (S.1765), (September 22, 2005) directed the establishment of the Pelican commission which would work with the Corps to develop a reconstruction plan. All projects within the recovery work plan were exempted from NEPA requirements (Luther, 2005).

On September 12, 2005, three Heritage Foundation analysts concluded that regulatory requirements should be waived to facilitate the clean-up and redevelopment. This was recommended in order to reduce the regulatory and bureaucratic processes and controls to let communities rebuild how they wanted. However. in a press release following this report the USEPA Administrator was reported as having said that current legislation was not standing in the way of USEPA's response (McCarthy and Copeland, 2006).

Despite this on September 16, 2005, S.1711 was introduced by Senator James Inhofe the Chairman of the Senate Environment and Public Works Committee

and Senator David Vitter of Louisiana. The provision allowed the USEPA to waive any law under its jurisdiction 'if it is necessary to respond in a timely and effective manner "to a situation or damage relating to Hurricane Katrina"' for up to 18 months. Interestingly as of February 2006 no action had been taken on any of this bill (McCarthy and Copeland, 2006).

3.3.2 State waste and emergency laws

The majority of the debris removal activities were carried out outside the state of emergency. Therefore, apart from the specific exclusion from NEPA requirements (and disregarding the new un-utilised powers given to USEPA), all federal laws had to be met. State and local laws, however, could be waived. In Louisiana, LDEQ issued Declaration of Emergency and Administrative Orders[1] (DEAO) to guide the demolition and debris removal works and formalise legal waivers. The DEAOs were the main legal framework guiding the waste management process. The DEAOs outlined measures to be taken in order to prevent irreparable damage to the environment and serious threats to life or safety. The details of the DEAO provisions will be detailed in the following sections, but broadly they include works pertaining to:

- Wastewater Treatment Systems
- Solid Waste Management
- Open Burning
- Air Pollution
- Asbestos clean-up
- Hazardous waste management

The measures included relaxation in permitting and quality assurance requirements, authority to make disaster damage repairs on solid waste management facilities and general waste management strategies (including waste disposal sites and waste acceptance criteria, waste separation, burning restrictions, carcass disposal, hazardous waste storage etc.). The orders maintained some stringent requirements such as the requirement for hazardous waste separation and prohibition of burning asbestos containing waste (McCarthy and Copeland, 2006).

Some processes were also streamlined to facilitate recovery. For example, due to the public health threat from the presence of the disaster waste, authorities exercised statutory powers to remove debris. Notification processes were streamlined to expedite debris removal processes, particularly where property owners could not be notified. In Louisiana regulatory requirements for consultation prior to issuing certain permits were reduced in the 4th DEAO in January 2006 (LDEQ, 2006d). The procedures categorised the level of damage in areas (using criteria such as newspaper delivery rates, service usage, schools rolls) and then outlined consultation requirements based on the need to make timely decisions but to also maximise public input into decision-making. FEMA also loosened their requirements for legal approvals to permit reimbursable work on private property (FEMA, 2005a).

[1] In accordance with Louisiana Revised Statutes 30:2001 et seq., and La. R.S. 30.2033 and 2011(D)(6).

The first DEAO was issued on 30 August 2005 with a duration 60 days. The order covered all parishes affected by the Hurricane (LDEQ, 2005b). By the eighth amendment on 17 January 2007 the emergency area had been reduced to eight out of the 25 original affected parishes (LDEQ, 2007a). The final (fifteenth) amendment was issued on 1 September 2009 (LDEQ, 2009) and included only six parishes. The final DEAO expired on 31 December 2009. Extensions of the DEAO for parishes would only be granted if it was proven (by the parish) that without the DEAO there would be irreversible effects on the environment and/or a serious threat to life or safety (LDEQ, 2007b).

Details around specific legislative changes are outlined in the relevant subsections of Section 3.5.

3.4 **Funding**

Under the Stafford Act, FEMA is authorised to release funds under the Public Assistance Program for certain response and recovery activities. Typically, the only eligible debris removal activity is removal of waste in public right of ways. Private property owners (including businesses) are expected to clear their own properties and move the debris to the right-of-way for clearance by designated disaster debris management contractors. Cost share is typically 75% federal and 25% non-federal (state or local) (Luther, 2008). Waste resulting from repairs and rebuilding are not eligible for FEMA funding unless it is part of an approved project. It is considered the insurance will cover the cost of such repairs (FEMA, 2007a). In general, FEMA classifies itself as the insurer of last resort.

Following Hurricane Katrina, several amendments were made to the typical allowances described above. First FEMA funding was increased to cover 100% of the debris removal works and second FEMA agreed to cover debris removal on private properties where it was demonstrated (by the local / state authorities) that there was a significant health and safety risk and there was a legal responsibility to manage the waste. Given the Department of Health and Human Services declared a health emergency in affected areas, FEMA determined that all hurricane-related debris in affected areas was eligible for funding (FEMA, 2005a). A fact sheet on private property debris removal funded by FEMA was prepared on 8 September 2005 (FEMA, 2005a) and the FEMA policy was signed on 15 September 2005 (FEMA, 2005b). However, it took some time for LDEQ to prepare streamlined processes for notifying and gaining approvals from private property owners. Provisions for private property debris removal were formally announced in the 4th amendment to the DEAO in January 2006 (although some individual parishes were approved prior to this (FEMA, 2005c). Initially the funding provisions were for the period up to 30 June 2006, however, this was incrementally extended in certain parishes, as required, until 31 July 2007. After which time debris removal operations federal reimbursement was reduced to 90% (Luther, 2008).

As well as funding for physical works, FEMA provides funding for some Federal government authorities. FEMA continued its funding of USEPA until

29 August 2008 at which point USEPA concluded its Katrina response activities (GAO, 2008).

Some homeowners had insurance as well. Insurance in the US is by hazard – in this instance private insurance covered hurricane damage and the National Flood Insurance Programme covered flood damage. Most people in hurricane zones had insurance for hurricanes, however, many people did not have flood insurance. Flood insurance is required by mortgage companies for any property in the 100 year flood zone. Houses without mortgages are not required to hold this insurance and as a lot of the houses in the affected areas were generational homes and were freehold, a large number of people did not have insurance. Flood damage caused by levee breach in Louisiana led to many insurance companies denying insurance claims for hurricane damage (The World Bank and UNISDR, 2007). Generally public buildings and public works take out insurance or set aside funds (self insured) for disaster events.

Where owners have insurance and receive money or in kind assistance (such as kerbside collection and demolition services) through the FEMA, they are legally required, under federal law, to reimburse FEMA via the local authority or state (FEMA, 2006; 2007a). However, it is unclear what, if any, mechanism was in place to manage this and how much money, if any, was recovered.

Hurricane Katrina was the first event in US history to formerly accept in kind and cash foreign aid. No processes had been established to manage foreign aid before. A task force was established within FEMA to liaise with the Office of Foreign Disaster Assistance (OFDA) and international donors to try and meet needs and minimise unwanted donations.

There were other informal funding mechanisms including some communities with access to diaspora networks and/or remittances. The Vietnamese community in east New Orleans were an example of this. Access to funds and strong community leadership led to an expedited recovery in this community (The World Bank and The United Nations, 2010).

3.5 **Waste management process**

The basic organisation of waste management is shown in the waste flow diagram shown in Figure 3-1.

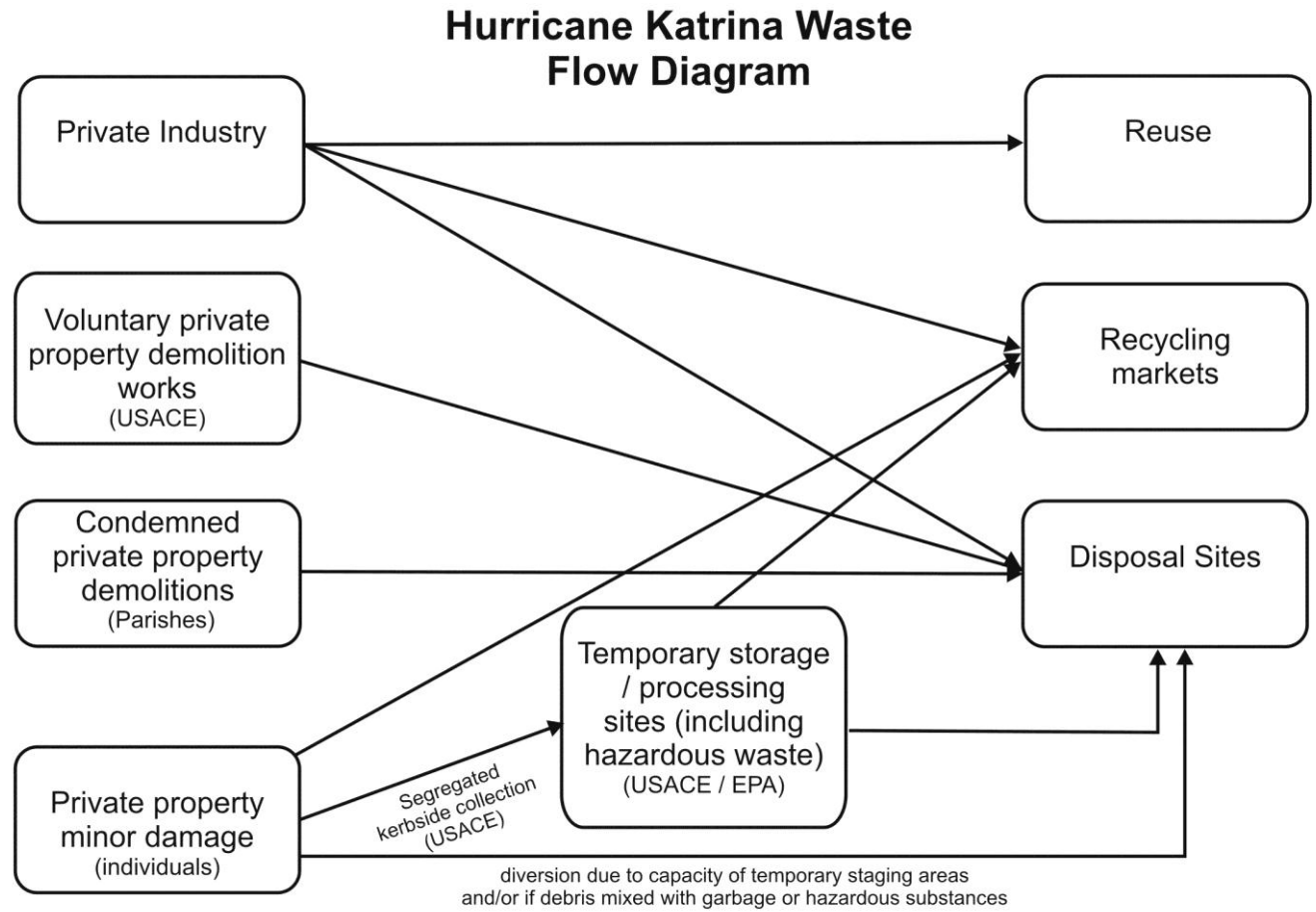

Figure 3-1 Hurricane Katrina Waste Flow Diagram

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3.5.1 Property clearance

Private property

As discussed in Section 3.4, private property clearance was primarily the responsibility of the property owner. However, if a property was deemed to be a public health risk by the local authority, the property owner could apply to their local parish or FEMA to have the debris cleared (Bauer, 2006). Every property owner was required to sign a right of entry agreement, as waste operators / local authorities are ordinarily prohibited from entering private properties unless there is an imminent health threat (Esworthy et al., 2006).

Historic properties

Any work carried out under FEMA's Public Assistance programme has to be carried out in accordance with the National Historic Preservation Act. This work requires liaison, consultation and right of entry permissions to be gained from various historic places trusts, organisations and authorities. Work on these properties had to be carried out with great care – in some cases work was carried out by hand (FEMA, 2006).

Waterway debris

Local authorities applied to FEMA for assistance in clearance of debris in waterways. Debris included vessels, tanks and vehicle removal. A FEMA and US Coastal marine led team was established to assess eligibility and the appropriate funding agency (FEMA, 2006).

The Comprehensive Plan for Disaster Clean-up and Debris Management (LDEQ, 2006a) included a section on management of debris in marsh areas. Retrievable debris, adjacent to a marsh or waterway had to be retrieved and managed in accordance with this plan. All debris in marsh areas had to be handled using ESF-10 protocol which sometimes involved marsh trustee consultation. Marsh burning is presented in the plan as a potential option for management (as it is used to control vegetation growth every 2-3 years anyway), however, caution is noted to consult with all relevant stakeholders/authorities (eight are listed in the plan) and to consider all potential hazards (environmental and public health and safety) before burning. It is unknown if burning was used in the response to Hurricane Katrina.

3.5.2 Demolition

As discussed in Section 3.4, where a public health threat existed, property demolitions were funded by FEMA. There were 2 categories of demolition – voluntary and condemned. Voluntary demolitions (that is those with the owners' permission) were carried out by private contractors engaged by the Corps/ FEMA commencing in March 2006. FEMA required condemned demolitions (those without owner consent) to be carried out by the Parish or appointed contractors. This handover to the Parish caused a 3-5 month delay as new demolition contracts had to be tendered and awarded. At the same time a 30-60 day condemnation public notice period was required prior to demolition. Condemned house demolitions commenced in March 2007 and

as of 1 August 2008 were numbered at over 16,000 (GAO, 2008)[2]. According to some reports there are still 'condemned' houses awaiting repair five years after the Hurricane (Trethewey, 2010).

No details have been obtained on the exact process around each property demolition. It is understood limited recycling was carried out and property owners were invited to be present to salvage personal belongings from their properties.

Aside from the federal and local demolition works, some non-government groups offered house demolition programmes. In October, 2005 Mercy Corps sponsored the deconstruction of a limited number of homes. The aim of the project was to redirect house demolition and the salvaged materials back under control of the homeowners. Most homeowners donated the used building-material to depots for low-cost resale. (Denhart, 2010)

The National Historic Preservation Act governs the protection of historical buildings. Debris activities must comply with this Act.

3.5.3 Asbestos

In the US, asbestos is governed by federal laws (NESHAP) which cannot be waived. USEPA was required to work with state environmental departments to determine regulations and procedures within federal limits to facilitate the clean-up.

The initial LDEQ DEAO reduced the 10-day notification period for asbestos removal works by a notification requirement within 24 hours of commencement. All standard asbestos handling requirements (such as wetting of demolition sites / debris, controlled demolition, air monitoring etc) were required to be met and disposal was to be at a Type I or Type II landfill[3]. Burning of asbestos was prohibited (LDEQ, 2005b). An amendment to the DEAO (4 days after the original declaration) clarified that a thorough inspection of a facility was only required if regulated asbestos was known to be present. It also specified that appropriate Personal Protective Equipment (PPE) was *recommended* and asbestos handler training requirements were reduced (including recognition of not previously Louisiana state approved qualifications and reduced requirements for notification of training course commencement) (LDEQ, 2005a).

Following this the October 2005 Hurricane Katrina Debris Management Plan (LDEQ, 2005c) was issued. In the plan asbestos handling guidelines were outlined including the requirement to have licensed asbestos handlers on all contracting teams. To facilitate this LDEQ reduced the licensing and accreditation period.

[2] Enclosure VI – Louisiana Department of Environmental Quality report comments, letter dated 14 August 2008, subject :Re: Draft Report of GAO's Review of Hurricane Katrina debris Removal and Disposal.

