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Appendix A:
Literature Review and Annotated Bibliography

This literature review examines available research related to the critical issue areas laid out at the inception of this NCHRP 08-107 applied research.

While the focus of the research has narrowed as a result of the research team's Phase I work and subsequent gap analysis which is reflected in the present form of the literature review, the full annotated bibliography remains intact as a resource for future investigations and research.

This appendix reviews administrative considerations including procurement and contracting methods, payment and cost methods, flexible emergency contracting procedures, and other topics involving concurrent regional emergencies for surface transportation.

Background and Purpose

The exploration of effective administrative strategies including procurement and contracting in concurrent regional emergencies shows evidence of a material gap in the current body of knowledge and the state of practice in the transportation sector as well as for state and local government agencies, in general. Anecdotally, the research team has consistently observed that state transportation agencies (STAs) and Metropolitan Planning Organizations (MPOs)that are not located in high-hazard areas either do not have emergency procurement and contracting procedures in place or that those policies are designed to manage minor roadway hazards such as a multi-car pile-ups or a moderate hazardous materials spill. This applied research's literature review provides a vehicle to examine administrative procedures, particularly procurement and contracting, in place for STAs and MPOs during "blue skies," utilizing normal day-today standards for administrative systems, as well as during emergency conditions at disparate magnitudes and impacts.

It was noted that even in STAs and MPOs with more substantial emergency procedures, the procedures do not contemplate the demands and complexities of concurrent regional emergencies. Where such procedures are aligned to perceived risks, they account for annualized risks (such as a "1 in 50-year" rate of return event), and procedures are typically shaped around the assumption that an event will impact a limited number of assets within a well-defined footprint. As such, emergency procedures are not scalable and almost invariably fail to define authorization triggers to pivot to the demands of moderate, major and/or catastrophic event.

This literature review contributes to the first part of a two-tiered applied research approach culminating in the publication of this applied research's primary deliverable, *A Contracting Strategies Guidebook for Administration of Concurrent, Regional Emergencies*. The purpose of the literature review is to provide a holistic overview of existing procurement and contracting methods and practices available during emergency response and recovery, particularly, in the event of concurrent regional emergencies. This review identifies the current state of the practice by STAs in these matters as well as other relevant topics that arise during such emergencies. It includes an analysis of constraints on flexible, post-disaster procurement and contracting methods and on innovative contracting techniques in general.

The sections that follow present a detailed review of the different critical issue areas identified, discussing existing practices and recommendations under each area. Transportation professionals can use a variety of contracting types to rapidly restore transportation networks, which is essential in restoring social stability and restarting the economy after a major or catastrophic disruption.

A.1 Role of Procurement and Contracting

Though the finance and administration section is integrated within the incident command system's organizational structure, this role can be treated largely transactional in stabilizing surface transportation assets and restoring essential traffic. However, the work of these professionals is key to the strategic, operational, and tactical implementation of rapid response operations for STAs as well as local government plans because their work determines the speed to project completion, multi-risk transfer, and cost controls for each procurement and contract as well as the disaster response and recovery portfolio as a whole. "Procurement has been distanced from policy and seen as a tool; however, the procurement role is more than a mere mechanism for acquiring products, because its outcomes and impacts are policy-related ends in themselves… Involving procurement before and after a disaster in meaningful ways can become a hallmark of government that is itself resilient, and will help its community recover more quickly" (Atkinson & Sapat, 2012).

A central challenge of disaster procurement and contracting is the urgency: STAs and local agencies must rapidly mobilize people and materials in service to urgent and wide-spread response and recovery needs. Acting too quickly and without risk management controls may result in unintended risks to government - from price gouging to inadequate contract terms and conditions. Another challenge for disaster procurement and contracting is that natural disasters do not adhere to localities and jurisdictions. This means that all planning, response, and recovery require coordination with multiple stakeholders, regional entities, and transportation asset owners and operators (National Academies of Sciences, Engineering, and Medicine, 2013).

A.1.1 Pre-Planning

Pre-planning for disaster recovery is essential. Making provisions in advance is the fastest way to react to an emergency, as STAs can develop the capacity to move without the need to expedite procurement procedures (National Academies of Sciences, Engineering, and Medicine, 2012). In an analysis of disaster procurement before and after Hurricane Katrina, researchers found that the local government activity was informed by the existence of open and accountable procurement and contracting systems prior to the hurricane. Systems contributing to resilient rebounds of the community featured transparent and accountable contract awards and consistent record-keeping. Parishes (counties) which did not have best-practice procurement systems already in place experienced slower and more difficult response and recovery efforts (Atkinson & Sapat, 2012).

As a part of pre-planning, multiple National Cooperative Highway Research Program (NCHRP) reports have found that building a standing list of prequalified engineers and construction contractors, pre-emergency, can assist with a timelier response. This kind of planning reduces the time to identify qualified sources of services, materials, and equipment. This can manage risk exposure and reduce the potential for protest or lawsuits. Setting up purchasing agreements ahead of time has also been found to expedite procurement processes. This can be done by listing all available contracts and the commodities available through a cooperative purchasing agreement process specifically designed for emergencies (Hurst et al., 2017).

A.1.1.1 Manual Back-Up Systems[1]

A key part of pre-planning is also considering the resources, or lack thereof, that the STAs have access to during and immediately following a disaster. There are needs in disaster procurement to provide for manual systems to back-up any technological enhancements which may fail as a result of a hazard event. For example, e-procurement will likely not be possible in the days and weeks following a hurricane, for any local or regional vendors that might be interested in pursuing the work offered. Even if the government's systems are working fine, there is no guarantee that vendors will be able to access procurement systems (e.g. that power is on, and internet access is available). Instead, procurement officials might have a paper-based vendor directory available to contact directly local vendors that might be interested in immediate, post-disaster contracting needs of a city or county. While this additional step requires set up time and integration and updates into emergency procurement procedures, it will aid in utilizing free and open competition to the extent to which prevailing conditions allow during rapid response encouraged under 2 CFR Part 200. In addition, backup systems for important document storage should be set up at alternative locations (National Academies of Sciences, Engineering, and Medicine, 2013).

A.1.2 Legal (Regulatory) Context

State law permitting, local agencies have the power to take whatever actions are necessary to provide for safety, health, and welfare of residents during an emergency.

Specifically related to procurement, the 2 CFR § 200 provides for the temporary suspension of competitive bidding requirements for construction contracts under emergency conditions and where governed by prudence. Under non-emergency conditions, FHWA requires consultant contracts to conform to the Brooks Act (23 CFR § 172.5a3) which requires qualifications-based selection for professional services. Under 2 CFR § 200 and FHWA requirements, contracts for construction to generally be awarded on the lowest responsive bid meeting the established criteria of responsibility, although other pricing methods such as unit cost and short-term time and materials contracts with not to exceed (NTE) thresholds are allowable where scope of work are largely undefined. Federal-aid primary, secondary and special roadway designations are eligible for federal funds administered by FHWA. Title 23 USC § 125 provides for Emergency Relief funding (FHWA ER) for the "repair or reconstruction of highways, roads, and trails, … that the Secretary finds have suffered serious damage as a result of— (1) natural disaster over a wide area, such as by a flood, hurricane, tidal wave, earthquake, severe storm, or landslide; or (2) catastrophic failure from any external cause"(Gransberg, 2013). During an emergency, agencies must still coordinate and comply with other state and federal agencies to meet the requirements such as those contained within the National Environmental Policy Act (NEPA).

A.2 Barriers and Success Factors

Alternative contracting method effectiveness can be measured objectively with metrics on schedule, cost, quality, and safety. Some barriers identified in an NCHRP report survey on implementing alternative

[1] Synthesis Report 438 and Document 206

contracting methods are listed below. The first two barriers listed were seen to be the most important obstacles to successful implementation (National Academies of Sciences, Engineering, and Medicine, 2008):

- Lack of prior expertise;
- Lack of enabling legislation (for design build [DB] and public-private partnership [P3]);
- Lack of resources, i.e., staff time;
- Lack of supportive organization structure for alternative contracting methods (ACM);
- Lack of funding;
- Adherence and familiarity with known and proven methods;
- Employee union opposition;
- Inexperience of contracting community;
- Lack of demand considering the type of projects;
- Lack of leadership for innovative actions; and
- Size of contracts.

Alternatively, the NCHRP effort revealed that successful projects using alternate contracting have included several of the following features:

- Articulating a department vision and objectives for project delivery performance;
- Additional staffing/consultants to meet project management needs;
- Creation of an alternative contracting methods (ACM) unit or office within an organization is a measure that expedites the use of ACM and including junior staff in the effort;
- Aligning project delivery methods and contractor selection with project needs;
- Improving coordination with MPOs;
- Early continuous contractor involvement from design to construction;
- Holistic design should include early collaboration with environmental regulators, construction managers, and designers to minimize environmental impacts and expedite permitting. This includes STAs and environmental departments coordinating on a “crosswalk” between technical detail/design and the information necessary for environmental approvals; and
- Establishing performance measures to monitor progress using data-driven analysis.

A.3 Procurement and Contracting (Project Delivery) Methods

A.3.1 Conventional Procurement Methods

This section reviews conventional and alternative procurement methods found in the literature. Conventional methods include low bid, alternate bid, best value, and sole source. Alternative contracting methods include bid averaging, reverse auction bidding, and cost-plus-time bidding.

According to Ruparathna and Hewage (2015), construction procurement is viewed through two main lenses. The first describes those of the view that procurement only involves the "purchasing transactions" involved in obtaining a built facility. The second view is that of those who see procurement more holistically and, therefore, involves the "process of satisfying [a] potential client with a need for [a] constructed facility" (Ruparathna & Hewage, 2015).

In the transportation industry, procurement processes cover all stages of the project including:

- **Pre-contractual phase** - defining requirements, planning procurement process, bid solicitation
- **Contracting phase** - bidder selection, pre-bid conference, proposal evaluation, purchase order
- **Contract administration phase** - contract amendments, monitoring progress, delivery follow up, progress payment administration)
- **Post-contractual phase** - final action contractor agreement, final contract amendment, complete financial audits, proof of delivery, return performance bonds and close-out, etc. (Ruparathna, 2013)

The sections below outline some conventional procurement methods.