[3] Type I landfills are for industrial and/or hazardous wastes. Type II landfills are typically for municipal wastes.

The second amendment (November 2005) of the DEAO reduced requirements for appointment of abatement project designers and reduced the fee for accrediting asbestos workers (LDEQ, 2005d).

In February 2006, the USEPA granted 'No Action Assurance' (NAA) letters in Louisiana (LDEQ, 2006a) to LDEQ, the Corps, local government and any parties acting under their direction. These letters allowed a relaxation in some standard asbestos demolition and disposal procedures (NESHAP regulations). LDEQ were also granted delegated authority to apply the relaxations to their own LESHAP.

The standard NESHAP/LESHAP requirements regulate handling, monitoring and reporting requirements for any asbestos containing structure except:

- Individual residential dwellings (with four units or less) and
- Structurally unsound buildings being demolished under a government order
- Buildings effectively demolished by a disaster (LDEQ, 2006a).

LESHAP regulations do not apply to these three exemptions above, therefore collection, transportation and disposal could begin immediately (LDEQ, 2006a)

The LDEQ NAA letters allowed for any hurricane related government ordered demolitions (which may be structurally unsound, moved off their foundations; or uninhabitable due to environmental reasons) to be carried out the same as structurally unsound buildings under NESHAP. That is no pre-demolition inspection was required and asbestos did not have to be removed prior to demolition, provided emission control measures were implemented. Notification, NESHAP handling (primarily wetting surfaces at all times), transport and disposal requirements still applied (LDEQ, 2006e). Segregation of asbestos was recommended in this case study, as long as it doesn't have a high chance of becoming friable. For Regulated Asbestos Containing Materials (RACM) in sound structures, buildings must be sealed and the RACM bagged and labelled. Occupational Safety and Health Administration (OSHA) regulations must be followed (LDEQ, 2006a).

The NAA letter also allowed for structural assessments (to ascertain unsoundness) to be carried out on groups of houses (as opposed to individuals) if necessary. Disposal location selection was deferred to the State provided the sites met the NESHAP regulations. Structurally sound or non-condemned, houses still had to go through standard "thorough inspection" processes prior to demolition (LDEQ, 2006e).

The NAA letter was reflected in the fifth amended DEAO in March 2006. This order also outlined reporting procedures for waste handlers – limiting requirements to one asbestos material report per day per contractor / landfill operator (LDEQ, 2006c) as opposed to one per truck load to landfill..

In the sixth amended DEAO in June 2006, LDEQ increased the disposal options established in the first DEAO. The revised order included deposition

at enhanced Type III (unlined construction and demolition) landfill. The requirements for approval as an enhanced Type III landfill include air monitoring, reporting and segregated waste placement procedures that meet NESHAP guidelines and as outlined in appendix J1 of the order. RACM material from properties with thorough inspections still had to be deposited in Type I or II landfills authorised to take asbestos (LDEQ, 2006e). These relaxed procedures have been adopted in the LDEQ Comprehensive Plan for Disaster Clean-up and Debris Management (LDEQ, 2006a).

Monitoring
Monitoring of demolition sites by USEPA and LDEQ was carried out from March 2006. Inspectors were present to ensure that the no action assurance provisions were being met and there were no significant hazards. If necessary, enforcement action was taken. The most common concerns identified were insufficient wetting of surfaces, using non-accredited asbestos handling personnel and insufficiently wrapping RACM (GAO, 2008).

3.5.4 Kerbside collection / transportation

Established disaster waste management processes in the US are designed around resident participation (USEPA, 1995; 2008). In most cases residents are expected to clean their own properties and place segregated debris piles on the curb for collection. The level of destruction of Hurricane Katrina – not just to homes, but to infrastructure and services – has meant that a lot of residents were slow to return and participate in this clean-up process, if at all. This had a significant impact on the nature and timeliness of the debris management process (Esworthy et al., 2006; Luther, 2008; Cook, 2009).

For residents who were able to use the kerbside collection it was requested by the Corps that the debris be separated as follows (Luther, 2008):

- White goods
- Metals
- Vegetative debris
- Electronic wastes
- Household hazardous waste
- C&D waste (including asbestos-containing material)
- Tyres

Collection vehicles would pass through the community to pick up respective piles of materials to take to landfill, reclamation (including recycling or reuse facilities) or burning sites as appropriate (as detailed in the following sections) (Esworthy et al., 2006).

In some instances residents did not separate their wastes, so debris collection crews were required to collect the mixed waste and take it to staging areas (see Section 3.5.5) for sorting (Esworthy et al., 2006). If garbage, however, was placed in public areas or was mixed with the household debris, the debris collection was not eligible for FEMA reimbursement and therefore was often not collected by contractors. Haulers described the commingling of hazardous and solid waste debris as an issue (O'Connell, 2005). Consequently, piles of

mixed waste were left on the kerbside indefinitely until a municipal waste collection truck or a non-government group such as the Tactical Trash Force could remove the debris (Jackson, 2008). There were also some allegations of residents separating materials for kerbside collection and out-of-town contractors coming along, mixing the waste and dumping it (Allen, 2007).

3.5.5 Temporary staging areas

Temporary staging areas were used throughout the city to sort, store and process collected (segregated and non-segregated) waste (Jackson, 2008). Temporary disposal sites were generally located by local government and then approved by LDEQ (LDEQ, 2006a). The first DEAO, 30 August, 2005, allowed for staging areas to be authorised by LDEQ personnel either by site visit or by a written application (LDEQ, 2005b). The LDEQ debris management plan (and later CPDCDM) provided generic technical and managerial guidance on selection and operation of temporary staging areas – including closure and monitoring. The plans identified the use of temporary staging sites for: staging and transfer of construction and demolition (C&D) debris; staging of vehicles and boats; staging of household hazardous waste; chipping, grinding and/or burning of vegetative debris; and staging of white goods, electronics and other consumer items (LDEQ, 2005c; 2006a). Due to the volumes of particularly Construction and Demolition (C&D) debris being generated, these sites alone could not process the waste and were used in conjunction with landfill disposal. Approximately 30 sites were required for Orleans Parish alone (LDEQ, 2006b).

3.5.6 Recycling and reuse

It is understood there were no recycling targets set for management of the debris. Resource recovery on a large scale was not deemed feasible due to the time to process such large volumes of material and landfilling was identified as the primary management option (LDEQ, 2006b). The 2006 CPDCDM, however, targets a legislative goal of 50% reduction by volume and weight before deposition to landfill for future disaster responses (LDEQ, 2006a).

Metals / Electronic wastes

Metal and electronic wastes (after certain materials, e.g. batteries, have been removed) were recycled as far as possible (Esworthy et al., 2006; Luther, 2008).

White Goods

In the DMP, LDEQ encouraged local governments to set up whiteware drop-off sites and encouraged contractors to separate white good as much as possible during demolition works. USEPA certified technicians were required to remove and dispose of refrigerants in accordance with USEPA regulations (LDEQ, 2005c). The initial LDEQ DEAO stated that white goods should be stored separately and securely away from other waste to prevent odour and vector problems and they must be managed within 90 days (LDEQ, 2005b).

C&D waste
The initial LDEQ DEAO stated that C&D debris did not have to be separated from other hurricane debris before disposal (LDEQ, 2005b). However, the second amendment to the DEAO highlighted recycling and reuse (or diversion) as a priority and that 'every effort should be made to minimize the disposal of reusable and recyclable material in landfills'.

The CPDCDM identified grinding as an effective means of volume reduction. Potential sites for grinding were proposed by local government, approved by LDEQ and the site operator was provided with a site operation plan by local government (LDEQ, 2006a). Grinding of C&D waste was the subject of some concern over compliance with NESHAP regulations (LDEQ, 2006b). Overall, there was limited recycling of C&D waste – the majority went to C&D landfills.

Vegetative waste
The DMP identified possible uses for chipping / grinding of vegetative waste, including mulch, boiler fuel, composting and included some technical advice on management of vegetative waste to avoid self-combustion (LDEQ, 2005c; 2006a). According to Esworthy et al. (2006) vegetative debris was cleaned and mulched for use as landfill cover. Luther (2008) also cited that some uncontaminated vegetative debris was burned. The 2006 CPDCDM states that landfill must not be the first option for vegetative waste (LDEQ, 2006a).

Composting was seen as impractical, and vegetative waste was a low priority when compared with the immense volumes of C&D waste to process (LDEQ, 2006b).

Vehicles and vessels
Holding sites for both vehicles and vessels were identified by local governments and approved by LDEQ. Vehicles and vessels were held for owner notification, and insurance and police inspection. Vehicles were then recycled and disposed. Disposal of any unclaimed cars was carried out with federal assistance as per local and state laws (LDEQ, 2005c; 2006a). Boat owners were much harder to identify than vehicle owners as the Boat Identification Numbers are not as well managed as their vehicular equivalent.

The fourth amendment of the DEAO identified the 350,000 vehicles to be disposed of. The 4-5 tyres per vehicle were identified as a significant drain on the Waste Tyre Management Fund which provides subsidies for resale and recycling of tyres. The DEAO removed the subsidy from tyre handling and required operators to record the resale, recovery or disposal of all tyres against the vehicle identification number for reimbursement using disaster debris removal funds (LDEQ, 2006d). The CPDCDM identifies that the suspension of WTMF subsidies may be implemented in future disasters (LDEQ, 2006a).

3.5.7 Hazardous and special waste

The initial DEAO granted all hazardous waste facilities extensions for storage of hazardous materials at their site. The extension was to facilitate time for repairs to facilities and to manage the large quantities of materials. The DEAO also stated that all hazardous wastes should be separated from the

hurricane debris, disposed of at permitted commercial hazardous waste facilities and generally managed in accordance with state regulations (LDEQ, 2005b). Generally LDEQ encouraged the establishment of drop-off sites and segregation for household hazardous waste but gave no further guidance on recycling and disposal (LDEQ, 2005c; 2006a).

USEPA operated a combination of hazardous materials (hazmat) drop-off events and kerbside pickups to manage the hazardous waste stream (FEMA, 2006). USEPA found that the volume of hazardous materials requiring treatment overwhelmed existing companies and a significant amount of USEPA effort went into trying to identify appropriate management options.

Putrescible wastes
High temperatures and prolonged power outages following the hurricane led to a big problem with rotting food waste. USEPA managed this process despite it being outside its usual jurisdiction. USEPA could deal with food waste in public places or if right-of-entry was approved by property owners or if local law enforcement requested clean-up. Residents were advised to place fridges, sealed with duct tape, on the kerbside for collection. Fridges were taken to a central facility where putrescible waste was removed and disposed of at Type II landfills (LDEQ, 2005c). White goods were recycled as described in Section 3.5.6.

Liquid Petroleum Gas Tanks
In general it was expected that most LPG tanks would be reusable. So officials (Liquefied Petroleum Gas Commission and Louisiana State Police Haz Mat Section) worked on recovering tanks and identifying and returning tanks to their owners (LDEQ, 2005c).

Floodwater sediments
According to the DMP floodwater sediments were to be transported to staging areas approved by LDEQ for testing and onward management. Vehicles transporting sediments were required to be covered. LDEQ stated that once disposed of and covered the only contaminant pathway would be leachability and this was to be monitored / assessed by sampling of the sediment (1 sample per 100 cubic yards of stockpiled material). The plan outlines appropriate disposal sites (Type I or II or C&D landfills) depending on the levels of contaminants in the soil. Record keeping was also required (LDEQ, 2005c). The authors have no information verifying the actual management processes followed.

Arsenic
In the US arsenic solids are typically disposed of in municipal or industrial (Subtitle D or suitably lined) landfills due to its potential to leach into groundwater. USEPA guidelines on construction and demolition waste management identify treated (including arsenic-treated) wood as a potentially hazardous substance which will generally not be permitted for disposal at construction and demolition (typically unlined) landfills (USEPA, 2004). However, during the hurricane response, the majority of timber was disposed of in unlined C&D landfills (see Section 3.5.9).

Formosan Termite
The DMP identified special advisory personnel at the Department of Forestry and Agriculture available to assist in finding suitable disposal options for the termite contaminated wastes. According to LDEQ, the termites thrive in landfill type environments (LDEQ, 2005b). Termite infested waste is also not permitted to be taken out of affected areas, including mulch made from termite infested wood. It was estimated that 80% of New Orleans trees were infested (Roper, 2008).

Munitions and Ordnances
USEPA also found itself managing ammunition and guns as the Sheriff, who usually manages this, did not have the resources to do so. These items were handled by an Emergency Response Specialists who were suitably trained, likely from the Department of Defense. Disposal of ammunition was required to be at appropriate hazardous waste facilities (LDEQ, 2006a).

3.5.8 Burning

Most states in the US (including Louisiana) ban burning as a means of waste disposal. However, much of the debris generated in Katrina was burned despite the hazards due to air pollution, and the requirement that only 'clean' (i.e. free from hazardous substances, which is difficult to achieve post disaster) debris should be burnt (Esworthy et al., 2006). USEPA gave some very general advice on acceptable protocols for burning debris but emphasised that any burning operations must meet with local or state regulations and/or emergency orders.

The initial LDEQ DEAO permitted local government or their agents to open burn vegetative debris provided that certain conditions were met (State of Louisiana Act LAC33:III.1109.D.6.) and provided LDEQ was notified within seven days (LDEQ, 2005b). An amendment of the DEAO allowed for individuals to also open burn vegetative debris with prior consent from LDEQ (LDEQ, 2005a). The revised DMP (14 October 2005) contradicted this order saying that all burning sites had to be approved by LDEQ prior to use (LDEQ, 2005c). The 2006 CPDCDM, however, stated that burning of vegetative debris may be allowed only on a case by case basis. Generally this will only be within the first 2-4 weeks of a response to clear access ways etc but prolonged burning may be approved in approved locations and with appropriate public health risk mitigation measures (LDEQ, 2006a).

The initial LDEQ DEAO stated that ash residue from burning yard trash or clean wood wastes must be disposed of at a permitted facility (Type II or III landfill) or disposed of on land in areas approved by LDEQ (LDEQ, 2005b). According to the October 2005 DMP and the CPDCDM, C&D debris ash could only be disposed of on land or at a landfill after the residue had been adequately tested for hazardous substances and analysed by LDEQ. Vegetative debris ash should be tested whenever possible prior to land application (LDEQ, 2005c; 2006a). The authors did not obtain any information on the processes around testing of ash residue prior to disposal.

In June 2008 a pilot study of waste reduction methods was initiated in St Bernard Parish at a former landfill site. The site used air-curtain burners to burn vegetative and C&D waste (that did not contain regulated asbestos waste). The original pilot was to include asbestos-containing waste but the potential health affects meant that it was eventually excluded from the programme (GAO, 2008). The GAO report did not comment on the outcome of the pilot project.

LDEQ reported opposition from citizens, environmental groups, local and federal government over burning of debris, mostly due to environmental and public health concerns. Burning of C&D waste was also been subject to some concern over compliance with NESHAP regulations (LDEQ, 2006b).

3.5.9 Disposal

Immediately after the Hurricane, the first DEAO (LDEQ, 2005b) permitted emergency repairs of previously authorised solid waste management facilities without prior notification to LDEQ. For example repair of stormwater or leachate systems damaged by the hurricane or flooding.

LDEQ identified landfilling as its primary management option – "the landfill option has proven to be reliable, expedient, protective of human health and welfare and the environment, and economically feasible" (LDEQ, 2006b). On 28 August 2005, LDEQ notified Parishes of all disposal and solid waste handling facilities that were authorised to accept Hurricane waste. Facilities were required to seek any modifications to their existing permits in arrears to reflect any long-term impacts of accepting the debris. Under the initial 30 August LDEQ DEAO, solid waste facilities were given authority to make emergency repairs necessary to restore function and prevent adverse environmental effects without prior notification to LDEQ. In addition all permitting fees were waived (LDEQ, 2005b).

The initial LDEQ DEAO made allowance that vegetative material could be deposited in Type II or Type III[4] landfills. The document also stated that all hurricane debris, non-recyclables and residuals from recycling efforts must be disposed of in Type II or III landfills. Putrescible waste had to be disposed of in Type II landfill (LDEQ, 2005b; 2006a). The CPDCDM (LDEQ, 2006a) states structural timber may also be disposed at Type III landfills and where possible their volume should be reduced prior to disposal.

In November 2005, a second amendment to DEAO was issued. This order allowed the expansion of waste acceptance criteria at C&D landfills to include some potentially hazardous materials including: furniture, carpet, painted or stained lumber and asbestos contaminated waste where it could not be separated (LDEQ, 2005d). Interestingly in June 2007 LDEQ changed their 'peace-time' C&D landfill acceptance criteria such that approval was only needed for disposal of furniture and carpeting (GAO, 2008). The expanded

[4] Type II landfills are municipal waste landfills. Type III landfills are Construction and Demolition landfills which are typically unlined.

C&D acceptance criteria was also reflected in their 2006 CPDCDM (LDEQ, 2006a).

To handle the large volume of potentially asbestos containing waste materials a fourth landfill type was created. The fifth DEAO introduced the concept of an "enhanced" C&D landfill. Any landfill operator wishing to receive potentially asbestos containing wastes had to apply to LDEQ for a permit as an "enhanced" C&D landfill. Operators had to have: appropriate air monitoring and reporting; dedicated asbestos disposal areas; no visible emissions or ensure daily cover of waste materials; fencing and warning signs; waste load record keeping; and they must comply with LESHAP regulation LAC 33.III.5151.N upon closure. In LDEQ's CPDCDM it was stated that the enhanced C&D landfill criteria (which meets NESHAP disposal standards) may be reactivated in a future event (LDEQ, 2006a).

As the recovery continued, the number of sites designated to accept the expanded waste criteria was limited. The tenth amendment of the DEAO (May 2007) was the first to limit disposal sites – it specified five landfill sites to accept Hurricane waste from six Parishes. The landfill sites were Gentilly, Highway 90, River Birch, Stranco, and Tidewater Sanitary Landfill. In the same DEAO all other sites were ordered to stop accepting hurricane debris (LDEQ, 2007b). Sites were chosen based on quantity and type of waste remaining, location, distance from site among other factors (GAO, 2008).

The LDEQ disaster management plans called on contractor knowledge of regulation and best professional judgement when determining final deposition options for the debris (LDEQ, 2005c; 2006a). Deposition of C&D materials at unpermitted (but deemed appropriate by LDEQ) sites is identified as a potential option in the management plans (LDEQ, 2005c; 2006a).

All oil contaminated debris was required by the DMP and CPDCDM to be disposed of in a Type I (industrial) landfill. Oil contaminated marsh grass, however, was permitted to be burned. Creosote treated timber also had to be disposed at a Type I landfill (LDEQ, 2005c), however, it is unknown how much treated timber was separated from the waste matrix.

Landfill operators

Some landfill operators reduced prices to increase market share and make some money. The State of Louisiana tried to regulate this by capping the volume of waste that could be taken by each facility.

Some haulers reported that landfills were ill-equipped to handle the debris volumes coming in (O'Connell, 2005). The Corps considered taking waste out of the region; however, local officials and waste facility operators opposed the move to prevent loss of revenue.

New solid waste facilities

The second amendment to the DEAO stated that any entity proposing to process or dispose of solid waste was required to provide financial security pursuant to a state law (LAC 33:VII, 3 E) (LDEQ, 2005d). This provision was

withheld from the fourth and subsequent amendments to the DEAO (LDEQ, 2006d).

Monitoring
LDEQ and USEPA carried out monitoring (water, air, waste) at disposal sites during the disaster debris operations. Inspections increased in frequency from weekly in October 2005 to daily in May 2006. Inspectors observed site operations and carried out waste inspections to ensure materials were within the landfills' acceptance criteria. Where necessary, enforcement action was taken (GAO, 2008).

Gentilly Landfill
The Gentilly landfill is located near the hurricane affected areas in New Orleans and is owned by the city of New Orleans. The landfill was closed in the 1980's, but was re-permitted (but not opened) in 2004 as a Type III landfill suitable for C&D and wood wastes. Following the Hurricane, in September 2005, the site was authorised to commence operations in line with its original permit. Following a petition against the landfills' operation by the Louisiana Environmental Action Network (LEAN), LDEQ revoked its original authorisation and authorised the site's operation under LDEQ DEAO and permitted the site to accept Hurricane C&D waste (under the expanded acceptance criteria) (LDEQ, 2006b). Several reports on the Gentilly landfill have raised concerns over the potential for migration of contaminants especially given the presence of "problematic" wastes such as furniture and wood paints (GAO, 2008). LEAN filed a lawsuit relating to Gentilly landfill. LEAN and LDEQ settled and a cap on daily waste acceptance volumes was set (Luther, 2008).

A consultant's report in 2006, contracted by FEMA, indicated potential concerns relating to subsurface soils and ground water contamination. Many of the concerns were addressed, in particular groundwater and geotechnical monitoring was implemented, debris loads limited and waste placement protocols established. The landfill operators were required to monitor groundwater and slope stability and meet a number of other LDEQ requirements (LDEQ, 2006b). As of 2008, geotechnical monitoring showed no significant movement of the waste mass. Groundwater and surface water monitoring detected water within existing health limits with the exception of some elevated metals in ground and surface water. The LDEQ, however, attributed this to the historically high metals in the surrounding soils (GAO, 2008).

Chef Menteur Landfill
Located in the heavily impacted St Bernard Parish, the Chef Menteur landfill was opened to accept C&D debris under an emergency executive order in April 2006. The landfill was ordered by the City of New Orleans to close in August 2006 following a lawsuit by LEAN over concern about discharge of contaminants into the neighbouring wetlands. Monitoring was carried out by USEPA following the closure and testing found that some contaminants exceeded state regulations, however, they had not been discharged from the site (GAO, 2008).

Illegal dumping and violations

Illegal dumping was a problem well before Hurricane Katrina, however, the extent of debris exacerbated the problem. According to Jackson (2008) this was due to residents frustrated by the slow clean-up and due to waste management operators taking short cuts. In March and April 2007, Operation Cleansweep was launched by LDEQ, EPA, the Corps, and the Louisiana National Guard to identify, prosecute and cease operations of any unauthorised facility. The Corps also carried out similar inspections and enforcement at wetland dumping sites (GAO, 2008).

As of 15 May 2008, 53 out of 120 regulatory violations issued by LDEQ to individuals and businesses related to solid waste management. The majority of those were due to improper disposal of C&D waste. Five landfills received enforcement orders for issues such as accepting unauthorised waste, effluent discharge, improper inspection and handling of waste, inadequate record keeping etc. Following the notices increased inspection were carried out until the appropriate standards were met (GAO, 2008).

3.5.10 Health and Safety

Multiple health and safety hazards associated with debris removal were identified by waste and emergency managers. Hazards existed to both the public and the workers and included use of heavy plant, unstable structures etc. and those hazards discussed in Section 3.1.2. Health and safety issues were monitored by USEPA, Centre for Disease Control and Prevention (CDC) and Occupational Safety and Health Administration (OSHA). These agencies also disseminated information and advice to clean-up workers and local government.

On-going testing and analysis of the flood water sediments by environmental scientists has unveiled a list of potential health and safety issues from the hurricane including mycotoxin exposures from mould, respiratory diseases from inhalation of aerosolised pathogenic microorganisms and chemical toxicants (Presley et al., 2005).

During initial stages of the clean-up, EPA and CDC advised that they did not believe exposure to the floodwater sediment contaminants would cause adverse health effects as long as the appropriate safety gear was worn, such as, gloves and safety goggles. They also advised that any body part in contact with the sediment should be washed with soap and water (USEPA, 2005c). LDEQ's DMP reflected this view by recommending bodily contact with and inhalation of the sediments should be limited. The DMP cites the National Institute for Occupational Safety and Health (NIOSH) and OSHA guidelines for handling the sediments (LDEQ, 2005c).

Allen (2007) reported that residents were not adequately warned by USEPA of the potential dangers associated with the sediments and debris. First, there was confusion between interpretation of monitoring results between the community and the USEPA. While test results obtained by both parties were similar, the interpretation of the results varied. According to Eswothy et al. (2006) USEPA was criticised for publication of soil analysis results on their

website without any discussion. One group accused USEPA of misleading the public by saying it was safe to go back when the results published exceeded health guidelines. The main confusion is the use of health-effects based exposure guidelines (usually for constant exposure over a 30 year period) rather than short term post-Katrina exposure.

Second, Allen reported that USEPA's advice on appropriate PPE for residents was inadequate. Only after lobbying by environmental groups did the USEPA advise residents of PPE equipment that should be used, however, the equipment was not typically available. Some NGO's began distributing the equipment. Third, Allen alleged that many migrant workers brought in to work for contractors were not given appropriate PPE.

3.5.11 Communication

The primary means of communication was radio and mass paper handouts. The large number of displaced people made personal communication difficult.

USEPA provided some information on their website and gave general guidance on how to deal with certain aspects of the waste following Hurricane Katrina, including asbestos, storage tanks, polychlorinated biphenyls, hazardous materials and demolition material (USEPA, 2005a). However, GAO (2007) determined that USEPA's public communication of the health and safety risks involved in residents returning home was inadequate. The reports were issued too late (3, 6 and 11 months after the disaster) and much of the early data did not clarify that the risk assessments were based on short term exposure to the hazardous waste components (as described in Section 3.5.10).

One of the waste contractors, Onyx North America, commented that communication was likely the toughest challenge, followed by logistics and proper staffing levels (O'Connell, 2005).

3.5.12 Other waste collection

Municipal waste collections were severely disrupted by the mass relocation of large sections of the population. The main concern for municipal waste collection services was whether sufficient space remained in the municipal landfills for the short and long term needs of the community.

In general municipal waste collection is carried out independently of disaster waste collections in the US system.

4 Analysis

The case study analysis follows the principles set out by Yin (2009) in *Case Study Research, Design and Methods*. The framework for the analysis is to form a case description of this embedded case study.

The authors' research into disaster waste management has identified five key factors that influence a disaster waste management system - these will form the unit of analysis. These factors are:

- The overall coordination of disaster waste management activities
- The funding mechanism for demolition and waste management
- The organisation and execution of the physical works
- The environmental standards used
- The public health and safety standards used.

It is these factors that determine the path and in turn overall success of the process. In order for lessons to be learnt that can help position communities to respond better in the future, it is important to understand these factors and anticipate how they may influence the success of a waste management programme.

To assess the impact of each of the above factors in the Katrina case the analysis focuses on: the related decision-making; the associated delays; the organisational aspects; the legal constraints; and the environmental, economic and social effects (both positive and negative). With limited data available from the waste management process (for example, data from the waste matrix, costs and social assessments), it is difficult to quantitatively assess the environmental, economic and social impact of the waste management processes. However qualitative assessments of the strengths and weaknesses within each key factor have been made.

For the purposes of this report and in line with New Zealand Ministry of Civil Defence and Emergency Recovery guidelines (MCDEM, 2005) environmental effects include direct effects on the natural environment including: natural resource degradation and/or depletion; waste pollution; amenity values; biodiversity and ecosystems. The environmental effects may have secondary effects on human health through contamination of waterways, soil etc. Social effects look at direct effects on human safety and wellbeing, health and welfare. In terms of waste this will largely include direct disease or health threat from the waste and health and safety issues related to handling of the waste.

4.1 Factor 1: Overall coordination of demolition and waste management works

4.1.1 Approach and rationale

The general approach to overall coordination of the waste management programme was as prescribed in the NRP. The NRP clearly outlines specific operational roles, delineated into ESFs, to be enacted in response to a disaster.

Each ESF had a government department as lead and they are responsible for ensuring legislative and organisational issues are in line so that the operational roles can be carried out. In the case of waste the primary lead agencies were the Corps and USEPA. The GCRO was established to coordinate FEMA / NRP activities across all affected states.

Generally, it appears that: USEPA would set minimum standards for waste management; LDEQ would ensure state laws met these and state minimum standards and were streamlined to expedite the clean-up; and it was up to local authorities to identify disposal sites and ensure that contractors had sufficient disposal, staging and recycling sites. The Corps would oversee implementation where requested by the local authority or state.

4.1.2 Delays

Given the information at hand, no specific delays can be attributed to the overall coordination efforts.

4.1.3 Organisational aspects

Emergency management operational procedures in the US are well established in the NRP. However, the role of strategic oversight of the overall recovery activities (both in terms of debris management and the overall recovery), in 2005, was reasonably undeveloped. Recovery was considered under the last of 14 ESFs. It was not until 2011 when a National Disaster Recovery Framework was ratified.

As discussed above, different organisations and different levels of government were responsible for different aspects of the waste management system. Within the NRP, the compartmentalised nature of the ESFs and the peace-time operational boundaries of the organisations involved could hinder cross function strategising, for example the management of hazardous waste (ESF10) being managed almost independently of general debris management activities (ESF3). Some debris operations were not explicitly covered under any ESF and required significant cross function coordination. Management of marsh debris, for example, required consultation with eight different stakeholders (LDEQ, 2006a). To increase coordination across FEMA activities, the GCRO was established.

However, no organisation coordinated the three levels of government and their respective waste management responsibilities. Thus, there appeared to be no organisation ensuring the demolition, collection, treatment and disposal systems were functioning, including: sufficient capacity; identification of system bottlenecks; complimentary laws; health and safety approaches; balancing of environmental and recovery outcomes etc. The unilateral decision to grant USEPA authority to waive any laws necessary to facilitate recovery (despite operational staff assuring authorities that they had sufficient legal flexibility already) was an example of this lack of coordination. It is noted that USEPA chose not to use this authority.

Strategic direction from federal, state and local authorities to operational organisations was also missing. LDEQ called on contractor knowledge and judgement to determine final deposition options for the debris (LDEQ, 2005c; 2006a). In taking this 'hands off' approach, LDEQ essentially allowed the contractors to determine the overall recovery goals. Contractor's primary objective is generally to generate profit. However, a disaster recovery effort should consider other community wide impacts such as environmental impact (level of recycling etc.), speed of recovery, traffic disruptions, etc. In addition to this, if the clean-up objectives are set by the contractor then the contractor may, depending on their contract conditions, essentially be accepting a greater risk in the event of adverse outcomes from the clean-up process.

Disaster waste management has a significant impact on the environment, the community and the recovery. Effective strategic management structures are, therefore, very important. The LDEQ's duty, and that of local authorities, should be to guide contractors in their efforts and to regulate waste management options such that community, rather than contractor-derived, objectives are met. Authorities should also direct prioritisation of waste management activities in coordination with other recovery activities.