A.3.1.1 Low Bid

In this procurement method, bid selection is based solely on price. This approach is traditionally used with the design-bid-build delivery method. Thus, the contract is awarded to the lowest bid received and the contractor's price is subsequently used as the project contract price.

North Carolina DOT defines this contracting method as "a fixed price including labor, overhead, non-salary direct costs, and fee for the performance of specific services." This type of contracting is typically used when projects have a well-defined scope of services, a low risk of unforeseen conditions as well as a low probability of scope changes once the project has begun. The contractor usually receives a set of bid documents from which quantity take-offs and price estimates (Caltrans, 2007). This type of contracting typically provides the least cost risk to owners and a higher cost risk to contractors.

This method provides a great risk transfer from owner to construction contractor. However, post-disaster scenarios can heighten the risk of attracting predatory construction firms that seek opportunities to expand scope. They begin with a low ball offer to win the contract, then find legal loopholes for scope creep and cost escalation. The owner has to ensure on low-bid construction if the bid comes in significantly under expected – there needs to follow up with contractor to ensure they fully understand the scope of the work (Cray, 2005; ICF International, 2008).

A.3.1.2 Alternate Bid

The objective of this method is to obtain a specified performance at the best value. Agencies receive multiple bids on two or more alternates of a specified design. At some point, the agency will decide which alternate provides the best value. This method has been successfully applied for projects where the competition will drive the most cost effective material choice or design approach (asphalt vs. PCC, steel vs. concrete), standardized projects that do not require a large design effort, small projects with a large pool of bidders, and projects with a well-defined scope and viable alternates (Caltrans, 2007).

Disadvantages associated with this method is that it may increase the bid protests, reduce the number of capable bidders, the difficulty of life-cycle costing, the requirement of full plan development for each alternate, and with multiple designs there could be conflicting details, specifications, and quantities (Caltrans, 2007).

The FHWA's traditional pavement policy discourages the use of alternate pavement type bidding on the basis that it is difficult to develop truly equivalent alternate designs for Portland cement concrete pavement and asphaltic concrete pavements. However, the FHWA has allowed states to evaluate the use of alternate pavement type bidding with bid adjustments to account for differences in life-cycle-costs under SEP-14. The Michigan DOT and the Louisiana DOTD have used life-cycle cost estimates to determine the successful lowest bidder (Caltrans, 2007).

One advantage of this procurement method relevant to post-disaster rebuilding is the ability to bid on multiple designs that have multiple levels of resilient asset protection. This can open the door to discussions with local agencies and organizations to consider better and stronger ways to rebuild during the contracting process. The disincentive to this is that it would take more money and time, which might not be appealing to emergency rebuilding projects (National Academies of Sciences, Engineering, and Medicine, 2013).

A.3.1.3 Best Value

Agencies using this procurement method seek to determine the best value bid from submitted bids by considering bid price along with other factors such as time, qualifications, quality and design alternates. According to NCHRP Report 561 *Best-Value Procurement Methods for Highway Construction Projects*, more than half of the 44 highway agencies surveyed in that report have experience using best-value methods, although usage factors such as selection criteria and other technical factors varied widely (Caltrans, 2007; Scott et al., 2006). This procurement method is best suited for complex projects that require specialized knowledge, equipment or technology (Caltrans, 2007). Time can be an issue with this method as more time may be needed to both prepare submittals and evaluate the bids (Oliva et al., 2009). The fact that this procurement method requires more time can be a hindrance with disaster recovery.

A.3.1.4 Sole Source

This procurement method is used for projects that have only one bidder where the agency is authorized to award directly to consultant/contractor of its choice without competition. This situation is commonly present when specialized work services need to be performed or during emergency situations. Contractors may be selected based on qualifications, existing relationships, or a proprietary product. Although this method limits full and open competition, it may be useful during extenuating circumstances to accelerate

the procurement process or when the product, material or equipment required cannot be supplied by any other contractor (National Academies of Sciences, Engineering, and Medicine, 2012).

A.3.1.5 Cost-Plus-Time

This procurement method is commonly referred to as A+B, where the bid amount is represented by "A" and the proposed project duration is represented by "B". The latter portion relating to time is a factor of cost and time in days. This value is determined by the STA and is commonly referred to Road User Cost (RUC). Subsequently, the contract is awarded to the bid with the lowest sum of bid amount, A, and project duration, B. This form of contracting can include incentives to speed up the project, such as basing the total project amount on project time or the completion date (Oliva et al., 2009).

The advantages of this method include a high likelihood of reduced contract time, minimized impacts to traffic during construction, innovative scheduling, maximized efficiency of crews and equipment, and can encourage greater coordination between prime bidders and subcontractors. The disadvantages include potential for sacrificed quality due to low time component, bid prices may be high with compared to conventional projects, and administrative and inspection costs may be higher due to accelerated schedule (Caltrans, 2007).

Accelerated work schedules and limited impact to traffic during construction associated with this method can be very useful to post-disaster recovery for essential roadways.

A.3.1.6 Multi-Parameter Bidding

Multi-parameter bidding extends the cost-plus- time (A+B) bidding to include an additional cost parameter (C) which can look at quality or warranty. The contract amount is based on the bid price, not the total bid value. The "C" component can increase or decrease the bid value. This method has only been used in conjunction with a warranty parameter for C. To incorporate a quality parameter into the bidding process, it is suggested using the multi-parameter equation in the form of (A+B)C, where C is a quality factor used to adjust the contractor's bid based on anticipated or bid quality levels (Caltrans, 2007).

This type of procurement encourages improved end-product quality, which can improve the overall life and resilience of the transportation project. This also can turn over the testing and inspection responsibility to the contractor, which would reduce the demands on the agency personnel to complete this step (Caltrans, 2007). This is useful during post-disaster rebuild considering the agency personnel are overworked and are required on multiple projects at once.

A.3.1.7 Qualification Based Selection/Two Phase Procurement

Qualifications based selection is a method where the consultant or contractor is selected on a basis of qualification alone with no price factors. Price is negotiated with the best qualified competitor. This method was codified at the federal level by the Brooks Act, Public Law 92-582 (1972) (40 USC 1101-1104) and regulated by Title 23 USC 112(b)(2)(A) and 23 CFR § 172.5(a)(1) (National Academies of Sciences, Engineering, and Medicine, 2012).

The NCHRP Synthesis 438 *Expedited Procurement Procedures for Emergency Construction Services* states that "under nonemergency conditions, FHWA requires funding recipient consultant contracts to conform to Brooks Act (40 USC 1101-1104) qualifications-based selection (QBS) and contracts for

construction to be awarded on the lowest responsive bid meeting the established criteria of responsibility (23 USC 112). However, federal regulations permit temporary suspension of competitive requirements for contracts consummated in emergency conditions. Noncompetitive procurement of engineering and design consultants in an emergency is addressed in title 23 Code of Federal Regulations (CFR) § 172.5(a) (3). The waiver of competitive bidding requirements for construction contracting in an emergency is addressed in 23 CFR § 635.204" (National Academies of Sciences, Engineering, and Medicine, 2012).

This method can also be looked as a two-phase procurement method, where qualifications are initially reviewed and cost is considered separately. These reviews cannot happen in parallel, one happens after the other. For this process to work, it is essential that the engineer's estimate be reliable and comprehensive. This is to ensure an agreement on price with bidders in order to avoid protest or cancellation of the bid. FHWA strongly encouraged this selection procedure for DB procurement in their 2002 design-build contracting final rule (Migliaccio et al., 2009).

A.3.1.8 Cost-Plus-Fixed-Fee

A cost-plus-fixed-fee contract is a cost-reimbursement contract that provides for payment to the contractor of a negotiated fee that is fixed at the inception of the contract. The fixed fee does not vary with actual cost but may be adjusted as a result of changes in the work to be performed under the contract. This contract type permits contracting for efforts that might otherwise present too great a risk to contractors, but it provides the contractor only a minimum incentive to control costs (48 CFR § 16.306).

A.3.1.9 Cost-Plus-Percentage of Cost

According to federal regulations, 2 CFR § 200.323, the cost plus a percentage of cost and percentage of construction cost methods of contracting is expressly forbidden. It is not allowable when federal funds support costs and is not appropriate for concurrent regional emergencies because it incentivizes the contractor to inflate prices in order to increase profitability. Cost-Plus-Fixed-Fee is an allowable alternative (see 3.4.8, above).