There are certain benefits to having a compartmentalised approach. This approach enables activities to be broken into manageable sizes, and helps to ensure suitably qualified people are working on areas within their expertise. In addition the approach can be quite successful if there is good cross organisational communication and collaboration. However, given the size of the response to Hurricane Katrina, relying on ad-hoc cross-organisational collaboration is unreasonable. As Moe (2010) identified, information sharing (lack of accurate information and assessments) and poor coordination between relevant authorities affected the Katrina clean-up process. Roper (2008) also observed that communication between local, state and federal authorities was ineffective. Roper also noted that some parishes within the New Orleans area operated independently and had "complex and constraining" rules around operating with each other.

It should be noted that the addition of a coordinating body can sometimes have a detrimental effect on the recovery. Establishment of another authority could add another layer of bureaucracy with negative effects on the overall recovery speed. This was reported in the response to the 2009 Victorian Bushfires with the establishment of a coordinating body the Victorian Bushfire Recovery and Reconstruction Authority (Brown et al., 2010a).

The emergency response arrangements in the US try to ensure a bottom-up approach – in that the lowest level of governance is delegated authority where possible. However, according to Weaver (2006) the almost complete collapse of low level government structures meant that the recovery was not effected appropriately. Weaver suggests a federal "push" model as opposed to the existing "pull" model where local authorities request assistance. This approach, however, is contrary to the bulk of the literature on engaging community in recovery. The essence of this failure is that the current system relies on a functioning local government and the system failed to adjust to account for the collapse of local structures.

4.1.4 Legal implications

The large number of DEAO amendments and legislative changes are perhaps evidence of the disjointed coordination efforts. While it is important and credible that authorities were prepared to remove legal or regulatory hurdles to facilitate a recovery, the constant flux of requirements may have impacted on the efficiency of the waste management process. Uncertainty in legal requirements could have a number of impacts:

- Community mistrust in the authority arising from constant changes in acceptable environmental and health and safety standards.
- Unwillingness of local authorities and contractors to formulate a long-term plan for waste removal if there is a fear that laws may change.
- Inability for facilities to forecast operations, costs, time, personnel requirements – which may have cost implication especially for operations such as recyclers.

It is difficult, in a reactionary situation such as in Louisiana, to determine and implement a long term waste strategy immediately post-event. A certain degree of flexibility and change is expected. However, the consistently short duration of the majority of the emergency orders - 60 days with possible extensions of 30 to 60 days - seems unreasonable relative to the scale of the disaster. Emergency orders should aim to give certainty in the clean-up operations. Not all emergency legislation was for a short duration. The NAA letters for asbestos management were valid for 12 months (LDEQ, 2006c) which is considered more reasonable. If strategic planning had been in place longer term waivers / DEAOs may have been possible.

4.1.5 Environmental

As discussed in Section 4.1.3, waste management decisions were essentially left to the contractors (within the bounds of law). Most decisions, therefore, were likely made considering primarily economic drivers – the cheapest option and/or the option that will render the largest profit for the contractor. Time and resource availability would also influence the approach. Thus the environmental outcome is heavily dependent on the state of the waste and recycling market, as well as the experience and knowledge of the contractor in waste management.

USEPA and LDEQ still performed their roles as regulatory authorities. They established minimum environmental standards which they deemed appropriate for the response to this disaster. However, the high number of regulatory violations relating to debris management indicated that their role was more reactive rather than proactive.

4.1.6 Economic

Waste management activities directly affect the rebuilding process and the resultant return of economic functioning. A strategic body to oversee and direct waste management activities (in coordination with other recovery activities) would have perhaps led to targeted recovery with more positive

economic impacts. For example prioritising works in a business district over residential areas, or targeting areas with displaced persons prior to less affected areas to encourage community repatriation.

4.1.7 Social

There appeared to be no one point of contact for communities for waste management issues. Implementation issues would be directed at the contractor or local authority, environmental issues at LDEQ or EPA, health and safety at DHHS.

4.1.8 Summary

Overall the strategic management and coordination of the waste management process was missing. Established operational roles worked well, as did organisations working within their peace-time capacities. However, there was a distinct lack of coordination across federal, state and local authorities with respect to waste management activities. There was also, perhaps as a result, minimal strategic direction given to implementing organisations in terms of how specific streams of waste should be handled.

Table 4-1 summarises the strengths and weaknesses of the overall coordination of demolition and waste management works.

Table 4-1 Hurricane Katrina overall coordination of demolition and waste management works assessment summary

	Strengths	Weaknesses
Organisational	• GCRO helped to coordinate FEMA activities. • Operational roles well defined. • Avoiding another layer of management may have avoided bureaucratic delays.	• No strategic oversight for waste management activities as a whole or within the recovery process. • Poor intra-government communication both at local level and between local, state and federal authorities. • Relied on contractor judgement to waste management options – potentially risk loading on contractor and allowing recovery to be dictated by contractor's objectives. • No direction given to contractors on desired environmental and social outcomes, including works prioritisation. • Established disaster response system did not adjust to account for collapse of local government.

Legal		• Large number of legislative changes (resulting from piece-meal coordination efforts) often with short duration – this made planning for waste management operators difficult.
Environmental	• USEPA and LDEQ established minimum environmental standards as appropriate to their authority.	• Environmental outcomes were dependent on contractor expertise and waste management market conditions.
Economic		• Waste management works were not actively prioritised to facilitate economic recovery.
Social		• No clear point of contact for waste management issues for the community.

4.2 **Factor 2: Funding mechanism**

4.2.1 Approach and rationale

As for overall coordination, FEMA funding processes, mechanisms and scope are well established (as described in Section 3.4). The systems appear to work well for most 'medium scale' disasters in US. However, the extent of the impact of Hurricane Katrina, in Louisiana, required extra-ordinary measures. FEMA recognised this and extended its funding scope. The amendments relating to waste management included:

- Increase of FEMA funding contribution from 75% to 100%.
- FEMA funding for demolition and debris removal on condemned private properties.
- Extension of funding period for USEPA.

The rationale behind the decision to increase funding was to save money for the heavily affected (and generally lower socio-economic) Parishes and to eliminate health and safety hazards for residents (FEMA, 2007b; Louisiana Homeland Security and Emergency Preparedness, 2007). That decision was jointly made by the President, FEMA and the affected States. To be eligible the States had to prove financial hardship. LDEQ publically recognised that funding availability was a limiting factor in their management options for debris (LDEQ, 2006a).

It is likely that the decision to fund the debris removal and demolition on private properties was largely influenced by the public health hazard posed by the contaminated sediments. The decision was also likely influenced by the slow return of residents and a realisation that many private property owners would be unable and/or unwilling to clear the contaminated floodwater wastes. In addition the lack of insurance for flood damage (as opposed to

hurricane damage) would have been a contributing factor as significant delays and complications in residents receiving insurance pay-outs were experienced.

The FEMA policy stated that debris removal on private property would only be performed to "address an immediate threat to life, public health, safety or property (FEMA, 2005b). It is unclear what basis or classification was used to determine if properties met the above definition.

Nick Russo, the federal coordinating officer for the Mississippi disaster recovery stated "The magnitude of this disaster makes it necessary to use every available resource to effectively clear debris and make communities liveable and functional once again," (FEMA, 2006). It is likely that these sentiments were shared in Louisiana also.

4.2.2 Delays

The extended funding contributions (from 75% to 100%) were confirmed 4-5 months after Hurricane Katrina. It is believed that no delays would have been incurred over the decision for FEMA to increase their contribution (to municipal clean-up and USEPA) as the clean-up in the first 4 months would have been carried out regardless of who was paying, provided cashflow (for contractor payment) was not a problem. The delay in funding for private property removal may, however, have impacted the overall recovery process.

There was a four month delay between FEMA signing their private property debris removal policy on 15 September 2005 (FEMA, 2005b) and the private property removal approach being recognised in a Louisiana's DEAO (LDEQ, 2006d). This delay was due to the time it took for LDEQ to establish streamlined notification procedures. Had this eventuality (FEMA paying) been identified prior to the disaster, streamlined processes could have been in place and this delay period could have been reduced.

Given the presence of floodwater in the worst affected areas until October 2005, debris removal in this area could not have commenced any earlier than October / November. However, if LDEQ were prepared for this outcome, the procedures around debris removal on private property (a task ordinarily carried out by property owners) could potentially have been prepared sooner than January 2006. Only after the processes were established could local authorities begin the difficult task of contacting and gaining permission for site entry to all the affected properties before work could commence.

If works had commenced sooner, then property owners would likely have been able to return to the community sooner. However, with 64,000 houses cleared from March 2006 to July 2007 (16 months) (Louisiana Homeland Security and Emergency Preparedness, 2007) the 4-5 month delay in developing procedures had a relatively small impact on the overall programme. It would be beneficial for a FEMA policy to be in place outlining a health and safety hazard threshold above which private property owners are not expected to clear their own properties. In addition, LDEQ should have organisational and regulatory procedures prepared for private property debris removal.

Many property owners faced significant delays in finding out the fate of their property from a combination of insurance companies, FEMA and local authorities. Some property waited up to two years to learn of the fate of their property (Denhart, 2010). Some believe this was due to the difficulty in distinguishing between flood and hurricane damage and the responsibilities of different insurance companies (The World Bank and The United Nations, 2010).

4.2.3 Organisational aspects

Generally the funding mechanism was straight forward from an organisational perspective. FEMA paid for all operations and the local authorities could elect whether they managed the physical works or whether the Corps managed the works on their behalf. Despite FEMA's clear regulations, problems were still faced when officials did not follow the procedures, in particular, procedures around tendering contracts. If procedures were not followed FEMA would not fund the activities, and a lot of time and resources allegedly went into advising and assessing the contractual processes in Louisiana. These resources could have been spent on other recovery activities.

FEMA funding also covered all aspects of the debris management process from collection through to processing and/or disposal (FEMA, 2007a). Therefore if temporary staging areas were required and/or additional recycling facilities etc then these activities were also covered under the funding umbrella. This meant that there was less potential for delays caused by non-funded waste management system components creating a bottleneck.

The funding also allowed for equal access to debris management operations for everybody. In a disaster such as this, where waste is spread between properties, questions of ownership and payment responsibility for mobilised waste are avoided.

The strict rules around FEMA funding meant that some contractors would not collect some debris. If debris was contaminated with garbage or it was suspected the waste was not disaster generated, then the piles would be missed. The authors believes that either Contractors, being paid on a lump sum basis, feared they would not receive their full payments; or potentially Contractors wanted to reduce the work to be carried out to maximise their profits. It is understood that this was not the intent of the FEMA regulations. The regulations are set to try and educate people on what they can and cannot put out for collection; however, it was expected that all waste collected within a specific time frame could reasonably be expected to be disaster waste. FEMA also wanted to avoid secondary hazards caused by piles of debris, such as blocked flow-paths, vermin and vector breading etc.

It is important to note that FEMA funding did not and does not cover waste management of repair and rebuilding. It is assumed by FEMA that insurance or recovery grants will pay for this. Thus each individual property owner or contractor is responsible for waste management. This means there is less opportunity to coordinate and maximise the efficient use of resources – especially in a situation where resources are likely to be limited. If additional

waste management facilities (staging areas, recyclable processing) are required to manage the large volumes of debris likely from reconstruction processes, it is unclear who would facilitate and pay these. The continuity through the waste management system is lost.

There were also some funding gaps identified during the clean-up operations. For example there were a large number of boats that sunk. The Coast Guard is responsible under the Stafford Act for clearing all debris in the shipping channel. However, no one is responsible for waste outside the shipping channel. This appears to be a funding gap as it is believed that if a boat has sunk it is not in the interest of the insurance company or the boat owner to salvage the boat.

Despite the legal requirement for those holding insurance to reimburse FEMA for any services received there did not appear to be an established mechanism to facilitate this.

4.2.4 Legal implications

The provision of funding for private property demolition and debris removal required the local authority to prove that the site was a health and safety risk and to ascertain the owner's approval prior to site access. If voluntary approval was not received then the council would have to condemn the property, whereby essentially taking legal responsibility for the property / waste. This process was clearly identified as a bottleneck and FEMA altered its policy to reduce requirements for legal approvals to meet streamlined processes by local authorities.

For homeowners who hold insurance and who receive assistance from FEMA (including kerbside collection services and private property clearance / demolition) there is a legal requirement to contribute the respective portion of your insurance pay-out. However, there appears to be no clear mechanism with which to fulfil this obligation.

All debris removal programmes are required to meet statutory requirements including those already established by the Stafford Act (FEMA, 2007a) (see Section 3.3). Some legal waivers used in response to Hurricane Katrina brought this condition into question. There was some concern that the expansion of the waste acceptance criteria at C&D landfills may have potentially excluded the disposal activities from funding. This was a result of some provisions under the Federal Water Resources Development Act, 2007 which governed certain waste being managed as C&D debris. However, it was determined that the expanded criteria met the broad definition of C&D waste in the federal regulations (GAO, 2008). This demonstrates that funding mechanisms need to be flexible enough to permit all reasonable legislative measures needed to facilitate debris management.

4.2.5 Environmental

As discussed above, there is a requirement that all applicants for FEMA funding must adhere to all environmental regulations. If any of these regulations are contrary to FEMA funding regulations then the funding applicant must apply for special consideration of the circumstances. For example after the Northridge earthquake, the city of Los Angeles was running short of landfill space and needed to start recycling of the disaster waste. FEMA stipulated that lowest cost solutions must be used, however, in this case recycling was not the cheapest option. The city of Los Angeles argued that even though it was not currently mandated, recycling was in their long term strategy for the town (State of California, 1997). For Hurricane Katrina, Louisiana did not have regulations mandating recycling, and so FEMA's lowest cost option policy meant that demolition and landfilling, rather than repair or deconstruction/resale, was used for all condemned houses, as this was the cheapest option (Denhart, 2010). However, if Louisiana had had other waste regulations in place, then other procedures could have been used.

For properties where clean-up is paid for by insurance, the environmental outcomes are dependent on the actions of the individual contractor and the waste management systems (ie, regulations and enforcements) put in place by the municipality. As for FEMA funded activities, contractors or insurers will undoubtedly opt for the lowest cost option that obeys environmental regulations. Therefore the environmental outcome is heavily reliant on the municipality's regulations. It is difficult, however, for individual municipalities to control the entire waste system. Strong public waste policy and potentially tax incentives would be required to influence the environmental outcome of a waste system when there is a range of regional, public and private facilities in the waste system. Louisiana, while encouraging recycling, for example, did not support this goal with relevant policy. In addition, if insurance or other funding is insufficient for repair and reconstruction, mismanagement of waste is a possibility. Certainly the illegal dumping by frustrated residents (Jackson, 2008) indicates that that is a plausible scenario.

4.2.6 Economic

As discussed in Section 4.2.1, one of the driving factors in the decision to increase federal funding share was to save money for the heavily impacted Parishes. This would enable funds available to the Parishes to be spent in other aspects of the recovery. Alternatively it is possible that if funds were lacking then this may have inhibited the Parishes ability to manage the waste and would have impacted on the time frame for economic recovery.

In terms of changing future behaviour, however, relying on a federal based approach may not be a good way to discourage building in hazard prone areas. Private disaster funding schemes such as insurance can potentially influence risk taking behaviour. For example insurance premiums can influence market value of properties to make hazard prone areas uneconomical to live in (The World Bank and The United Nations, 2010). If federal funding is provided in place of insurance then less ownership of the risk is taken and mitigation measures (such as relocation) are unlikely to occur. In that case there is

greater need for government regulation of hazard prone areas to prevent exposure to hazards.

Overall the FEMA approach to kerbside collection allows for the majority of those affected with minor damage to clear their properties quickly and return to normal activity. In this case it was recognised that to facilitate that return to normal economic and social activity private property demolition and debris removal would have to be carried out.

4.2.7 Social

Any funding mechanism that facilitates a timely recovery will have positive social effects. The ability for residents to use the kerbside collection allowed for minor to moderately affected people to clean-up and get on with their lives. In addition the kerbside collection allowed affected persons to be involved in their own recovery which has positive effects on their psychological recovery (Denhart, 2009). However, in this case as observed by Cook (Cook, 2009), the largely relocated population in New Orleans rendered the kerbside collection highly ineffective and inefficient.

The funding of debris clearance on properties where there was a public health threat facilitated the return of thousands of families (Louisiana Homeland Security and Emergency Preparedness, 2007) that otherwise might not have had the means to pay for or facilitate the debris removal. Property clearance, for example, allowed for displaced residents to apply for and receive FEMA trailers to live on their site until rebuilding is complete. Clearance of properties in turn helped to facilitate community-wide recovery and reduce public health threat.

Under the 'ordinary' insurance style approach, there does not appear to be any onus on property owners to clear properties after they have received an insurance payout. This leaves the potential for houses to be left in ruins indeterminately. While all property owners correctly have the right to determine the fate of their building individually (within public health limits), some balance needs to be achieved with the impact of these individual decisions on the wider community.

The lowest cost management option approach, as described in Section 4.2.6, does not always have a positive social impact. Denhart (2010) observed that demolition was not always the most positive psychological end to a house for some property owners and commented that property owners had little choice of demolition options for their property. The funding provided was only for property demolition. Unless property owners had their own funding and contractors there was no other option. Thus the property owners are not empowered to make their own decisions about this aspect of the disaster recovery. The Mercy Corps deconstruction project allowed for more owner involvement and control over the fate of their building. Again, it would be beneficial for FEMA's funding policy to allow for non-financial benefits to be measured.

The discretionary nature of the federal funding provision is also concerning. Federal funding is not absolute and is subject to change depending on the current political environment. The increase from 75 to 100% cost share for example may not have been implemented by another government or at another time. It has been shown that flood disaster declarations in the US are more frequent in re-election years (The World Bank and The United Nations, 2010). Disaster victims and local authorities relying on aid are therefore very vulnerable to the political dimensions at the time.

4.2.8 Summary

Overall increased federal funding provided a platform for a comprehensive debris management system to be built on. The funding ensured equal and full access to clean-up resources to ensure a community-wide public health threat was eliminated, and so enabled recovery. Had the recovery relied on individuals and insurance companies there would have been significant organisation difficulties and delays and the environmental quality may have been harder to control.

Table 4-2 summarises the strengths and weaknesses of the funding decisions.

Table 4-2 Hurricane Katrina funding decisions assessment summary

	Strengths	**Weaknesses**
Organisational	• FEMA funding extent and modalities were well established and clear. • FEMA funding covers all aspects of the waste management system. • FEMA funding allows equal access for everyone to debris management operations, particularly where debris is moved between properties during a disaster.	• FEMA contractual requirements not well followed in Louisiana – leading to funding delays. • Strict rules around waste eligibility caused confusion among contractors and some waste was not collected. • Lack of funding for repair and reconstruction may have led to a loss of overall organisation and resource use efficiency (including identification and facilitation of additional waste management facilities if required) • Funding gap for boats outside the shipping channel. • No mechanism for insured property owners to reimburse FEMA for services received.

Legal	• FEMA and local authorities both recognised the need to expedite property access processes to avoid a bottleneck.	• No clear mechanism with which to recover insurance monies for insured property owners receiving FEMA assistance. • Concern over certain legal waivers used which contravened federal law (and therefore FEMA funding eligibility).
Environmental	• FEMA requires all works to be carried out in accordance with current environmental legislation.	• FEMA's lowest cost requirement does not allow for non-financial (environmental) benefits to be measured. • Limitations in insurance funds for repair and rebuild may cause poor waste management. • Environmental outcomes for repair and rebuild are dependent on individual contractors, insurers and municipal waste systems and policies.
Economic	• Additional federal funding would free local funds (if available) to invest in other aspects of recovery. • Federal funding facilitated the clean-up and thus return of residents and return of economic activity.	• Reliance on federal funding may discourage future disaster mitigation measures (such as relocation)
Social	• Kerbside collection enables public participation. • Kerbside collection encourages timely waste management on all private properties • Private property clearance facilitated a community-wide recovery. • Federal funding provided a means to eliminate the public health threat posed by the debris.	• Kerbside collection effectiveness relied on public participation of a relocated population. • Lowest cost requirement did not allow for non-financial (social / psychosocial) benefits to be measured. • Federal funding leaves the community vulnerable to political influences at the time of the disaster.

4.3 **Factor 3: Physical works organisation**

4.3.1 Approach and rationale

The organisation of the physical works was largely dictated by the terms of the FEMA debris management funding guidelines. The guidelines clearly outlined

which works were eligible for reimbursement including the human resources that may carry out the works.

Ordinarily the FEMA guidelines assume that private property owners will manage disaster waste from their own property and place it on the kerb or take it to a collection centre for management (as decided by the local authority). Contractors appointed by the local authority or the Corps would manage the waste from there, including management of temporary staging areas. In some cases the local authority would use their own resources to manage the waste.

In this case a slightly different approach was necessary. The large number of displaced people following Hurricane Katrina and the level of hazard in the waste, particularly in New Orleans, meant that private property owner participation was generally not desired. Consequently contractors were employed to remove debris on private properties in addition to the kerbside collection. Generally the waste was separated on site and taken to temporary staging facilities for further sorting and onward recycling.

In addition some houses required not just debris removal but demolition as well. Demolition works are ordinarily arranged by individual property owners (and funded by insurance companies). Again because of the scale of the event, resource demands, absent residents etc, these works were included in the scope of the debris removal works. However, the Corps-appointed contractors could only carry out works on properties where authorisation was obtained from the property owner. Any works on condemned properties had to be facilitated by contracts under the local authority for legal reasons. Generally the waste from demolition works were not separated and were taken directly to C&D landfills. It is believed this was due to time constraints and resource limitations as well as the funding policies discussed in Section 4.2.

Generally and in this case, existing private recycling and disposal facilities are utilised. Some additional disposal facilities were required but they were generally managed by private companies or by the local authority (as some manage disposal sites as part of their peace-time operations).

4.3.2 Delays

Overall it is difficult to assess the delays of using a contractor approach. According to some local authorities the time frames for clean-ups by large Corps appointed contracting firms were considered too slow for some local authorities – particularly in Mississippi. Subsequently some local authorities opted to manage their own clean-up contract to expedite the process. Many did so successfully. This suggests that larger contractors might not have been as efficient as small contractors in this case. However, at the other extreme, if each individual property owner had been responsible for their own clean-up then it is likely there would have been significant delays around property and kerbside clean-ups.

There was a noticeable delay caused by the handover of demolition responsibilities from the Corps to local authorities. On completion of

voluntary demolitions there were still tens of thousands of homes 'unclaimed' but posing a public health hazard. FEMA was required to hand over the responsibility of these properties to the municipality. The municipalities were clearly not ready for this and there was a further 3-5 month delay while a demolition contract was tendered and awarded (in parallel with a 30 day notification period for residents) (GAO, 2008). The effect of this delay is difficult to assess. There could possibly have been a political desire to delay house condemnation as long as possible to ensure owners had a chance to claim their property. However, there would also have been a need to mitigate any public health hazard and to facilitate community recovery. A well publicised minimum claim period for personal property would be a good addition to the FEMA recovery guidelines. The municipality then could tender contracts for and notify building owners of condemned property demolition ahead of time.

There were also delays caused while the municipality (and their contractors) established the demolition system. After handover in March 2007, only 1000 properties were demolished to May 2008, a further 15,000 properties were demolished in the next three months up to August 2008 (GAO, 2008).

4.3.3 Organisational aspects

The operational roles and responsibilities are clearly defined under the ESFs. In addition the modalities of implementing waste management activities are more or less dictated by the FEMA funding guidelines. However, there were several organisational aspects specific to hurricane Katrina which impacted the debris operations.

Public participation

The US is subject to frequent disaster events. As a result of this, a comprehensive and highly prescriptive debris management approach has been established by FEMA. While much of the guidelines are for any scale disaster, there are some implicit assumptions that may not be appropriate to apply in a larger scale disaster. The assumption of resident participation is an example of this.

The FEMA debris management system relies heavily on residents being present and assisting with clean-up activities. In addition to public participation, the system inadvertently relies on local recycling and scavenging companies to be present post-disaster. Companies offer to clean-up private properties (for kerbside collection) in return for the rights to any salvaged items. Both the residents and these companies were absent or ineffective. As identified by Cook (2009) resident participation assists the clean-up both in terms of time and cost savings. Public participation also contributes to building resiliency and ownership of hazards by residents within a community. While public participation is ideal, it must be recognised that this approach is not possible in every emergency management response situation.

In the case of Hurricane Katrina, several factors contributed to the non-return of residents and their subsequent non-participation in debris management. These factors included: the relocation of many residents out of state (and/or

the lack of accommodation close to the affected properties); the health hazards and resulting inhabitability of the homes; the degree of trauma experienced in the population; the lack of services in the community (including water, sanitation, health care, security, fuel); and the presence of debris. While some of these factors could have been controlled by better emergency and recovery management, factors such as trauma and health hazards are not so easily controlled.

So while many authors have attributed the slow clean-up process in New Orleans to the absent residents (Luther, 2008; Cook, 2009) this is only true in the context of the FEMA-prescribed participatory approach. Had another approach to debris management been employed that factored in the absent population, the clean-up may have proven quicker.

Following the Victorian Bushfires, Australia in 2009, a state funded demolition and debris disposal programme was launched. The state recognised the potential hazards in the waste and the need to avoid the potential delay in recovery of the area that would be felt if residents were required to clean-up their own properties. The programme used a registration process for residents to apply to have their property cleaned-up. The residents only needed to return to their properties once to salvage personnel belongings, and after that all the demolition and debris removal was taken care of. The benefits of this approach are many: residents are able to put their energies into returning to or finding employment; the potential community health risk will also be reduced; there will be a visual sign of recovery in the community. It would be difficult to make this a mandatory process and privacy issues may deter people from registering on such a service.

There are of course limitations to a resident-independent approach to debris management. The works will cost more. More demolition crews will be required. While the delays in clean-up may be less, the actual work will take longer as demolition crews try and sort debris and likely recycle to the extent that is economical.

Contract approach

FEMA's funding mechanism appears to favour a contract approach for public property clearance. If a municipality were to use their own staff and equipment, only straight-time (ie not overtime) costs would be covered by FEMA. In addition equipment would not be reimbursed for idle time or labour operation costs. As a result of the FEMA regulations an industry of disaster waste management specialists has emerged in the US (Fickes, 2010). Contractors often have disaster specific equipment on standby and have pre-existing contracts with local authorities for immediate mobilisation in the wake of a disaster.

As discussed in Section 4.2.3, the single contract also allows for all aspects of the waste management programme, including operation of temporary staging sites, recycling and disposal facilities, if appropriate. This can create synergy within contract operations and contractors can control their operations more effectively. However, in this case contractor programmes were dependent on privately owned recycling and disposal facilities.

A large contract approach, particularly where resources are limited, enables a certain level of prioritisation and efficiency in operations. Recordkeeping and monitoring operations, emphasised as important by LDEQ (2005d) are also simpler to monitor and implement through a single contract.

The usual process for debris removal and demolition on insured properties was not feasible given the sheer scale of the event. Insurance companies generally assess and value damage on properties, compensate the property owner accordingly and then it is up to the property owner to facilitate the works. In this event it was simply not possible to have all properties managed independently by each property owner. It was far simpler and quicker to contribute a portion of the insurance pay-out to the debris management works. This also allowed for management of debris throughout the waste management cycle, prioritisation of resources and for economies of scale to be taken advantage of.

Condemned properties
As discussed previously, the management of the condemned demolitions was handled by the Parish. It is unfortunate that the processes and skills developed during the voluntary demolitions (by the Corps) were not able to be utilised for all the demolitions. The slow start-up of demolition indicates a period of adjustment and establishment of processes for the new contractors.

4.3.4 Legal implications

Liability, particularly in the litigious environment of the US, is a concern of any waste management operation. The potential long term environmental impacts of waste management, in particular, should be a concern of any organisation involved in waste management operations. Organisation of the physical works can complicate legal responsibilities. For example, a contractor is engaged to collect, transport and sort the waste and take it to the disposal site. They generally have contractual responsibility for the waste during that time. At the disposal site, the site owner essentially accepts liability for the waste. This scenario is true in peace-time situations as well. However, the difference in a disaster situation is the increased uncertainty in the composition of the wastes. This is due mainly to the mixed nature of the wastes and the time pressured post-disaster situation. Following Hurricane Katrina there was concern over the risk of contamination at C&D landfills accepting mixed wastes. There were waste acceptance criterion in place, however, for the reasons mentioned above, some environmental groups were concerned about the potential for contamination. If contamination fears are proved correct – who would be responsible? The contractor who collected and 'sorted' the waste? The landfill operator who accepted the waste? The Corps who manage the contract? USEPA who regulate the disposal facility? FEMA who paid for the operation? This equation becomes even more complicated if insurance or privately engaged contractors had carried out the works on private properties while using the FEMA or local authority temporary storage sites.

The authors' are unaware of the contractual agreements that were in place for this event, however, the higher risk in a disaster situation must be acknowledged throughout the entire chain of waste management. Thought must be put into who should carry that risk and how to minimise the escalation of risk down the management chain.

The other legal consideration affecting the demolition works was the inability for the Corps-appointed contractors to carry out 'condemned' property demolitions. This resulted in a handover to the municipality and a retarded demolition programme. The authors do not know if there were legal reasons behind the handover of physical works or whether it was an organisational decision, perhaps due to the expected delay in the notification procedures. Either way, the legal processes around management of condemned houses caused significant delays.

4.3.5 Environmental

Some recycling and debris reuse advocates have cited the default option under FEMA regulations of contracting disaster waste activities as a limiting factor in maximising recycling. Contractors in the past have brought in the wrong equipment and not processed materials to match the markets that are available for example grinding the vegetative debris prior to burning or landfilling it, instead of chipping the debris and using it for biofuel (Yepsen, 2008). Limited recycling was carried out following Hurricane Katrina but it is unknown whether this can be attributed to the contract approach, or other factors described in Section 4.4.1.

According to Allen (2007) the use of contractors from outside the area led to some irresponsible waste management. Allen cited incidents where out-of-town contractors would mix piles of segregated wastes and cart to a dumpsite. As external contractors they allegedly had no interest in favourable environmental outcomes for their region. However, other reports suggest lack of recycling was due to lack of capacity at temporary staging areas (LDEQ, 2006b).

The use of contractors, however, does provide the potential for streamlining of environmental practices. Contract terms, condition and deliverables can be written to very effectively direct the environmental outcomes of a project, such as recycling targets, acceptable disposal facilities etc. Environmental monitoring of a centralised contract is also potentially simpler for a regulatory authority (who is likely to be overwhelmed by the disaster). Processes can be streamlined through the contractor and monitored centrally, rather than individually through multiple contractors engaged by private properties.

4.3.6 Economic

The FEMA contract approach to public waste collections offers economy of scale benefits. The kerbside collection eliminates the need for individual property owners and insurance companies to facilitate their own (minor) debris management, thus, likely reducing the overall cost of the works. This,

in effect, would be a cost saving for insurance companies. In theory cost savings to the insurer will get passed on to the property owner via lower premiums and this in turn should positively impact the economy. In the case of Hurricane Katrina, this benefit was extended to private property demolition and debris clearance.