A.3.1.10 Simplified Acquisition Threshold

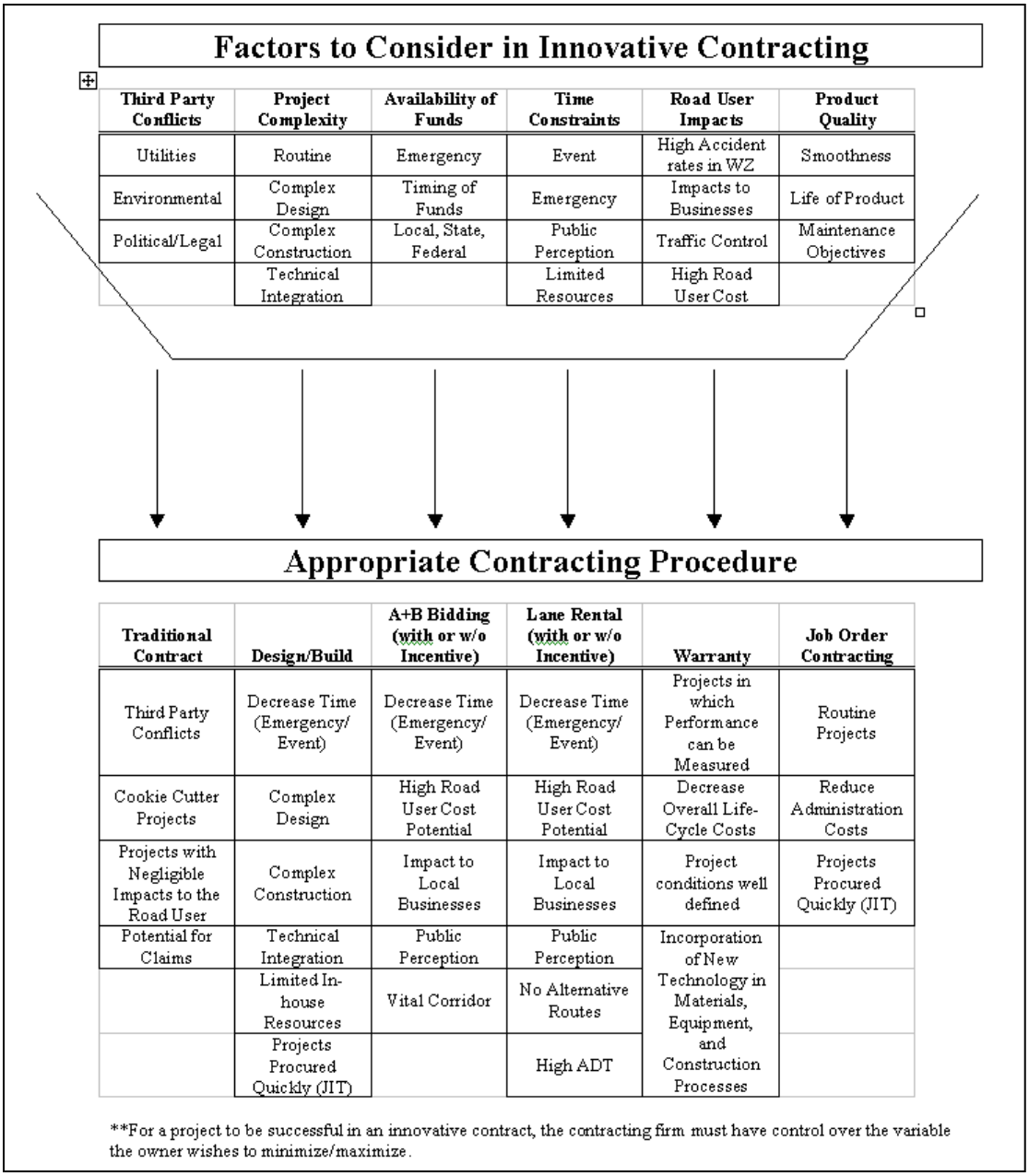
Simplified acquisition threshold means the dollar amount below which a non-Federal entity may purchase property or services using small purchase methods. Non-Federal entities adopt small purchase procedures in order to expedite the purchase of items costing less than the simplified acquisition threshold (2 CFR § 200.88).

A.3.2 Alternative Procurement Methods[2]

A.3.2.1 Bid Averaging

This procurement method seeks to promote reasonable pricing among contractors. The winning bid is the bid closest to the numerical average of the submitted bids after removal of the highest and lowest bids. This method of procurement is not allowed by the FHWA for federal-aid transportation projects (Scott et al., 2006).

[2] https://www.law.cornell.edu/cfr/text/2/200.88



Factors to Consider in Innovative Contracting

Third Party Conflicts	Project Complexity	Availability of Funds	Time Constraints	Road User Impacts	Product Quality
Utilities	Routine	Emergency	Event	High Accident rates in WZ	Smoothness
Environmental	Complex Design	Timing of Funds	Emergency	Impacts to Businesses	Life of Product
Political/Legal	Complex Construction	Local, State, Federal	Public Perception	Traffic Control	Maintenance Objectives
	Technical Integration		Limited Resources	High Road User Cost	

Appropriate Contracting Procedure

Traditional Contract	Design/Build	A+B Bidding (with or w/o Incentive)	Lane Rental (with or w/o Incentive)	Warranty	Job Order Contracting
Third Party Conflicts	Decrease Time (Emergency/ Event)	Decrease Time (Emergency/ Event)	Decrease Time (Emergency/ Event)	Projects in which Performance can be Measured	Routine Projects
Cookie Cutter Projects	Complex Design	High Road User Cost Potential	High Road User Cost Potential	Decrease Overall Life-Cycle Costs	Reduce Administration Costs
Projects with Negligible Impacts to the Road User	Complex Construction	Impact to Local Businesses	Impact to Local Businesses	Project conditions well defined	Projects Procured Quickly (JIT)
Potential for Claims	Technical Integration	Public Perception	Public Perception	Incorporation of New Technology in Materials, Equipment, and Construction Processes	
	Limited In-house Resources	Vital Corridor	No Alternative Routes		
	Projects Procured Quickly (JIT)		High ADT		

**For a project to be successful in an innovative contract, the contracting firm must have control over the variable the owner wishes to minimize/maximize.

Source: (Utah Technology Transfer Center, 2010)

Figure A-1: Factors to Consider in Innovative Contracting

A.3.3 Local Firms

Jurisdictions may consider policy requirements or public relations benefits of contracting with local firms for disaster-recovery services and consider ways of establishing mechanisms within prime contracts or pre-established agreements with select local firms to facilitate contracting. “The Army Corps of Engineers reported receiving over 6,300 phone calls within two weeks after Katrina landed, many from local and regional contractors who have complained that their calls [seeking work] were ignored” (Cray, 2005). However, Federal regulations places stringent limits on selection criteria favoring local firms which is expressly prohibited under 2 CFR § 200 in selecting construction contractors.

In the 2015 update to the Brooks Act (23 CFR § 172), it states, “evaluation criteria such as knowledge of locality and familiarity of the general geographic area are qualifications that a consultant may need to demonstrate to compete for a project and may be included along with technical criteria (Federal Highway Administration; U.S. Department of Transportation, 2015). A consultant could demonstrate knowledge of locality and project site without having a physical local office and thus the need for limitation on evaluation of a ‘local presence’ is unrelated to technical expertise of the firm.” Despite the arguable value of local knowledge, the Brooks Act limits aggregate criteria including locality and other factors represents not more than 10% of the selection criteria in a qualifications-based evaluation for professional services. It is important to consider the local vendor market relatives to local complexities to transportation projects; however, this asset does not outpace the important of free and open competition to the extent practicable in post-disaster conditions.

A.3.4 Conventional Contracting Methods

This section reviews conventional and alternative contracting procedures for project delivery found in the literature. The most common conventional method is design-bid-build. Alternative contracting methods include design-build, public-private partnerships (P3), indefinite delivery/indefinite quantity (IDIQ), construction manager/general contractor (CMGC), and construction manager at risk (CMAR).

A.3.4.1 Design-Bid-Build

The design-bid-build method (DBB) is the most widely used project delivery method. In this method, the design and construction phase are treated as separate, components and can, therefore, be carried out by separate entities; however, the two phases must be sequential. Thus, the STA either develops the “bid set” engineering design in-house or awards the engineering to a private sector firm, and then separately and distinctly awards the construction contract in a separate procurement action. This method provides the STA greater control over the design and construction phases than other methods. As a result, the STA is also responsible for potential costs associated encountered during construction, which result from design errors and omissions since the error is not the fault of the construction contractor. Some advantages of the DBB method include (Molenaar et al., 2014):

- STA controls design and construction;
- Design changes can be easily accommodated before start of construction;
- Design is complete before construction award;
- Allows for a fixed cost at contract award until change orders;
- Low bid costs allow for maximum competition among contractors; and
- STA controls design/construction.

Although this is the most commonly used method of project delivery, DBB may not be suitable for all project types. Some identified risks and disadvantages of DBB include the significant expertise and resources required on the side of the STA. This approach creates an environment of shared responsibility for project delivery between the owner and contractors. (Molenaar et al., 2014).

A.3.5 Alternative Contracting Methods

A.3.5.1 Design-Build

In the design-build (DB) delivery method, a single entity is contracted to design and construct a project. The selected contractor provides design, engineering, and construction services based on predetermined criteria and requirements established by the STA. Variations of this project delivery method include the modified design-build method, where significant portions of the design are completed by the STA before soliciting low bids. Figure 2 through Figure 5 provide an overview of the current regulatory landscape for design-build projects (Design Build Institute of America (DBIA), 2018).

In terms of project acceleration with this method, the literature points to DB plus incentive/disincentive clauses as producing cases of successful project acceleration (Caltrans, 2007; Schexnayder & Anderson, 2010). Because DB uses a single contract between the project owner and design-builder, which cover design and construction (using design parameters and performance criteria) more risk is transferred to the bidder (Caltrans, 2007). Also, since the DB delivery method shortens the DBB steps, environmental issues are handled consistently throughout design and construction stages. This reduces environmental risk and allows for more creative mitigation strategies (National Academies of Sciences, Engineering, and Medicine, 2015c).

In one example by del Puerto et al. (2017), the Minnesota Department of Transportation (MnDOT) used emergency contracting procedures to reduce project schedule following the collapse of the I-35W highway bridge in 2007. The agency used a streamlined DB process with a best value award that included extensive confidential one-on-one meetings with each design-builder to discuss questions and allow for innovation via alternative technical concepts (ATCs). A key factor in MnDOT's success with the relatively quick procurement process, and later, against the lawsuit brought was their extensive experience with DB (best value award was allowed via legislation in 2001). Major incentives and disincentives were used to truncate construction time. MnDOT also strove to "build the largest project possible with the smallest environmental process" and minimized permitting due to exigent circumstances via NEPA "categorical exclusion." MnDOT successfully defended itself against an award protest because it published the details of the project's proposal evaluation plan, making it transparent, and strictly followed the plan throughout the procurement and award process (del Puerto et al., 2017).

In another example, the Florida DOT (FDOT) was responsible for reopening a 2.5-mile section of I-10 bridges over Escambia Bay destroyed by Hurricane Ivan in 2004. Officials selected DB because the urgency of the work demanded that a single point of responsibility for the simultaneous design and construction phases. FDOT chose to constrain design to favor available materials and resources and was able to re-open one side of the bridge within three weeks. One key lesson learned is that "speed can only be achieved if FDOT is willing to accept available materials for repair" (Gransberg, 2013).

Recommendations provided from the DB case examples include the following:

- Using a two-step right-of-way acquisition with right of entry easement for immediate access to the construction site with guaranteed timeline for each parcel's financial closure;

- Coordinating single points of contact in each agency for all permit communication and a commitment to expedite project permit issuance;
- Keeping tight control of project scope to avoid delays from exceeding permit constraints;
- Encouraging a very interactive preproposal period with frequent one-on-one meetings with each bidder;
- Allowing DB teams to confidentially obtain decisions on alternative technical concepts before committing to them in the final proposal;
- Making a transparent evaluation plan/award method to defend against future lawsuits; and
- Using incentives directly tied to timely/early completion.

Other advantages of DB have been recorded in the literature. According to the *Accelerated Bridge Construction Manual* by Culmo published by FHWA, most agencies consistently report expedited project schedules by using the DB process. It also provides contractors some flexibility since the design can be tailored to the contractor's expertise and available equipment. Additionally, contractors have the ability to make modifications to preliminary designs as a cost saving measure as well as incorporate innovative construction processes. Lastly, owners have also reported being able to quickly obligate monies on "meaningful capacity projects" (Culmo, P.E., 2011).

The NCHRP Synthesis Report 438 *Expedited Procurement Procedures for Emergency Construction Services* found that most transportation agencies use expedited design-bid-build procurement processes to procure emergency design and construction services, as it is familiar to them and can mitigate certain risks. This familiarity among agencies often translates into confidence, therefore time-sensitive decisions can be made with less fear of procurement law violations (National Academies of Sciences, Engineering, and Medicine, 2012).

Some drawbacks of the DB process include a reduction in owner control of the final design with changes requested after bids often leading to additional costs. The project owner also needs to be able to clearly articulate the desired project outcomes. For example, complete design drawings at completions are typically not available using DB unless especially delineated by the owner in the project requirements. On the contractor side, the increase in risk may also be seen as a drawback; however, the DB process allows contractors to manage risks using innovative solutions.

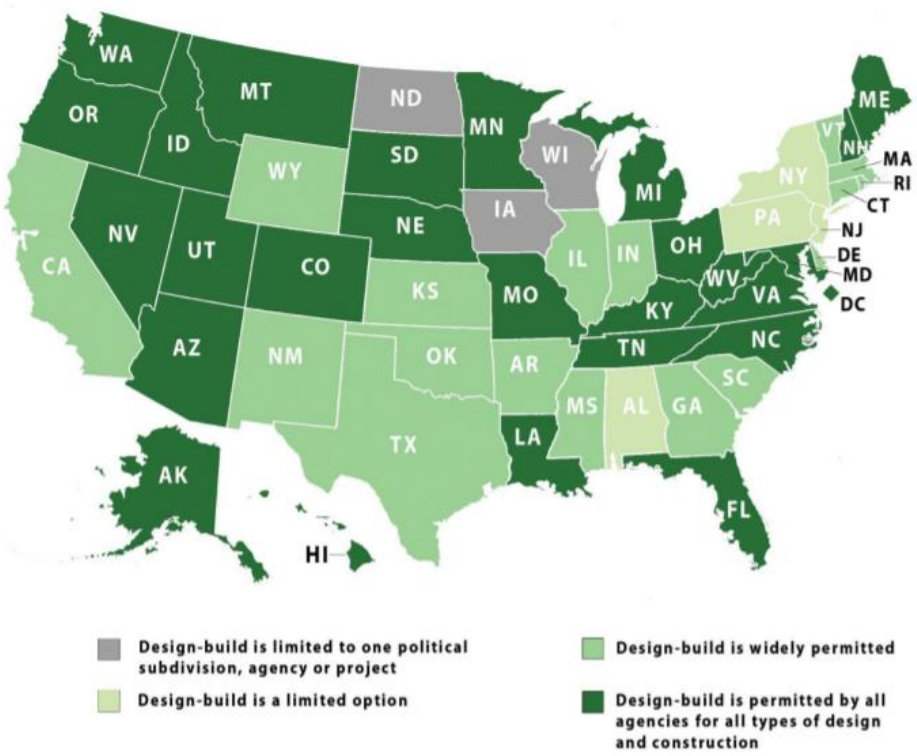


Figure A-2: Design-Build State Authorization for 2018

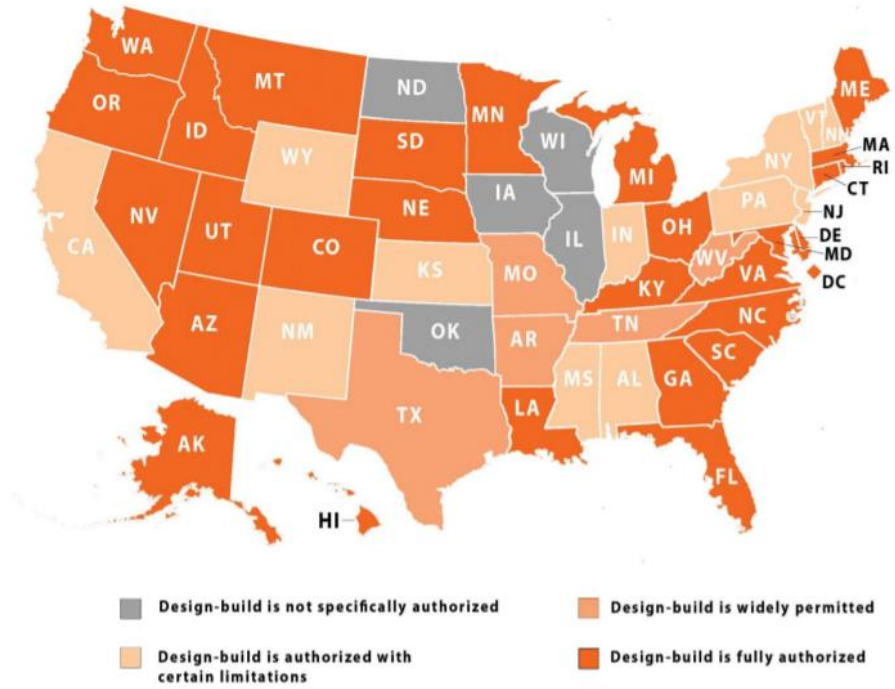


Figure A-3: Design Build Authorization for Transportation for 2018

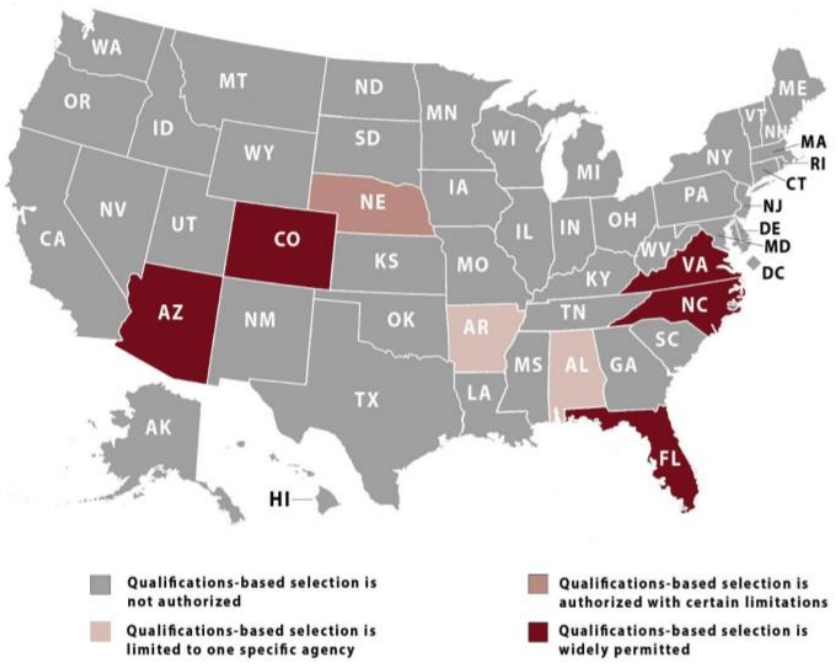


Figure A-4: States with Design Build Qualifications Based Authorizations

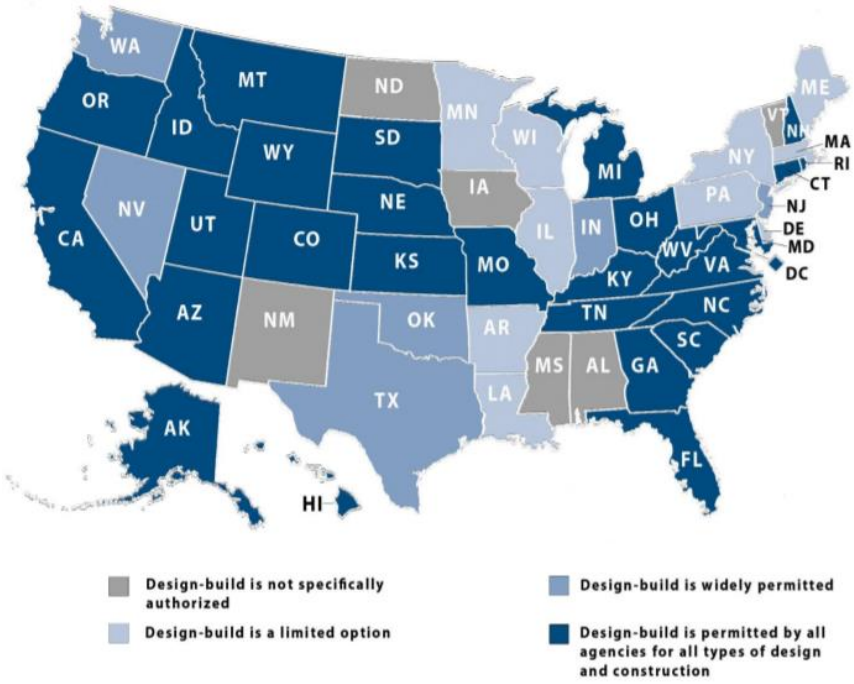


Figure A-5: States Granting Local Design Build Authorization

A.3.5.2 Public-Private Partnerships (P3s)

Public-private partnerships (P3s) are "contractual agreements between a public agency and a private entity that allow for greater private participation in the delivery of financing of projects" (DeCorla-Souza, 2013). Typical P3 projects involve the contractor designing, building, financing, operating, and maintaining the infrastructure. P3s are not typically used in post-disaster scenarios, however there is potential worthy of further exploration. If a STA wishes to use FHWA's ER funds, they must secure special dispensation from FHWA and get co-participation and approval from FHWA. This needs to be done before moving forward with any P3 process.

A.3.5.3 Indefinite Delivery/ Indefinite Quantity (IDIQ)

The Indefinite Delivery/Indefinite Quantity (IDIQ) contracting type, also known as open-ended contracting, is based on job/task orders. Contractors are competitively selected with no guarantee of award during the contract performance period and then typically bid on specific task orders with specifications developed from unit prices for each item. Total work quantities are not specified at the time of IDIQ vendor selection. IDIQ allows for the delivery of services or products that are not known at the time the contract is executed which provides a level of flexibility needed in emergency situations (National Academies of Sciences, Engineering, and Medicine, 2015b).