In addition, the use of large contracts (four in Louisiana) allowed for economy of scale. If additional recycling facilities for example were going to be set up each contractor could set up a facility within their zone. If smaller contracts had been actioned (for example one for each Parish), a larger number of smaller recycling facilities would not have been as economical. While FEMA's funding guidelines clearly establish what works will be paid for and that the lowest cost option should be taken, they do not consider benefits of economies of scale.

The large contracting firms used in disaster response in the US (including Hurricane Katrina), however, are often from out of town and local labour is not always maximised. This has a direct impact on the financial gains from job provision. The large scale of Hurricane Katrina reduced the options for use of local labour, as discussed in the following section.

Use of out of town contractors not only threatens use of local labour, if not well managed, but also the use of local waste services. Corps-engaged contractors contemplated taking waste out of the region but were opposed by local waste facility operators. Maintaining services within the region is important for stimulating post-disaster economies. Conversely external contractors bring more people into the area and may stimulate support services such as hospitality. As noted by O'Connell (2005) many waste contactors had to supply accommodation and food for their staff to enable them to work in the area.

4.3.7 Social

Public participation

Some authors argue that property owner involvement in the debris removal and demolition process has psychological benefits (Denhart, 2009; Brown et al., 2010a). The Hurricane Katrina demolition and private property removal project did not involve public participation. While necessary from a public health point of view, the project would not have generated the same positive psychological response from individuals. The Mercy Corps deconstruction project, however, heavily involved property owners. Many building owners believed the process gave buildings a "dignified end". It also empowered building owners to take control of their property – not just the ownership of the recovered materials but the ability to determine the fate of the building. Many materials were given away in a process assimilated to "donating organs" (Denhart, 2009).

However, given the large threat to public health and safety and the high level of damage, it would have been difficult to involve property owners in works on their own properties. Instead the focus must be on the positive impact to the community as a whole. Having a centralised contract allowed properties and

the public health threat to be efficiently removed, which in turn removed the reminder of the disaster and so helped facilitate rebuilding activities.

Contract approach
The use, or lack of use, of local contractors was a concern for local residents. While FEMA noted in their guidance documents that local contractors should be used where possible, there is no minimum requirement. The size of the disaster, the number of displaced persons, the large competitively bid contracts, licensing issues for transportation of hazardous wastes particularly across state borders etc. all contributed to the limited use of local contractors following this event. The authors do not have data on the utilisation rate of local contractors; however, complaints were received by FEMA indicating that the community was dissatisfied with the work distribution process.

Public health and safety
The allegedly slow performance of the Corps contractors raises public health concerns. Slow handling of waste can cause serious health concerns for the wider public – particularly where there are acutely hazardous substances in the waste or waste may encourage vector breeding, see Section 3.1.2. Mitigation measures, such as mass spraying for vector control was possible, however, there was a significant risk to response workers. Inhalation of dust particles from dried sediments was also cited as a problem with potential health impacts for exposures greater than one year (see Section 3.1.2).

Conversely, the degree of hazards in the waste meant that certain precautions had to be taken to protect the debris removal workers. A factor in the slow response speed may well have been the health and safety precautions necessary. For example, separating hazardous materials from kerbside waste prior to pick up; or wetting C&D debris where asbestos is present or suspected.

4.3.8 Summary
Overall the contract approach to debris removal and demolition works allowed for greater streamlining of the clean-up operations. The high level of displaced property owners, and high degree of health hazard present in the waste matrix, necessitated a coordinated and large-scale response. It was not feasible to rely on a conventional FEMA response where private property owners cleared detritus from their own properties. The contract approach allowed for environmental and public health risk mitigation procedures to be put in place. Limited use of local contractors was noted by the community.

Table 4-3 summarises the strengths and weaknesses of the organisations of the physical works.

Table 4-3 Hurricane Katrina physical works organisational decisions assessment summary

	Strengths	Weaknesses
Organisational	• FEMA regulations encourage pre-establishment of disaster waste contracting industry and pre-arranged contracts for fast mobilisation. • Single contract allows for control of waste management chain (up to recycling and disposal). • Single contract enables resource and work prioritisation.	• FEMA regulations relied on public participation which was not feasible in this case. • Contractors programme dependent on privately operated recycling and disposal facilities. • Established demolition processes were lost in the handover from the Corps to the Parish.
Legal		• Liability of waste management process is unclear. • Legal processes around condemnation of houses resulted in disruption to physical works and retarded demolition works.
Environmental	• Centralised contracts facilitated environmental monitoring.	• Contractors not always familiar with recycling options and approaches. • Some (non-local) contractors allegedly did not manage waste in environmentally sound ways.
Economic	• Economies of scale achieved in FEMA contract approach generate cost savings. • Out-of-town contractors create demand for support services such as hospitality.	• There were no controls over use of local labour and waste facilities, which reduced direct benefits to the local economy.
Social	• Large public health threat removed relatively efficiently by centralised contractors. • Slower clean-up by USACE contractors potentially due to worker health and safety precautions.	• Limited use of local contractors. • Property owners disempowered by demolition process. • Demolition (compared to deconstruction) has potentially negative psychosocial impacts. • Slow clean-up by USACE contractors increased public health threat.

4.4 Factor 4: Environmental approaches

4.4.1 Approach and rationale

Over the course of the debris management process a number of waste management environmental processes, standards and objectives were established to direct the waste management process in an efficient and effective way. The decisions made and the reasons for these decisions are summarised below.

i. Solid waste facility repair

The first DEAO made special provision for solid waste facilities to make immediate repairs to facilities without prior notice to LDEQ. While not documented explicitly it is likely this was to mitigate any potential environmental effects due to hurricane damage and to ready facilities for the influx of hurricane generated debris.

ii. Recycling

The first DEAO included a dispensation to allow C&D waste, if mixed with other wastes, to be disposed of at permitted municipal landfills (ordinarily it must be separated and disposed of separately). This decision was likely made to facilitate removal of waste during the emergency and early recovery phase of the works. This was removed at the issuance of the second amendment of the emergency order on 2 November 2005. The second amendment to the DEAO in fact highlighted recycling and reuse (or diversion) as a priority and that 'every effort should be made to minimize the disposal of reusable and recyclable material in landfills'.

In 2006, the Comprehensive Plan for Disaster Clean-up and Debris Management was issued under a directive of the 2006 Louisiana Legislature Senate Bill 583, Act 662. The Bill outlines the priority of debris management options as *"to the extent that they are appropriate, practical, efficient, timely and have available funding: recycling and composting; weight reduction; volume reduction; incineration or co-generation; and land disposal"* (LDEQ, 2006a).

Disposal was the last priority for waste management options in Louisiana and conservation of landfill space is identified as a primary objective of the clean-up (LDEQ, 2006a). However, a number of factors contributed to mixed waste disposal and limited recycling and a justification for opening Gentilly landfill that landfilling was "proven to be reliable, expedient, protective of human health and welfare and the environment, and economically feasible" (LDEQ, 2006b). The reasons for lack of recycling include:

- Time constraints on contractors (Roper, 2008; Ardani et al., 2009).
- Lack of contract specific requirements for recycling (Roper, 2008).
- Contract payment methods (payment per load to staging area or landfill) (Ardani et al., 2009).
- Mixed nature of the waste (Roper, 2008).
- Presence of formosan termites (Roper, 2008).
- Presence of asbestos.
- Flood damage to gypsum (Roper, 2008).

- Lack of education / awareness of recycling options (Roper, 2008; Yepsen, 2008).
- Limited number of temporary staging sites (LDEQ, 2006b).
- Cheap disposal fees (Roper, 2008).
- Large collection area (Roper, 2008).
- Possible disruption and/or capacity of local or regional recycling industry and/or funds to purchase capital equipment (Ardani et al., 2009).
- Extended 'crisis' mentality leading to inertia in establishment of recycling facilities (Ardani et al., 2009).
- Directives mandating transport of vegetative debris from processing sites to landfills or air curtain incinerators (Ardani et al., 2009).
- Lack of capital equipment or operating space to recycle (Ardani et al., 2009).
- Lack of assured income from tipping fees or from electricity sales (waste to energy technology) (Ardani et al., 2009).
- Lack of concerted effort to coordinate redevelopment activities to realize eco-industrial improvement (Ardani et al., 2009).
- Lack of a plan and/or means to implement recycling opportunities identified in the plan (Ardani et al., 2009).
- Absence of residents to carry out initial waste separation (Cook, 2009).

So while the intent to separate was there, the systems and facilities were not put in place to ensure these objectives were met.

iii. Waste treatment

It is understood that separation of hazardous materials is standard procedure for management of disaster waste, however, it is unknown if there is a legal requirement to separate. Inclusion in the first and subsequent DEAOs made the separation compulsory. The DEAO also emphasised that management of hazardous materials must be in line with LDEQ rules and regulations.

Limited open burning is permitted in Louisiana, but provisions were made after the hurricane such that no prior permitting was required to carry out open burning. This provision was clearly in an effort to maximise debris management options available and to remove delays due to permitting processes.

iv. Disposal

The first DEAO included a number of guidelines on the appropriate disposal of certain hurricane waste streams including asbestos, ash (to landfill and land), putrescibles, white goods, construction and demolition waste, animal carcasses and vegetative debris (LDEQ, 2005b). In most cases this was a steam-lining and clarification of existing waste management procedures.

According to LDEQ, the sheer volume of debris made disposal of C&D waste at Type I and II landfills unfeasible. Type III landfill disposal was seen as "the most expeditious and environmentally sound manner as possible under the circumstances" despite the potential for contamination. Reasons for this decision included the reduced cost of disposal; the time-lag that would be

incurred when new lining for cells in Type I and II landfills would need to be constructed; and the reservation of space in Type I and II landfills for industrial and municipal wastes (LDEQ, 2006b).

In addition to this decision the waste acceptance criteria at Type III landfills was expanded. Furniture, carpet, painted or stained lumber contaminated waste where it could not be separated (LDEQ, 2005d) were also included. Again this appears to have been in an effort to expedite the clean-up. Some Type III landfills were also reclassified as 'enhanced C&D landfills' to increase disposal sites that could take asbestos contaminated wastes.

Several additional disposal facilities were opened to increase disposal capacity for hurricane debris and subsequently remove bottlenecks at disposal facilities (see Section 4.4.2). Sites were chosen because they were close to the affected area (to reduce haul times and costs). Gentilly landfill and Chef Menteur landfills were two such landfills.

4.4.2 Delays

In general it appears that environmental standards were reduced and regulations streamlined in order to avoid and/or minimise delays in the recovery process. Environmentally favourable options, such as recycling, were considered too time and resource intensive given the scale of damage and the absence of residents to assist in sorting. Permitting and disposal regulations were streamlined to also reduce delays in clean-up and in the case of emergency solid waste facility repair – to mitigate potential environmental effects.

According to LDEQ (2006b) the new landfills were introduced in an effort to increase the speed of debris removal. In fact expediting the debris removal process was a reason cited in the formal decision notification to use Gentilly Landfill for Hurricane Debris. LDEQ implied that the existing disposal rate in Louisiana was limited by the 50,000 cubic yards per day safety limits (due to landfill stability and worker safety) and that was delaying the clean-up effort. LDEQ estimated that the disposal time would halve if Gentilly landfill was opened. However, aside from an LDEQ document no reports have been sighted that specifically cite disposal rates as a limiting factor in the debris clearance process above truck availability, improper or slow kerbside waste segregation etc .

The disputes resulting from the opening of Gentilly and Chef Mentuer landfills (the latter lasting 6 months) according to Weaver (2006) did not cause delays to the overall waste management programme / recovery. However, the disputes undoubtedly took resources away from other recovery activities and some impact on the recovery would have been felt indirectly.

4.4.3 Organisational aspects

Stream-lining of regulations and procedures and reduction of notification periods allowed for greater flexibility in the work planning. Shorter periods allowed for the clean-up programme to be more fluid and respond to

unforeseen circumstances with greater ease. For example the reduced notification period for emergency repair of solid waste facilities allowed for quick resurrection of solid waste facilities. If peace-time notification periods had been in place and facility operators had to wait for approval before repair not only could this have led to environmental contamination but it could have delayed the entire clean-up process.

As noted in Section 4.4.1, low recycling facility capacity was one factor in the ineffectiveness of recycling efforts. In addition hazardous waste treatment organisations were apparently overwhelmed by the quantity of debris. This disconnect between the proposed system (in this case with the goal of maximising diversion) and the system capacity, directly affects waste managers' ability to meet the desired goals. It is unclear in this situation whose responsibility it was to ensure that these systems were aligned (as discussed in Section 4.1). The Corps or local authority appointed contractors carried out works within the environmental boundaries set by LDEQ and financial constraints established by FEMA. However, no organisation appeared to be overseeing the strategic management of the waste to try to, where possible, ensure not only minimum standards were met but environmental (and financial) outcomes were optimised, including identification and establishment of additional recycling and waste processing facilities. In fact, LDEQ's disaster management plan called on contractor knowledge of regulation and best professional judgement when determining final deposition options for the debris (LDEQ, 2005c; 2006a).

The lack of system cohesion was also a problem in terms of disposal. Disposal facilities if not owned by the local authority, needed to be permitted by the local authority and LDEQ. Thus, the Corps contractors had to liaise closely with local authorities to advocate for additional facilities if required. However, evidence suggests that communication and coordination between these groups may not have been effective. For example, the contractors initially considered taking waste outside the affected region as the fastest and cheapest solution available at the time. This was not the desire of the LDEQ or the community. The contractors were possibly wary of the inevitable delays in citing new waste disposal facilities.

The form of contract and payment for contractors did not incentivise recycling. For example, many contracts were written such that contractors were paid by the cubic yard to disposal, and therefore there was no incentive to separate (Roper, 2008). Contracts could have been written to mandate more recycling, including provision of additional facilities if necessary (see above).

Waste monitors at landfills only carried out visual inspection and were not engaged to sort through trucks (Roper, 2008). This process has a limited effect on minimising contaminated material entering the landfill. However, given the large number of trucks (three thousand trucks each day at Old Gentilly landfill (Roper, 2008)) it is not clear whether a more rigorous system would have been feasible. There are two approaches – either try and maintain peace-time 'standards', but with an expedited process (such as this ineffective monitoring); or to accept that the risks are higher and standards will not be

reached and to mitigate effects where possible. It is important to realise that in a disaster situation it is inevitable that the risks faced will increase as our ability to manage them reduces.

4.4.4 Legal implications

Ordinarily most federal laws cannot be waived. However, following Hurricane Katrina there was a special law passed that enabled USEPA to change any law under its jurisdiction to facilitate the clean-up. To the authors' knowledge this bill was never used. USEPA, state and local authorities preferred to work inside federal law, where possible reducing regulatory procedures and protocols instead and if necessary changing state or local laws.

Consequently all the environmental regulations for management of hurricane waste were at state or local level. The primary mechanism for the waivers was the LDEQ DEAOs. The DEAO's purpose was to "prevent irreparable damage to the environment and serious threats to life or safety in the Emergency Areas". The major drawback of the DEAOs was the short duration of the orders – the first only being current for four days before being updated. This short duration did not allow for certainty in the debris management response planning. Ardani et al (2009) observed that there was an extended 'crisis' mentality in the recovery effort. The short duration of the emergency order would have likely exacerbated this. Without certainty in the legal constraints on the waste management system it was difficult and commercially risky to plan using the relaxed legal boundaries.