From 2007 to 2019, STAs have been required to go through the Special Experimental Project No. 14 - Alternative Contracting (SEP-14) when evaluating contracts that do not fully comply with Title 23 but are considered competitive. In early 2019, the FHWA released Notice N5060.2 on Indefinite Delivery/ Indefinite Quantity Contracting for Low-Cost Federal-Aid Construction Contracts. IDIQ contracting and Job Order Contract (JOC) contracting methods will continue to be administered under the Special Experimental Project Number 14 (SEP-14); however, under special circumstances, this notice allows IDIQ contracting and JOCs for low-cost federal-aid construction contracts without advance SEP-14 approval. This aids an emergency mobilization because it reduces STAs time to contract. Under the FHWA Notice N5060.2, if the IDIQ or JOC contract meets the requirements, below, STAs do not need prior SEP-14 approval:

- The contract is low-cost that is short-term, awarded to the lowest responsive bidder, and does not exceed $2,000,000 per year; [3]
- The contract must be single-award- task or work order contract;
- The actions will be for construction projects qualifying for National Environmental Policy Act (NEPA) categorical exclusions (23 CFR § 771.117);
- The work complies with Title 23 requirements during construction; and
- The contract and project will comply with applicable Disadvantaged Business Enterprise (DBE) provisions (49 CFR Part 26) (Federal Highway Administration, 2019c).

[3] https://www.fhwa.dot.gov/legsregs/directives/notices/n5060-2.cfm

The primary benefit of IDIQ contracting is the flexibility allowed in quantity ordered and delivery schedule (Rueda-Benavides & Gransberg, 2014). The NCHRP Synthesis Report 438 *Expedited Procurement Procedures for Emergency Construction Services* found that establishing this contracting type in advance is the surest contractual means to minimize the impact of an emergency (National Academies of Sciences, Engineering, and Medicine, 2012). IDIQ provides an effective means for maximizing the efficient use of funding (National Academies of Sciences, Engineering, and Medicine, 2015b). Other benefits include time savings, opportunities for smaller companies to bid, and competitive pricing by awarding multiple IDIQ contracts. STAs can use IDIQ contract vehicles to keep firms available on-call for specific work to be done quickly. For example, New York DOT (NYDOT) used its IDIQ entitled, Emergency Bridge Repair/Replacement Job Order Contract in New York, in the aftermath of Hurricane Irene in 2011. FDOT's IDIQ contracts for hurricane debris removal only come into effect if a hurricane hits the contractor's geographic area of responsibility (Rueda-Benavides & Gransberg, 2014). More advantages of IDIQs are shown in Table A-1 below.

Table A-1: Contracting Advantages by IDIQ Model

	- Owner only has to deal with one contractor	**Level 1**
Single Work Order	- Owner can keep lower inventory levels - Flexibility in quantity and delivery scheduling - Supplies and services are ordered when they are really needed - Agencies commit only for a minimum or no amount of work to be ordered - Owner can direct shipments directly to the users	
Single Award / Multiple Award	- Allows contractor involvement in preconstruction activities - Fast use of year-end funding - Lower cost in future issuance of work orders - Useful contracting option during emergencies - Increase quality and timeliness of delivery	**Level 2**
Multiple Award	- Reduce potential for graft and corruption - Highly competitive - Lower bid prices - Larger participation of small-size and disadvantaged business - Preference over single award contracts expressed by the FAR	**Level 3**

Source: NCHRP Synthesis Report 473 (National Academies of Sciences, Engineering, and Medicine, 2015b)

IDIQs can take many forms: multiple-work-order contracts with multiple contractors, multiple-work-order contracts to a single contractor, and single work order to a single contractor (Rueda-Benavides & Gransberg, 2014). Multiple award contracts have more apparent benefits but also are more complex and require more administration. The main disadvantage of IDIQ, particularly compared to Construction Manager-General Contractor (CMGC), is the inability to determine a reliable guaranteed maximum price.

Multiple awards of IDIQ contracts serve as a useful tool during emergencies. Such contracts can be used to narrow down a set of contractors that are capable of providing the services needed during an emergency and reduces the resources required to respond to any potential orders. Specifically, the 48 CFR

§ 16.504 describes indefinite-quantity contracts as one that "provides for an indefinite quantity, within stated limits, of supplies or services during a fixed period."

To effectively use IDIQ contracts post-disaster, the following approaches should be used (Wilkinson, 2007):[4]

- Acquisition planning;
- Commercial commodities and commoditized services;
- Open contracts;
- Simplified contracts; and
- Use of central purchasing bodies as gap fillers.

Some agencies like to award a large number of small IDIQ contracts, like Missouri DOT (MoDOT) which awarded 86 IDIQ contracts since April 2010. Conversely, agencies like FDOT have found success in awarding large contracts on a less frequent basis. FDOT combined DB with IDIQ methods used to execute two $20 million contracts in three years (Rueda-Benavides & Gransberg, 2014). IDIQ contracts are primarily used by federal agencies, serving as a replicable model for state and local agencies seeking to adopt this method.

A.3.5.4 Construction Manager / General Contractor (CMGC)

The Construction Manager / General Contractor (CMGC) project delivery method consists of two phases, design and construction, and allows an owner to engage a construction manager during the design process to provide constructability input. The Construction Manager is generally selected on the basis of qualifications, past experience or a best-value basis. During the design phase, the construction manager provides input regarding scheduling, pricing, phasing and other input that helps the owner design a more constructible project. At approximately an average of 60% to 90% design completion, the owner and the construction manager negotiate a "guaranteed maximum price" (GMP) for the construction of the project based on the defined scope and schedule. If this price is acceptable to both parties, they execute a contract for construction services, and the construction manager becomes the general contractor (Federal Highway Administration, 2019b).

Section 1303 of the Moving Ahead for Progress in the 21st Century Act (MAP-21) authorizes the use of the CMGC contracting method. This final rule implements the new provisions in the statute, including requirements for FHWA approvals relating to the CMGC method of contracting for projects receiving Federal-aid Highway Program funding (Federal Highway Administration, 2019b).

A.3.5.5 Construction Manager at Risk (CMAR)

In this method, a Construction Manager commits to delivering a project within a GMP to the project owner. The GMP is a two-step process and is typically based on a partially completed design and includes the CM's estimated cost for the remaining design features, general conditions, a CM fee, and construction

[4] https://www.law.cornell.edu/cfr/text/48/16.504

contingency. If using the CMAR method, the FHWA requires a fixed-fee structure for federal-aid projects. This includes providing professional services and acting in the interest of the owner during the project. The CMAR contract holder assumes majority of the project risk, as the individual is required to provide the contract within the GMP regardless of the bids that are received. Under this method, the owner is allowed to open it up to other contractors and solicit additional input after the design is done. (Caltrans, 2007).

A.3.5.6 Alliance Contracting

This program delivery method is based on parties working together and sharing risks and responsibilities of on a project. One benefit of this approach is having access to construction personnel during the design phase of a project. Early contractor involvement shows a significant improvement in cost performance and cost accuracy of reconstruction projects (Botha & Scheepbouwer, 2015). The NCHRP Synthesis Report 466 outlines the principles of alliance contracts. Some of the key points include all project decisions being made collectively and unanimously and the transparent sharing of information between partners. Under traditional contracts and partnering, there is potential for one team to make profits from a project while other partnered firms or teams actually may incur a financial loss. With alliancing, there is a joint rather than shared commitment; if one party in the alliance underperforms, then all other alliance partners are at risk of losing their rewards. Although risks are shared, this does not completely embody legal risks (National Academies of Sciences, Engineering, and Medicine, 2015a).

This kind of contracting is useful in post-disaster scenarios where local or state organizations are under distress and unable to cope with disaster impacts. State, territory, and regional alliances allow for a greater degree of capacity and diversity to deliver disasters contracts. See section *5.1 Interagency Acquisitions* below for related information to this method.

A.4 Cost and Payment Methods

This section reviews conventional and alternative payment methods found in the literature. Conventional methods include lump sum bidding or low bid and fixed price contracting. Alternative methods include incentive/disincentives, no excuse incentives, interim completion (milestone) dates, contract force accounts, and lane rental.

A.4.1 Contracting Methods

The NCHRP Synthesis 379 Report, *Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion*, identified the five alternative contracting methods cited below as having the highest potential to accelerate project completions (National Academies of Sciences, Engineering, and Medicine, 2008).

A.4.1.1 Incentive/Disincentives (I/D)

This is a contracting provision that provides monetary compensation (incentives) for each day that a certain work is completed ahead of schedule or meets its goals. Disincentives are penalties paid by the contractor for each day exceeding a specified time or failing to achieve the set contract goals (Molenaar et

al., 2014). In other words, I/D provides incentive payments for completing work ahead of schedule and disincentives payments for failing to meet the completion date.

The main advantage of this method is faster project completion. Additionally, some STAs have stated that a potential advantage is the reduction in costs associated with construction engineering inspection because of shorter project durations. Some related disadvantages of this method include the possibility of reduced project quality because of the reduced schedule, an increase in project cost, and the potential of contractors to adjust bid prices due to the impact of disincentives. Table A-2 summarizes some other advantages and disadvantages of I/Ds.

Table A-2: Advantages and Disadvantages of I/Ds

Advantages	Disadvantages
Significant reduction in project time; Encourages contractors to use time-saving means and methods to accelerate construction.	Higher bid costs and project costs; Acceleration may over-extend agency and contractor personnel (associated costs may be offset the overall shorter construction duration); Acceleration could compromise project quality.
Minimizes cost and time impacts to the traveling public for projects having high average daily traffic (ADT); Shifts more risk to the contractor for providing the optimum combination of time, cost, and efficient planning and management of the work.	The agency bears the risk of accurately estimating the critical I/D time and not delaying the I/D date; Agencies have reported that contractors may complete the I/D work and earn an incentive without expending extra effort and that contractors have earned incentives even when the project has been delayed; Agencies have reported that disincentive payments are difficult to recover.