The scope and purpose of the DEAO also appeared to change over the course of the recovery. For example as affected parishes were cleared, they were removed from the DEAO and the streamlined procedures it provided. After previously having the DEAO lifted, four parishes were re-added to the fifteenth DEAO. The parishes were added due to a large number of pending demolitions which were deemed 'vital to the recovery of these areas' and the works would have been delayed without the flexibility provided by the DEAO. The decision was clearly based on recovery yet the DEAO purpose relates to threats to life and safety. This uncertainty, as well as short time frames, in the use of waivers or DEAOs makes planning difficult.

The opening of the Gentilly and Chef Menteur landfill, in addition to the expanded waste acceptance criteria, generated opposition from environmental activists. Despite the waiver (to expand the waste acceptance criteria in the C&D landfill) being made legally under provisions of emergency legislation, activists filed two lawsuits opposing both landfills' operation and challenging the expanded waste acceptance criteria. The lawsuit at Chef Mentuer landfill was upheld and the lawsuit against Gentilly resulted in reduced activities at the site. This outcome indicated that the quality assurance processes behind the issuing of legal waivers were not robust. While legal waivers are an important part of a disaster response there must be boundaries and checks around the appropriate use of them (Brown et al., 2010b).

In addition liability around the use of legal waivers was called into question. A special report on the Gentilly landfill by EPA determined that there was no

way to protect FEMA or USEPA's Superfund[5] (environmental remediation fund) against future liability due to inappropriate use of landfills under emergency mandate (Luther, 2008). Thus decision-makers are in a difficult position where they want to make quick decisions but they also need assurance that they are making informed decisions to avoid liability. Unfortunately given the time-constrained nature of disaster response – assurance in the outcome is not always possible. It is interesting to note that Gentilly landfill initially tried to open under 'peace-time' permitting, however, after petitioning by LEAN to prevent it opening, LDEQ used emergency powers granted under the DEAO to open the landfill. In the authors' opinion this was a positive move which ensured the opening of the landfill was recognised specifically as a disaster response measure under disaster legislation, as opposed to a hastily certified facility under peace-time regulations. While the exact justification for this change is unknown there may also have been long term liability concerns which contributed to the decision.

4.4.5 Environmental

The emergency repair of waste facilities allowed for immediate action to be taken to mitigate potential environmental effects. Emergency repair of existing facilities is seen by the authors as an essential element to any disaster waste plan. Legal and organisational structures need to be permanently in place to support this. Classifying waste management services as a lifeline or critical infrastructure may be one way to do this (Brown et al., 2010c).

Recycling has many environmental benefits over disposal. Recycling saves landfill space (for non-recyclable items) and reduces demand for raw material resources in the future. However, as discussed in previous sections, for a number of reasons recycling was not generally practiced in the response to Hurricane Katrina. So all these potential benefits were lost. It is interesting to note that recycling in New Orleans prior to Hurricane Karina was at about 6-9% in New Orleans (Roper, 2008).

Instead of recycling, authorities and contractors favoured the use of C&D landfills. But with limited sites available measures such as streamlined disposal guidelines and expansion of facility waste acceptance criteria were implemented. As a result C&D landfills were accepting waste with higher risk than in peace-time and posing a higher risk of environmental contamination. For example elevated contaminant levels were detected in the sediments. Deposition of these sediments in C&D landfills could have long term effects on the environment. Some studies have shown As, Fe and Pb levels in the soil in excess of USEPA acceptable levels for chronic exposure and, in the case of Pb, exceeding levels which require prioritised remediation (Presley et al., 2005).

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[5] Release of hazardous substances is governed by the Superfund law (officially, the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA). Section 104(a)(1) of the act (42 U.S.C.§9604(a)) provides the President and USEPA (or delegated officials) broad authority and flexibility to respond whenever there is a release or threatened release of a hazardous substance, or a pollutant or contaminant that may present an imminent and substantial danger

If this soil was disposed of unlined (such as Type III or C&D landfills) and/or inadequately capped landfill sites there is potential for leaching of these heavy metals into groundwater or migrating into surface waters.

Esworthy et al noted that some of the sites were contaminated pre-Katrina and elevated levels of lead in particular have already been documented (Esworthy et al., 2006) implying that the contamination resulting from the disaster may not have been as severe as some believe. This may be true, however, collection and deposition of contaminated materials in one location would increase localised risk of contamination. The report also implied that if levels prior to a disaster were below standard then accepting increased contaminant levels post-disaster was more acceptable. In fact, if resources are available, and/or historic and current environmental remediation is a priority, the clean-up operation presents an opportunity to carry out wider scale remediation.

In the past hurricane debris sites have been the source of environmental contamination. In New Orleans, following Hurricane Betsy in 1965, a previously closed landfill was reopened to take hurricane waste. In 1990 the site, after being built on as a site for affordable housing, was designated a Superfund site due to extremely heavy metal concentrations (Allen, 2007).

There were some environmental benefits from using landfilling over recycling. These included reduced transportation (fossil fuel use / carbon dioxide production) as the sites were close to the affected area and removal time reduction (reducing the risk of environmental contamination from unmanaged waste). The proximity of the sites also allegedly reduced incidents of illegal dumping by contractors and potentially by residents frustrated by the slow clean-up (LDEQ, 2006b; GAO, 2008).

4.4.6 Economic

It is unclear whether a cost-benefit style analysis was carried out while determining whether or not to use recycling. From the literature reviewed and personnel spoken to it appears that the decision to landfill over recycling might have been based primarily on speed, shortage of labour and simplicity (given the lack of existing recycling facilities). The authors do not have any quantitative data on the relative costs of landfilling over recycling at the time. However, it is understood that the value of recyclables, especially metal, at the time was very low. Management of hazardous items such as fridges, which can have high salvage value, for example, were only carried out by contractors for the handling fees rather than the value of the recyclables. In addition it is understood that there was high competition between disposal facilities and prices were driven down – further limiting the feasibility of recycling. The state identified this drop in the market and intervened by regulating waste quantities going to each facility.

The Mercy Corps deconstruction project demonstrated some of the potential benefits of using deconstruction (which maximises salvage of materials) over demolition. Salvaged materials were on sold at 50-90% less than retail lumber yards – this offered cost savings in the rebuilding phase following the

disaster. It also boosted materials available for the rebuild which would mitigate the reported price inflation of building materials during the rebuild. Overall the project found deconstruction to be comparable or more favourable to demolition when material resale is included in the net cost calculation (Denhart, 2010) even when the market values were low as described above. However, it should be noted that this study was only for a limited number of houses. If this was done on a larger scale, the economics of deconstruction may well change with the potential flooding of recycling and reuse markets, for example. Costs would also vary wildly between contexts depending on value of recyclables, price and availability of disposal sites, labour costs etc.

It should be noted that the FEMA regulations state that revenue from recyclables should offset the cost of debris removal. If a local authority carries out the work the value obtained from sale of the recyclables should be returned to FEMA. Given the requirement for local authorities to use the lowest cost option as well, recycling will be practiced if the market is favourable and/or the local regulations require it. If a contract is issued, generally the contractor retains ownership of the materials and the value of the contract allows for this. So in theory, if competitive bids are received contractors will have included recycling as much as possible to reduce the price. However, in a catastrophic event such as Katrina, where there are limited contractors available to carry out the works at such a large scale, there is a possibility that contractors do not consider recycling to be practicable and don't include it in their price. If recycling is a priority for local or state authorities then local regulations, levies, taxes etc have been set up correctly such that recycling becomes a favourable option. Contract payment terms could also be written to favour recycling including using time and cost (labour hours and truck use) versus measure and value (payment by tonnes moved).

The relaxation of disposal criteria and additional sites has several economic benefits including:

- Faster debris removal leading to expedited rebuilding
- Lower haul distance and cost
- Lower labour costs than recycling

According to LDEQ, the economic benefits of opening the new landfill sites, outweigh the environmental impacts (LDEQ, 2006b). However, depending on disposal costs, landfilling could be a more expensive option. In addition the elevated risk accepted, by relaxing these regulations, increased the potential for contamination which could lead to high remediation costs in the future.

4.4.7 Social

The effect of environmental standards and approaches had mixed impact on the community. According to Ardani et al. (2009) communities and experts alike were in favour of recycling. However, recycling was believed to unreasonably slow the clean-up process whereas landfilling allegedly reduced the clean-up time (LDEQ, 2006b; GAO, 2008) which has positive social impacts.

The opposition to the re-opening of Gentilly landfill by a local environmental action group (LEAN) provides a very interesting insight into the social attitude toward debris management. LEAN would have been keenly aware of the devastation of Katrina and the need to dispose of the debris in order to recover and move forward. However, the group was not prepared to accept a negative long-term environmental outcome in favour of expedient clean-up operations. This indicates that some people in affected communities are not solely focussed on the immediate recovery and are looking at the longer-term impacts as well. This example also demonstrates the opposing drivers of contractors and the community when designing waste management systems. Managers see proximity of a site to the affected community as a positive (lower costs and haul distances). However, the community may see it as risk-loading an already impacted community.

Conversely there was frustration by residents over the slow clean-up as demonstrated by illegal dumping and the comingling of waste at the kerbside. Comingling of waste at the kerbside also led to increased public health hazards (LDEQ, 2006b; GAO, 2008). It was this latter frustration and public health hazard that appeared to be the main driver in the clean-up process and many of the environmental approaches were aimed at reducing the time to clean-up and consequently alleviating this frustration.

4.4.8 Summary

Overall the relaxation and streamlining of environmental standards had positive impact on the speed of the recovery process. Quality assurance around use of legal waivers, however, was not well managed. There was a significant degree of uncertainty arising from the short duration of the DEAOs. Liability around use of legal waivers was also called into question, particularly where relaxed procedures rather than reduced standards were implemented.

Table 4-4 summarises the strengths and weaknesses of the approach to environmental standards taken.

Table 4-4 Hurricane Katrina environmental standards assessment summary

	Strengths	Weaknesses
Organisational	• Streamlining of regulatory notification periods allowed for more fluid programming of clean-up works.	• No organisation overseeing the strategic management of the waste to minimise environmental impact / reliance on contractor 'best judgement'. • Contract payment terms did not encourage recycling. • Ineffective load monitoring at landfill.

Legal		• Short duration of DEAOs and associated environmental waivers. • Lack of clarity on the purpose and scope of the DEAO provisions. • Long-term implications of legal waiver use is unclear. • Processes around assuring quality outcomes of legal waiver boundaries are unclear. • Waivers provide no liability protection.
Environmental	• Emergency repair of solid waste facilities mitigated potential environmental contamination. • New landfills reduced haul distances. • Increased speed of clean-up reduced potential for illegal dumping.	• Resource depletion due to limited recycling. • Elevated risk of contamination at landfills due to relaxed disposal guidelines.
Economic	• Landfilling possibly cheaper given low value of recyclables at the time (less labour and transport costs). • Relaxed environmental standards led to faster debris removal and subsequent rebuilding.	• Limited salvage of C&D material potentially increased cost of clean-up and did not supplement materials for rebuilding. • FEMA payment guidelines do not consider environmental outcomes. • Relaxed disposal standards could lead to costly future site remediation.
Social	• Relaxed standards led to a faster clean-up which meant reduced frustration and reduced public health risks.	• Communities wanted recycling. • Communities were concerned about long-term implications of environmental waivers.

4.5 Factor 5: Public health and safety standards

4.5.1 Approach and rationale

The USEPA identified standard asbestos handling and disposal procedures as a contributing factor to the slow debris removal process. Subsequently USEPA moved to reduce the handling requirements: "EPA…is providing debris management guidance to ensure minimization of exposures while expediting cleanup." (Luther, 2008). This was a conscious decision to reduce handling requirements and asbestos management procedures in order to reduce community public health hazards of the unmanaged waste and

expedite clean-up. However, in doing this, the authorities were potentially increasing the health and safety risk to workers and community exposed during clean-up operations. As discussed in Section 3.5.3, relaxations included contractor certification, notification, asbestos inspection requirements and handling requirements.

Public health and safety in general was governed by USEPA pre-disaster exposure standards. Where no pre-disaster exposure standards existed (such as mould and some of the bacteria found in the flood water sediments), basic health protection advice was formulated and disseminated. Section 3.1.2 outlined a number of specific hazards identified in the waste matrix, including sediments, dust, mould and arsenic. The authors have not found any information on the basis for these post-disaster guidance notes.

4.5.2 Delays

As stated above, it was believed that the existing health and safety regulations, in particular around asbestos were too slow and cumbersome for the situation. Relaxations in some of the regulatory requirements were believed necessary to speed-up the recovery and avoid delays. LDEQ estimated that the relaxation in management requirements reduced the demolition time for homes by 2 to 3 days per house (GAO, 2008) considerably reducing the aggregated clean-up time.

4.5.3 Organisational aspects

The Department of Labour is included in ESF. This in theory ensures that worker health and safety are considered when designing waste management strategies. The coordination between waste managers and the Department of Labour was unclear.

The relaxation in regulatory requirements relieved authorities such as USEPA and LDEQ of some of their duties and allowed them more time to meet and carry out more programme oversight work to identify and manage key areas of concern (GAO, 2008). In particular, the expansion in criteria of buildings with LESHAP exemption significantly reduced regulatory workload.

In addition, the relaxation around contractor accreditation increased the pool of workers available to carry out the works. This expedited accreditation process, however, potentially lowered the quality and skill of workers handling the asbestos. Thus authorities have potentially accepted lower quality of work (and thus increased associated health and safety risks) for increased quantity.

The reduced notification period (from 10 days before to within 24 hours after commencement) for any demolition works with asbestos allowed for greater flexibility in the programming of works.

4.5.4 Legal implications

The approach taken by waste managers was to alter the regulatory procedures around the state asbestos laws, while still adhering to the federal laws. The federal law therefore acted as a kind of absolute minimum standard acceptable in any given situation. This is an possible way of bounding emergency law changes, provided the federal law is written with consideration for emergency situations.

Liability was a concern when managing asbestos related issues. Exposure to asbestos can cause mesothelioma - a rare and aggressive form of cancer. The disease can take up to thirty years to develop. After the legal actions that followed 9-11 (Phillips, 2010; 9-11 Research, accessed 2011), USEPA were cautious about liability issues. Prior to Hurricane Katrina a federal bill was proposed to establish a national fund to compensate persons for exposure to asbestos and limit the liability of asbestos manufacturers. The bill called the "Fairness in Asbestos Injury Resolution (FAIR) Act of 2005" was not passed.

Waste managers had to balance the danger to the public (by removing hazards quickly) while also protecting contractors. The authors' are not aware of any significant legal action regarding worker or public health and safety following the clean-up efforts to date. However, in 2007 Louisiana considered implementing a Bill similar to the 2005 Fair Act limiting liability of asbestos-related industries for adverse health effects resulting from asbestos exposure. The Bill was spurred by a recent lawsuit against a contractor who had supplied asbestos contaminated soil to a customer. To the authors' knowledge this Bill was never passed.

4.5.5 Environmental

Non-removal of asbestos prior to demolition eliminates the potential for recycling or reuse of the C&D material. It is unknown whether the presence of asbestos was a significant factor in the lack of recycling.

4.5.6 Economic

In terms of direct costs, the expedited procedures would have greatly reduced management. Removing standard requirements to double wrap asbestos in plastic and to separate all asbestos out prior to demolition would have decreased the cost considerably.