Source: Modified from Caltrans (2007)

A.4.1.2 No Excuse Incentives

Under the no excuse incentive method, a “drop dead date” for completion of a phase of work or a project is set. If the work is completed on time or early the contractor receives the full amount while, aside from force majeure during construction, the contractor has no excuse to not meet the deadline. This method is best applied when it is beneficial to complete a project by a certain date but not necessarily earlier such as when there is a sequence of multiple contracts. However, the study by Caltrans (2007) found that the no excuse method increased cost (9% increase in Florida), potentially compromised quality to meet the incentive date, and strained agency-contractor relations (Caltrans, 2007).

A.4.1.3 Interim Completion Dates

Interim completion dates, also known as milestone completion dates, represent “a payment provision method designed to expedite completion of specific portions of a contract by providing contractors with incentives for milestone completion on or before a specified date this type of provision also includes a disincentive amount if the milestone is not completed by the given date” (Molenaar et al., 2014).

In the NCHRP Synthesis 379 survey, 70% (21 out of 30 participating agencies) had implemented this method more than 10 times demonstrating that this method is widely used (National Academies of Sciences, Engineering, and Medicine, 2008).

A.4.1.4 Contract Force Accounts

A contract force account, or time and materials (T&M), is a payment method typically used for additional work for which a unit price or lump sum amount cannot established (2 CFR § 200). In order for T&M to be allowed within the narrow parameters contemplated under 2 CFR § 200, it must include a not-to-exceed (NTE) threshold or ceiling. The method bases payments on hourly rates and quantities for resources such as labor, materials, and equipment used in performing the work which are substantiated with detailed invoices. This method is only used after a determination that no other contract vehicle is suitable such as when a definitive scope of work cannot be defined. If the contract ceiling price is exceeded that the contractor does so at its own risk.

5This method is typically appropriate where work must be taken in exigent conditions and/or for small and simple projects that need to be completed immediately to stabilize conditions. For this reason; it is commonly used for the mobilization of small construction contractors for maintenance.

A.4.1.5 Lane Rental

Lane rental is a supplemental payment provision that aims to limit general road user impacts. In this method, the construction contractor "rents" lanes for a period of time to perform work. During this time, rented lanes are closed to traffic for work. Fees charged for lane rentals can range from hourly to daily rates, or some other unit of time. Rates are determined by the type of lane closed and time of day for which the lane will be closed (National Academies of Sciences, Engineering, and Medicine, 2008).

A.5 Flexible Emergency Contracting Procedures

When concurrent regional emergencies occur and multiple routes are affected, transportation professionals may need to rely on the FHWA's emergency contracting procedures which are in accordance with 2 CFR § 200. Flexible emergency contracting procedures should be scaled to accommodate the needs for concurrent regional emergencies which might require the execution of 100+ contracts within weeks of the disaster. It is important that agencies understand FHWA's Emergency Relief (ER) funding program and the parameters that must be met for reimbursement. Contracts supported through FHWA ER funding must meet all conditions required by 23 CFR § 633A which regulates highway contracts involving federal funding (Kirk & Mallett, 2018).

Emergency contracting challenges encountered by government agencies are well documented in the literature. "Inadequate planning, poor preparation, and poor definition and communication of responsibilities" were some of the challenges documented by the US Government of Accountability Office's (GAO) report following Hurricane Katrina's aftermath (U.S. House of Representatives, 2006). The report noted that several agencies were unfamiliar with the emergency contracting procedures. This led to the consolidation of emergency procurement information by the Office of Management and Budget (OMB) through the 2006 release of Federal acquisition regulations (FAR) Part 18 (Jeffrey & Menches, 2008) and subsequent consolidation of OMB Circulars into 2 CFR in 2015.

[5] https://www.law.cornell.edu/cfr/text/2/200.318

Besides strategies developed by STAs to support emergency contracting, the federal government continues to also provide resources that support transportation emergency response and recovery. The *Emergency Acquisitions Guide* is a source of consolidated information on flexibilities allowed during emergency contracting (Office of Federal Procurement Policy, 2011). Among other things, the guide discusses acquisition flexibilities available under 48 CFR Part 18. Specifically, it identifies techniques or procedures that may be used to streamline standard acquisition processes. This includes limiting the both number of sources and the use of full and open competition for urgent requirements; soliciting from a single source for certain threshold limits under certain circumstances; using oral requests for proposals under certain condition; using interagency acquisitions; using federal supply schedules (FSSs), multi-agency blanket purchase agreements (MPAs), and multi-agency indefinite delivery contracts (Jeffrey & Menches, 2008; Wilkinson, 2007).

It is commonplace for agencies to assume that new approaches not included in the CFR/FAR are prohibited. However, according to 48 CFR § 1.102-4(e)/FAR 1.102-4(e), "if a policy or procedure, or a particular strategy or practice, is in the best interest of the Government and is not specifically addressed in the FAR, nor prohibited by law (statute or case law), Executive order or other regulation, Government members of the Team should not assume it is prohibited. Rather, absence of direction should be interpreted as permitting the Team to be innovative and use sound business judgment that is otherwise consistent with law and within the limits of their authority. Contracting officers should take the lead in encouraging business process innovations and ensuring that business decisions are sound." Under such circumstances where the allowance of an innovative contracting strategy is unclear, agencies are encouraged to seek legal guidance clarify options. According to the *Emergency Acquisitions Guide*, agencies are fully authorized to design such mechanisms as long as sound business judgement is used and consistency with the law is maintained (Emergency Acquisitions Guide, 2011).

Some of these flexibilities identified are discussed below. [6]

A.5.1 Interagency Acquisitions

Use of Interagency acquisitions is presented as one of the flexibilities provided by the *Emergency Acquisitions Guide*. Agencies that use this approach have access to prequalified sources from other agencies as well as the ability to tap into other available resources. This is especially useful during emergencies when extensive damage disrupts suppliers/sources and hinder response and recovery efforts. Such contracts include:

- Federal Supply Schedules by the GSA (48 CFR § 8.404);
- Multi-agency bulk purchase agreement (BPA) under a Multiple Award Schedule (FAR 8.405-3(a)(4));
- Government-wide acquisition contracts established under Section 5112(e) of Clinger-Cohen Act; and

[6] https://www.law.cornell.edu/cfr/text/48/1.102-4

- Multiagency contracts pursuant to the Economy Act (48 CFR § 17.502-2)(EAG, 2011).

Purchases using interagency acquisitions may be made in one of two ways (Office of Federal Procurement Policy, 2011)[7]:

- Direct acquisition – a requesting agency (the agency with the requirement) places an order directly against another agency's contract; and
- Assisted acquisition – where an agency delivers a disaster response construction project on behalf of the requesting agency through a memorandum of agreement.

Additionally, in accordance with 48 CFR § 17.503, the *Emergency Acquisitions Guide* states that interagency acquisitions made under the Economy Act must be supported by a determination and finding (Office of Federal Procurement Policy, 2011).

If agreements are in place, mutual aid agreements are tools which can be used under such circumstances. Agencies can develop mutual aid agreements, also known as alliance contracting, with other agencies and governments at the state and local levels. These agreements set roles, responsibilities, and methods to best accomplish necessary repairs. The main challenge that usually hinders successful implementation in transportation agencies is the lack of knowledge on the extent of available aid or the necessary procedures required to request the needed aid. The key in successful implementation is to have such agreements in place prior to the occurrence of an emergency. Advance agreements avoid significant issues that could overshadow the benefits. These include conflicts about reimbursement, liability, and misunderstanding about project roles and responsibilities. Best practice shows that agreements should be based on a needs assessment, a resource inventory, and also guided by a mutual aid committee.

A.5.2 Oral Solicitations[8]

In situations where the time required for an agency to process a written solicitation would delay work or services required for emergency response or recovery, oral Request for Proposals (RFPs) are authorized under the 48 CFR § 15.203(f)/FAR Part 15 203(f). This exception may only be used when the subsequent delay would be considered a detriment to the government and no notice is required.

9Oral solicitations still require compliance with other FAR requirements and requires the contracting officers to compile supporting documentation including "a description of the requirement; rationale for use of an oral solicitation; sources solicited, including the date, time, name of individuals contacted, and prices offered; and the solicitation number provided to the prospective offerors."

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[7] The Economy Act (31 U.S.C. 1535) authorizes agencies to enter into agreements to obtain supplies or services from another agency. The FAR applies when one agency uses another agency's contract to obtain supplies or services. If the interagency business transaction does not result in a contract or an order, then the FAR does not apply. This requires a presidential declaration to be enacted.

[8] See Section 3.3.6 Alliance Contracting for additional information.

[9] https://www.law.cornell.edu/cfr/text/48/15.203

A.5.3 Letter Contracts

Letter contracts serve as preliminary contacts that allow agencies to begin work during emergencies, which require immediate response and action. In such situations, as per 48 CFR § 16.603-2 agencies are allowed 180 days after the letter contract date or before 40 percent of the work is completed for a definitive contract to be completed. In extreme cases, further exceptions may apply for the time requirement.

A.5.4 Exceptions for Full and Open Competition[10]

48 CFR § 6.303-2/FAR 6.302 provides exceptions for full and open competition under circumstances with unusual or compelling urgency. The exception still requires written justifications and approvals under Subpart 6.303 and 6.304 to be provided; however, agencies are allowed to submit the stated documentation after the contract has been award if the prevailing circumstances are such that an unreasonable delay due to document preparation would be detrimental. Waiving the full and open competition requirement still requires the contracting officers, to the extent practicable, to solicit offers from as many sources as possible.

Contracting on an open market can significantly reduce the estimated cycle times for obtaining goods and services in an emergency. In one study, awardees with statutes that permitted them to obtain goods and services in the open market had an average procurement cycle of 6 days, while those without had a cycle of 17 days (Hurst et al., 2017). [11]

A.5.5 Use of Commercial Item Procedures for Acquisition of Noncommercial Items

Under 48 CFR § 12.102(g)/FAR 12.102(g), services that do not meet the definition of commercial items may still be acquired if the following conditions are met:

- The contract or task order has a value of $29.5 million or less,[12]
- Meets the definition of a performance-based acquisition (at FAR 2.101)
- Uses a quality assurance surveillance plan;
- Includes performance incentives where appropriate;
- Specified a firm-fixed price for specific tasks to be performed or outcomes to be achieved; and
- Awarded to an entity that provides similar services to the general public under terms and condition similar to those in the contract or task order.

A.5.6 Waiver of Bid Guarantees

During emergencies, bid guarantees may be waived if it is concluded that such arrangements are not in the best interest of the government. Bid guarantees may be waived either on a transactional basis or as a

[10] https://www.law.cornell.edu/cfr/text/48/16.603-2

[11] https://www.law.cornell.edu/cfr/text/48/6.303-2

[12] https://www.law.cornell.edu/cfr/text/48/12.102

class waiver. This flexibility can be implemented by an agency head or designee according to FAR 28.101-1.

A.5.7 Price Adjustments

The FHWA's Technical Advisory 5080.3 outlines the criteria and project conditions for use of price adjustment contract provisions. Due to the volatility of construction materials and supplies prices significant problems can arise for contractors to prepare realistic bids. As a result, there is often price speculation and inflated bid prices in order to account for potential price increases. The Technical Advisory 5080.3 provides contracting authorities with information for development and application of price adjustment provisions in order to transfer a portion of the risk to the contracting agency and lower the bids (Federal Highway Administration, 1980).

A.6 Optimum Procurement Involving Multiple Corridors and Stakeholders

A.6.1 Optimum Procurement Involving Multiple Stakeholders

Effective emergency response and recovery operations often require coordination by multiple stakeholders. The literature points to the use of public-private partnerships for this purpose. Particularly, the area of preparedness provides opportunities for the private sector to identify and showcase innovative technologies, risk reduction strategies, and advanced emergency planning. During emergencies, private partners can assist with the procurement of emergency related goods and services. Consequently, the right statutory frameworks need to be in place to make the best use of private sector resources.

Three recommendations include: having private sector members of agency emergency management committee; use of no-bid contracts should be a last resort; and adopting provisions and regulations to allow private sector integration into emergency management (National Academies of Sciences, Engineering, and Medicine, 2013).

A.6.2 Optimum Procurement for Multiple-Corridor Prioritization

When a major disruption occurs on multiple corridors, response and recovery efforts need to be coordinated in a way that ensures service restoration in the most efficient way possible. Resources needed for response and recovery including equipment and materials, construction contract labor and craft, and rights of way need to be prioritized to ensure efficient allocation of resources. Consequently, clear recovery priorities need to be articulated by the managing transportation agencies to support the resilience of the entire network. By identifying service restoration priorities, resources may then be allocated in order of priority.

Priority identification may sometimes prove difficult in the absence of objective data. Agencies must understand the significance of different corridors within a network and the impact of restoring a corridor's service on the overall network. Many authors in the transportation resilience literature have explored network resilience in the context of service restoration and resource expenditure.

Vugrin, Turquist, and Brown developed an approach for calculating the systemic impact and total recovery effort for a network. The authors modeled the transportation network as a series of discrete links

and nodes which result in reduced capacity when damaged during a disruption. Movement of origin-destination flows then incurred a cost in addition to inducing link flows. Costs included travel time, distance, fuel consumption, and other context sensitive factors. Using this, the authors formulated a bi-level optimization model for network recovery (Vugrin et al., 2014).

Ip and Wang also assessed the transportation network resilience by using a quantifications-based resilience evaluation approach. This approach was predicated on the notion that survivability of any two nodes depends on the number of independent paths between them. Thus, the optimization model used in this work applied the weighted average number of passageways between a node and all other nodes in the network as the resilience measure. This approach of evaluating redundancy of network link is transferable to corridor evaluation for prioritization. Agencies that identify redundant links within a network could incorporate it as a prioritization criterion for service restoration and therefore resource allocation (Ip & Wang, 2009).

Another study by Taylor and Susilawati measured changes to accessibility levels at different network states to assess network vulnerability. The authors compared levels of remoteness of localities within a study region on the basis of the extent or impact of network degradation on an accessibility/remoteness index. Similarly, by taking a user-based approach to prioritization, agencies can identify areas and communities that could be severely impacted by the loss of a corridor. In the case of multiple corridors, access to the most vulnerable communities may be prioritized over others as these areas may lower community resilience than others. Subsequently, interagency teams responsible for emergency response planning must have good data, not only on traffic and freight volumes, but also on vulnerable populations within the region (Taylor & Susilawati, 2012).

A.7 Coordination of DOT Plans by Federal, State and Local Agencies in Advance of Major Disruptions

Coordination of plans by transportation agencies at various levels of government prior to a major disruption is critical for ensuring the appropriate response and recovery strategies are implemented to minimize losses and rapidly restore essential traffic conditions. Such coordination includes that among states agencies only, federal and state agencies, or any other combination of the three types of governmental entities. In cases where a disruption affects multiple jurisdictions (e.g. multiple states), coordinating state plans may prove challenging as different states may have different priorities when it comes to response and recovery.

The sections that follow describe some efforts used by agencies at different levels of government to prioritize emergency preparedness, response and recovery efforts. Some challenges to such interagency coordination are also discussed.

A.7.1 Prioritization of Federal, State and Local Plans

Despite the differences in jurisdictional priorities, some commonalities exist in the way response and recovery efforts are planned. Generally, transportation agencies have identified various methods of predicting the potential impacts of major disruptions and have used these methods to subsequently

develop appropriate response mechanisms. Some factors used in predicting impacts include the following (Federal Highway Administration, 2018):

- Identification of transit dependent populations;
- Identification of aging or vulnerable infrastructure using technical, environmental, economic, risk metrics;
- Identification of service areas and infrastructure most susceptible to speed reductions and loss of ridership;
- Impacts that would force firms and businesses to relocate;
- Identification of natural hazards such as seismic areas, flooding or landslides;
- Coastal areas susceptible to impacts from tides and tsunamis; and
- Areas susceptible to extreme weather including weather events that can be compounded by tidal impacts.

Examples from the literature show that prioritization is mainly focused on the most vulnerable populations and infrastructure. The identified potential impacts are also used in parallel with maps of existing infrastructure (e.g. bridges, culverts, and other structures). Prioritization has also focused on the most utilized infrastructure and services where the greatest impact will occur from a disruption. Many of these analyses use geographic information systems (GIS) to identify geographic trends and geospatial relationships (Federal Highway Administration, 2018).

For special prioritization and planning, several states have also identified special cases to focus on including maintenance facilities and communities at risk of being cut off in the event of an emergency caused by severe weather or some other hazard. In one example, a state developed a model that used sea level rise to identify urban centers that would potentially be lost and also identify new centers might be developed as a means of guiding future infrastructure investment and development of housing stock. A review of other state plans revealed some key areas to focus on during plan development. Recommendations included the following (Federal Highway Administration, 2018):

- Need for comprehensive assessments of key structures;
- Capital investment in resiliency and protection of critical assets;
- Incentives to encourage resiliency;
- The ability for local jurisdictions to influence emergency planning and preparedness guides;
- A plan for staffing in order to respond to an emergency;
- Increasing public awareness; defining agency responsibilities in case of an emergency; and
- Advance contracting and updating public emergency response policies.

A.7.2 Common Challenges in Coordinating Emergency Plans and Procedures

FHWA conducted a series of workshops across 30 regions involving the transportation community and first responders on common issues in emergency transportation operations preparedness and response. This section summarizes the common issues identified during the workshops (Houston, 2007).

- **Regional Coordination in Emergency Transportation and Evacuation Route Planning:** Coordination of evacuation routes among different jurisdictional entities was identified as a challenge. It was revealed that evacuation plans prepared at the city or county level often create inconsistencies as such routes are rarely coordinated across county or state boundaries. Such inconsistencies can lead to inefficiencies during evacuations. For example, where coordination between local and state emergency procedures does not exist, traffic diverted from highways onto local streets may not be appropriately accommodated. The necessary operations controls such as special signal timing plans may not have been develop and or, adequately tested (Houston, 2007).
- **Coordination among Emergency Operations Centers:** Workshop participants also identified communications and coordination among Emergency Operations Centers (EOCs) as a challenge. The EOCs can be established at multiple levels of government, that is, at the city, county and state levels. Development of strategies for improving cross-boundary communications among the centers during emergencies is key for smooth response and recovery operations.
- **Understanding of Incident and Unified Command Systems:** As part of the National Incident Management System (NIMS), the Incident and Unified Command System (IUCS) provides the framework for command, control, and coordination of resources during an emergency. Although public safety responders are well familiar with its structures and operations, many STA personnel, including some who may be critical during emergency response are not. To provide a solution for this issue, the FHWA developed the *Simplified Guide to the Incident Command System for Transportation Professionals*. The purpose of the guide is to educate stakeholders such as STA personnel and others who may be critical incident response (Ang-Olson & Latoski, 2006).
- **Prioritizing Resources:** During an emergency, agencies are taxed with ensuring a system does not fail catastrophically. For response purposes as well as community continuation, agencies must maintain a certain minimum level of service following an incident. This is usually challenging; as all agencies may not have clear guidance on resource prioritization and allocation. Additionally, regions that span multiple jurisdictions usually share resources such as professional service contractors which can become problematic when regional emergencies occur.

A.8 Supply Chain Issues in Emergency Procurement and Contracting (Risks and Strategies)

A major challenge that confronts STAs in the aftermath of a disaster is the availability of construction contractors and materials to support recovery efforts. This is usually a result of one or more disruptions within the construction supply chain. After a major disaster, a damage assessment is first conducted to provide details on the extent of repair or reconstruction required. This information is then used to procure the necessary materials and services. However, when there is a break in the construction supply chain,

that is, the flow of resources from suppliers to manufacturers, manufacturers to distributers, and from distributers the site, recovery efforts are hindered.

A.8.1 Supply Chain Risks

Supply chains are impacted by a variety of risks which can be classified by source, nature of impact, and extent of influence (McKinnon, 2014). Among these are extended value chain risks and operational risks. Extended value chain risks refer to those that originate from either upstream suppliers or and downstream distributors. Such risks may arise from many factors including the following:

- Hub and spoke approach – where large volumes of freight pass through only a few corridors and ports;
- Centralizing inventory;
- Centralized production by manufacturers; and
- Clustering of suppliers with similar products.

Operational risks are those related to the internal processes within the organization conducting the risk audit (McKinnon, 2014). In this case, internal processes of a transportation agency pose risks to the success of the supply chain. For example, these can include flaws in the planning process, specifications, procurement, and contracting.