The increased speed of debris removal resulting from the expedited asbestos management procedures allowed for a faster clean-up period. As with other measures discussed above, a faster clean-up helps to speed-up the rebuilding and return to economic activity.

4.5.7 Social

According to Denhart (2010) health and safety in New Orleans is not well practiced. There is a general perception that health and safety precautions are just a government constraint. During the Mercy Corps deconstruction

programme a concerted effort was made to educate on health and safety issues. It is unknown whether the same was carried out for the Corps contractors.

In September 2007, monitoring of 10% of FEMA-funded demolition sites was carried out to assess the effectiveness and potential impact of the asbestos management practices. Data obtained was also used to inform the public of the actual risks. It was shown that 1 out of 1,170 sites was above the legal health-limit. USEPA attributed this to erroneous monitoring equipment due to overloading (GAO, 2008). To date the author has not seen any reports on the adverse health effects from reduction in the asbestos handling guidelines, but as noted in Section 4.5.4 symptoms can take up to 30 years to develop.

As discussed in previous sections, generally a faster demolition period will have positive effects on community rejuvenation.

4.5.8 Summary

Overall the relaxation in procedures around asbestos handling was essential for the expedient removal of debris. Expedient removal reduced the public health hazard from unmanaged debris while mitigation measures were in place to protect workers. The federal laws formed a minimum standard for asbestos handling procedures.

Table 4-5 summarises the strengths and weaknesses of the approach to public health and safety standards taken.

Table 4-5 Hurricane Katrina public health and safety standards summary

	Strengths	Weaknesses
Organisational	• Department of Labour is included in NRP coordination structure – ensuring worker health and safety is considered in debris management operations. • Relaxed process relieved regulatory authorities from cumbersome monitoring – allowing more time for strategic planning and overall system monitoring. • Relaxation in certification procedures increased the pool of workers to carry out the works. • Reduced notification period allowed for greater flexibility in programming of works.	• Relaxation in certification procedures potentially decreased quality of work (increased health and safety risk).

Legal	• Federal law acted as a 'minimum standard' for asbestos management.	• Assignment of liability arising from changing of regulatory procedures was not clear.
Environmental		• Relaxed asbestos regulations may have contributed to limited recycling of C&D wastes.
Economic	• Reduction in asbestos handling requirements would have reduced the direct cost of demolition and debris management. • Reduction in asbestos handling requirements would have reduced demolition time and allowed for expedited rebuilding.	
Social	• Faster debris removal would have had positive impacts on community rejuvenation.	• Reduced standards would have increased risk to workers and community during asbestos removal (levels later proven to be acceptable).

5 Planning for the future

5.1 Future disaster waste management

In the US, local governments and contractors alike are generally fairly well prepared to respond to disasters due to the frequency of storm events and established FEMA funding requirements. As discussed earlier these established procedures have increased preparedness through requirements and incentive for local government to prepare debris plans. In addition requirements for establishment of pre-disaster contracts have led to the emergence of a disaster waste contracting industry.

Early in the debris management process a number of challenges were identified in terms debris management (Esworthy et al., 2006).

- Scale of the clean-up
- Health and safety of workers
- Landfill capacity
- "Capability of, or community resistance to, applying 'best practices' for waste management.
- Volume of hazardous materials and ability to separate these from non-hazardous materials
- Slow return of residents and their non-participation in clean-up activities
- Asbestos drawing out demolition works

- Human remains
- Public health protection while allowing access to homes and businesses
- Public involvement in clean-up decisions
- Communicating the degree and nature of risks to the public.

A number of the above challenges were addressed as part of this unique response. However, some of the above challenges have led to permanent changes to disaster response in Louisiana and the US. The following measures have been proposed and in some cases implemented to improve responses to large-scale events:

1. *Standby recycling contracts*. The LDEQ CPDCDM recommends that standby contracts for implementation and operation of recycling activities, including market identification and facilitation, should be established (LDEQ, 2006a).
2. *Pre-approval of temporary waste management sites*. Under the 2006 LDEQ CPDCDM the temporary waste management sites authorised for Hurricane Katrina and Rita have been pre-approved for future use in a disaster, provided: site surrounds have not changed; the authorisation to operate has not previously been revoked; and the site use is the same as for Hurricane Katrina / Rita (LDEQ, 2006a).
3. *Pre-approval of burning sites*. As for staging sites the CPDCDM indicates that local government should propose burning sites for pre-approval by LDEQ. Post disaster LDEQ would then assess suitability of the site and the necessity for burning in the disaster context (LDEQ, 2006a).
4. *Private property debris removal*. Since Hurricane Katrina, processes for private property debris removal and demolition have been set out clearly in FEMA's Debris Management Guide. Required processes include health and safety risk assessments , approvals / legal authority for land access, demolition methods and record keeping (FEMA, 2007a).
5. *Implementing memorandums of understandings between states*. Implementation of shared resources agreements between (non-neighbouring) states has been recommended. FEMA has existing policies on these agreements but there are no current requirements to establish them and they are uncommon.
6. A*sbestos regulations*. The CPDCDM outlines existing asbestos regulatory requirements (certification, inspection, permitting etc), expedited accreditation processes and describes best practice methods. The plan notes that No Action Assurance letters were issued for Hurricane Katrina and that they may be an option in the future. However, the plan does not indicate under what circumstances it may be activated again.

5.2 **Recommendations**

In general the US continues to learn from past experiences and update their already well established debris management systems. Weaver (2006) suggests that debris management plans should be more scripted in order to

avoid some of the legally contentious decisions that were made, in particular regarding disposal at Gentilly and Chef Mentuer landfills. However this approach is not desirable because of the number of variables involved in disaster waste management (disaster size, location, extent, timing, human impact, degree of public or environmental health hazard etc) would make a scripted plan unfeasible. The prescriptive approach of FEMA limits the flexibility in a system to manage emergencies which defy certain assumptions: for example, resident participation where there is a public health hazard or an absent population. They also fail to identify potential limitations such as appropriate disposal facilities or work bottle necks such as asbestos management. Post-disaster management systems need to be flexible enough to deal with unforeseen and/or non-ideal circumstances. Decision-making processes and acceptable outcomes should be explored and incorporated into the guidelines - to provide procedures which guide and support the decision-maker in a post disaster situation where access to information and time are both limited.

Below are several recommendations for improvement of disaster waste management programmes in the future. The recommendations are divided into the organisations responsible for each respective action.

FEMA

- Consider a tiered response system where different mechanisms are triggered for different scale and type of events.
- Where possible, reduce the prescriptive nature of the guidelines to allow waste management needs dictate the funding rather than the funding dictating the waste management operations.
- Develop and implement a coordination mechanism for cross-ESF coordination (such as the GCRO) – possibly linked to tiered response above.
- Develop and implement a coordination mechanism for local, state, FEMA coordination for large scale events (linked to tiered response above).
- Establish public health and safety limits for personal property owner participation in property clearance (linked to tiered response above).
- Determine (and legislate for) a maximum time frame for 'claiming' damaged property of disaster affected properties.
- Revise the scope of debris eligibility criteria: for example, removal of boats outside the shipping channel.
- Improve education and understanding by contractors of the intent of the FEMA guidelines on waste collection criteria (to allow mixed waste loads).
- Consider how waste from building repair and rebuilding will be funded / managed (for example funding of temporary staging facilities or additional recycling facilities).
- Establish a mechanism for recovery of insurance monies for FEMA rendered services.

Insurance Companies

- Bridge the gap between flood and hurricane insurance – to acknowledge multi-hazard events.
- Consider mechanisms for coordination of debris management activities between private insurers (or their contractors) when FEMA does not assist in private property clearance (for economy of scale).

Environmental and public health authorities

- Consider liability implications of reduction of environmental standards – who currently holds the risk and who should hold the risk.
- Permanently allow for emergency repair of solid waste facilities in an emergency.
- Establish guidelines on handling of typical disaster generated debris without current exposure guidelines (e.g. mould, mildew, fungi)
- Consider mechanisms for effective use of local labour and waste facilities.
- Develop a management system for waste resulting from repair and rebuilding of damaged properties in planning documents.
- Establish minimum asbestos handling / management guidelines including guidance on when NAA letters would be reactivated.

Local authorities

- Establish a registration process for displaced persons (to facilitate recovery works including debris removal).
- Consider regulation of disposal costs.
- Prepare procedures around condemnation of houses / private property debris removal.

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Appendix A

- **ESF summary**

Summary of debris related activities within ESF

Below is a summary of activities relating to waste management as provided for in the NRP 2004 (Homeland Security, 2004). Note that the plan has been updated (now called the National Response Framework 2008(Homeland Security, 2008)) and the ESF function annexes can be found at: www.fema.gov/emergency/nrf/. The most notable changes to the ESF, relating to waste management, are the additions to ESF #11 of activities by the Advisory Council for Historic Preservation and the National Records and Archives Administration. In addition, the recognised members of the National Voluntary Organisations (in ESF #6) for disaster relief have been named and their core areas of assistance outlined.

ESF #1 – Transportation

- *Department of Transportation* – regulation, safety and security of transportation systems. Monitoring and reporting of transportation system status.
- *Department of Defense / USACE* – restoration of inland waterways, ports and harbors.
- *Department of Homeland security* – recovery and restoration of critical infrustructure

ESF #2 – Communications

- *Department of Homeland Security* – restoration of communications systems

ESF#3 – Public Works and Engineering

Coordinated by - *Department of Defense* / US Army Corps of Engineers (USACE)

Primary Agencies

- *Department of Defense / USACE* – infrastructure protection and repair, construction management and critical infrastructure liaison
- *Department of Homeland Security / FEMA* – resources and support; provision of federal disaster grant assistance

Other agencies

- *Department of Agriculture* - engineering and contracting / procurement personnel
- *Department of Commerce / National Institute of Standards and Technology* – procurement of consultants to assess structural integrity of building and lifelines
- *Department of Energy* – shares information on energy system damage and restoration. Support and expertise of radiological contaminated debris.
- *Department of Health and Human Services* – coordinates, monitors, provides expertise etc for contaminated debris management; supplies personnel to assess solid waste facilities
- *Department of Homeland security / Office of Infrastructure Protection* – risk assessment and prioritisation of infrastructure restoration.

- *Department of Homeland security / US Coast Guard* – mitigation of hazards to navigation or debris in navigable waters
- *Department of Labour* – Worker safety advice on debris removal and building demolition
- *Department of Transportation* – personnel and support for assessment, debris cleaning and restoration of national transport infrastructure.
- *Department of Veterans Affairs* – engineering personnel
- *USEPA* – Assists locating disposal sites for debris clearance; assists contaminated debris management by coordinating, assessing, providing expertise etc; cleanup and safety guidance in areas affected by hazardous substances
- *General Services Administration* – personnel and contractors to assists in assessments, inspections and clearance monitoring.
- *Nuclear Regulatory Commission* – Assist, coordinate, provide expertise, monitor etc radiological contaminated debris
- *Tennessee Valley Authority* – provides personnel to assist in damage assessments and debris removal monitoring

ESF #4 - Firefighting
- *Department of Defense / USACE*– provides services to rural and urban fire services including demolition services.

ESF #5 – Emergency Management
- *Department of Homeland Security / FEMA*–overall coordination for emergency management
- *All other agencies support support this function.*

ESF #6 – Mass Care, Housing and Human Services
- *Department of Health and Human services* – Technical assistance for shelter operations including waste disposal
- *National Voluntary Organisations Active in Disaster*

ESF #7 – Logistics Management and Operations Support
- *General Service Administration Department of Homeland Security / FEMA*–overall coordination for logistical support

ESF #8 – Public Health and Medical Services
- *Department of Health and Human Services* – assessment of public health needs and health surveillance
- *Department of Agriculture* – support for public health matters in radiological incidents and support disposal of animal carcasses.
- *Department of Defense* – provides assistance in managing human remains, provides military medical personnel to assist HHS in protection of public health eg solid waste disposal.
- *Department of Energy* - Control and mitigate radiological hazards to workers and public
- *Department of Labour* – worker health and safety
- *Department of State* – coordinates international activities related to chemical, biological, radiological and nuclear incidents

- *USEPA* – provide technical assistance and environmental information for assessment of public health risks involving hazardous materials

ESF #9 – Search and Rescue

- *Department of Homeland Security / FEMA* – operational overview of search and recue including building collapse operations
- *Department of Defense / USACE* – structural stability and safety assessment

ESF #10 – Oil and hazardous materials

Coordinated by – USEPA

Primary agencies:

- *USEPA* – inland areas or incidents affecting both inland and coastal;
- *Department of Homeland security / US Coast Guard* – coastal incidents

Other agencies

- Department of Agriculture (USDA) – measures impact of incident on natural resources under its jurisdiction
- *Department of Commerce / National Oceanic and Atmospheric Administration* – expertise on oil and hazardous material effects and cleanup; survey and obstruction location for safe vessel movement
- *The Department of Defense* – on-scene coordinators for response of hazardous material release from its operations
- *Department of Energy* – on-scene coordinators for response of hazardous material release from its operations; advice on identification and extent of radioactive releases and removal and disposal of radioactive contaminants
- *Department of Health and Human Services* – With EPA and USDA ensure proper disposal of contaminated food.
- *Department of Homeland Security / Office of Infrastructure Protection* – restoration of critical infrastructure
- *Department of the Interior* – provides advice and assistance to minimise injury to natural and cultural resources
- *Department of Labour* – worker health and safety
- *Department of the State* – facilitates a response where discharge or release crosses international boundaries
- *Department of Transportation* – provides expertise on transportation of oil and hazardous materials
- *Nuclear Regulatory Commission* – coordinate with EPA emergencies involving radiological and chemical release.

ESF #11 – Agriculture and Natural Resources

- *Department of Agriculture* – Food Safety inspection service including disposal of contaminated products to protect public health and environment; mitigation or elimination of infected or contaminated items that threaten public health; assists with prevention and control of any highly contagious or zoonotic diseases including carcass disposal; protection of natural and cultural resources and historic properties.

- *Department of Commerce / National Oceanic Atmospheric and Administration* – provides baseline data and expertise.
- *Department of Defense / USACE*– provide expertise and resources for disposal of contaminated and uncontaminated debris including animal carcasses affecting natural and cultural resources and historic properties
- *Department of Homeland Security* – restoration of critical infrastructure including prioritisation of resources.
- *Department of the Interior* - provides advice and assistance to minimise injury to natural and cultural resources and historic properties
- *Department of Labour* – worker health and safety under this ESF
- *USEPA* – technical assistance for hazardous agents, contaminated agriculture and food crop decontamination and disposal.

ESF #12– Energy
- *Department of Energy* – Restoration of energy systems

ESF #13– Public Safety and Security
- *Department of Justice* – critical infrastructure protection, security planning and technical assistance, technology support, and general law enforcement

ESF #14 – Long-term Community Recovery and Mitigation
- *Department of Agriculture* – loans and grants for agriculture sector
- *Department of Homeland Security / FEMA* – coordination of long-term recovery
- *Department of Treasury* – removal of impediments to economic activity
- *Small Business Administration* – long-term loan assistance
- *Department of Commerce* – economic impact assessment
- *Department of Defense / USACE* – assists in planning and preparation of debris management plans
- *Department of Energy* - Provide technical advice on radiological debris management
- *Department of Health and Human Services* – expertise on long-term health
- *Department of the Interior* – technical assistance in community planning
- *USEPA* – Advice on planning for contaminated debris management

ESF #15 – External Affairs
- *Department of Homeland Security* – provides support and mechanisms for implementation of NRP