A.8.2 Strategies for Enhancing Transportation Supply Chains

Procurement is a critical component of disaster recovery and can also be highly dependent on freight transportation especially immediately following a disaster. Some strategies identified in the literature to improve freight resilience include:

- Use of multiple ports;
- Off peak freight movement;
- Improved communication;
- Flexible transportation;
- Domestic sourcing; and
- Customs Trade Partnership Against Terrorism (C-TPAT) certification.

Other strategies identified as essential to ensuring an effective supply chain during emergencies include the use of contingency and continuity plans by agencies. The key element identified is preparation and such plans enable transportation agencies to think through potential scenarios and negative outcomes that may arise during emergencies. Preparedness provides the agency information of the areas in the supply chain where emergencies could have the strongest impact. STAs must have robust emergency plans and insist that suppliers demonstrate they have them as well (Pitera & Goodchild, 2009; Ta et al., 2010).

A.8.3 Supply Chain Performance

Research in supply chain disruptions specifically related to transportation recovery or reconstruction is limited in the literature. However, many of the strategies and lessons from general supply chain resilience literature are applicable to STAs and other transportation agencies. For example, Beamon (1999) studied humanitarian relief supply chains by reviewing existing frameworks to develop a set of performance measures and metrics for relief supply chains. His work outlines the following three types of performance measures (Beamon & Balcik, 2008):

- **Resource Metrics:** these are metrics related to the availability of resources to meet a set of specified objectives. Resource metrics can also be described as metrics that measure the level of system inputs;
- **Output Metrics:** effectiveness of supply chain;
- **Flexibility Metrics:** range of possible operating conditions that are profitably achievable by the chain.

By applying such measures of performance to transportation reconstruction and other transportation recovery efforts, agencies are provided with a structure and framework useful to understand and mitigate supply chain disruptions.

A.9 Best Practices and Lessons Learned from Regional Emergencies

Best practices from regional emergencies include the examples below:

- An overall conclusion from AASHTO's Resiliency Case Studies was that organizing repair and response contracts, as well as regional collaboration with who may aid in an emergency be done during an emergency planning phase. Vermont, Louisiana, Colorado, North Carolina, Oklahoma, and Florida all echoed this as being key to efficient emergency response (AASHTO, 2018);
- FHWA hosted a series of best practices workshops mentioned above in Section 7.2. Their findings were grouped into common categories: Interagency Coordination and Communication; Emergency Operations; Equipment; Intelligent Transportation Systems; Mutual Aid; Threat Notification, Awareness, and Information Sharing; and Policy (Houston, 2007);
- Recommended practices for emergency preparedness include: developing a plan; establishing evacuation routes; having mutual aid agreements in place; having a policy addressing service and facility closures; fare suspension; preplanning for special needs populations; backup communications; exercises and mobilization planning; fueling vehicles prior to emergencies; establishing command structure; accounting and record keeping policies; debriefing; and working with MPO's to develop partnerships within a region (Chandler & Sutherland, 2013).

Lessons learned from regional emergencies include the examples below:

- FTA oversight reviews identified the lack of needed controls for oversight of Hurricane Sandy relief funds. FTA needs to improve their ability to verify eligible expenditures and ensure approvals of change orders comply with FTA policy. A *Hurricane Sandy Disaster Relief Oversight Plan* was

put into place. A major finding included the need for more staff to address project controls (Office of the Inspector General, 2016);

- After Hurricane Katrina, the GAO found that the response could have benefitted from adequate planning and preparation to anticipate needed goods and services, improved communication about specific responsibilities across agencies and jurisdictions, and an additional number of deployed personnel to provide effective contractor oversight. Practices identified to better manage disaster related procurement include: developing knowledge of contractor capabilities and pricing for commodities and services; establishing scalable operations; formally assigning disaster responsibilities and participating in joint training, and providing sufficient numbers of field staff (Cooper, 2005; U.S. Government Accountability Office, 2006; Woods, 2006);
- Post-mortem analysis on Hurricanes Katrina and Rita found that we need a national action plan with emphasis on when and how the federal government will take action in disasters. The plan cannot be dependent upon state or local governments or organizations. Additional issues identified and targeted for improvement included: information gaps between data and the need for decisive actions; lack of initiative (reactive versus proactive); ability for the federal government to respond when local and state governments are overwhelmed; lack of agility to address needs due to government procedures; agencies are unfamiliar with their roles and responsibilities under the National Response Plan; ineffective command and control within and between military and civilian agencies; lack of emergency housing and overwhelmed supply chain (U.S. House of Representatives, 2006).

As a result of disasters like Hurricane Katrina, FEMA in cooperation with other federal agencies developed the *National Disaster Recovery Framework*. This is a guide that enables effective recovery support to disaster-impacted States, Indian Tribal governments, Territorial and local jurisdictions. It provides a flexible structure that enables disaster recovery managers to operate in a unified and collaborative manner. It also focuses on how best to restore, redevelop and revitalize the health, social, economic, natural and environmental fabric of the community and build a more resilient Nation (Federal Emergency Management Agency, 2016).

- NCDOT found that having Memorandum of Agreements (MOAs) issued with counties before an event has been helpful for debris removal following an emergency. These could also be set up with other local and state entities for more widespread disasters (AASHTO, 2018).
- Additional case studies have been collected focusing on relationships and their value to recovery; simplified design; phased approach to recovery; using existing infrastructure footprints; collaboration; oversight and environmental management; preparing for the unexpected; and integrating recovery into existing planning (AASHTO, 2018).

A.9.1 Project Delivery

Additional research that was found on the topic of resiliency and project delivery includes the following:

- FTA published the *Disaster Response and Recovery Guide for Transit Agencies*, a manual for transit agencies specifically to address funding and reimbursement for service restoration after an emergency or disaster. The federal, state, regional and local roles in emergency recovery are defined. FTA also provides best practices to assist in planning for emergencies. Many of these ideas have transferable benefits to STAs (Federal Transit Administration, 2006).
- Long term airport, rail, and port disruptions can hamper recovery efforts by introducing serious and sustained supply chain disruptions related to the movement of labor and materials. Aviation is an important component of emergency response, and loss of an airport for an extended period of time can have unforeseen impacts to recovery efforts and the local economy. Business continuity plans are developed to minimize those impacts; however they are flawed in that they often do not address emergency management (U.S. Department of Homeland Security, 2015).

A.10 Conclusion

In conclusion, the literature shows that there is a multitude of procurement, contracting, and payment methods that STAs and local agencies can use to complete transportation projects. However, specific restrictions and considerations exist for emergency scenarios when it comes to funding. If a specific method is used or used incorrectly, there is the possibility that the funding agency may delay or completely deny reimbursement of these expenses. Also, when considering disaster scenarios, the challenge of urgency emerges as STAs and local agencies must rapidly mobilize people and materials in service of wide-spread response and recovery needs, which can lead to rushed and unvetted decision making. Through adequate pre-planning, STAs and local agencies can more effectively choose methods and significantly reduce risk to their agencies and the public.

An overall message found in the literature was the need for diverse and regional disaster planning and coordination. As natural disasters do not adhere to localities and jurisdictions, all readiness planning, response, and recovery requires coordination by multiple stakeholders and must contemplate the specific conditions involving all regional critical transportation corridors. Forming relationships and planning administrative actions early can result in more efficient and effective rapid response operations that reduce risks and save time and costs. Similarly, robust planning for resilient recovery carries the same benefits and also creates opportunities to leverage long-term improvements to surface transportation infrastructure.

A.11 Annotated Bibliography

Ahmed, I., Sultana, I., & Azeem, A. (2017). Development of an inventory model for two suppliers with random capacity considering supply disruption. International Journal of Logistics Systems and Management, 26(1). https://doi.org/10.1504/IJLSM.2017.080630

This paper presents an inventory model considering two suppliers with random capacities evaluating a supply disruption. The research was done in response to evaluating supply

disruptions such as natural disasters, equipment failures and transport challenges. The material lays out a hypothetical example to show the results of the model.

Alipour, A. (2017). Enhancing Resilience of Bridges to Extreme Events by Rapid Damage Assessment and Response Strategies. Journal of the Transportation Research Board, 2604(1), 54–62. https://doi.org/10.3141%2F2604-07

The U.S. highway transportation network consists of more than 650,000 bridges that are essential to maintaining the performance of the network. The existing bridges are, however, vulnerable to a variety of natural and manufactured (human-caused) hazards and may act as bottlenecks in the case of any failures. The most common extreme events include natural hazards, such as ground excitation during earthquakes, high wind and storm surges in hurricanes, and scouring and debris impacts during floods. Despite several advances in the technologies available for the design of new bridges and the retrofitting of existing ones, incidents in which bridges fail partially or completely after an extreme event still occur. In such cases, it is important for the federal, state, and local authorities to identify the damaged bridges, quantify the extent of the damage, plan for rapid recovery, and provide alternative routes for emergency response and evacuation activities. For this purpose, NCHRP Synthesis Topic 46-11 gathered the relevant information on the technologies available for the rapid assessment of damage to highway bridges after an extreme event, the availability of data from these techniques to transportation agencies and bridge owners, decision-making tools or processes that would use the data, and the emergency planning protocols in place to address the failures in bridges. This paper provides a summary of the findings of that project.

Alleman, D., Antoine, A., Gransberg, D. D., & Molenaar, K. R. (2017). A Comparison of Qualification Based-Selection and Best Value Procurement for Construction Management/General Contractor Highway Construction. Transportation Research Record: Journal of the Transportation Research Board, 2630. https://doi.org/10.3141/2630-08

Faster project delivery and the infusion of contractor knowledge into design are the primary drivers for choosing construction manager/general contractor (CM/GC) project delivery. This paper focuses on the use of qualifications-based (QBS) and best-value (BV) procurement approaches, how and why agencies use each, and their associated opportunities and obstacles. Data for this study were obtained from a majority of federally funded CM/GC projects completed between 2005 to 2015. The findings are that BV and QBS projects characteristics and performance have no statistically significant difference. The choice of BV or QBS coincides with the agency's CM/GC stage of organizational development and influences of non-agency stakeholders on the CM/GC process. When agencies and the local industry are new to CM/GC, they were found to use BV as it is closer to the traditional procurement culture and it is perceived to result in a fair market project price. Alternatively, agencies and local industry partners with an established history of using CM/GC were found to choose QBS. The low level of design at the time of procurement, means that assumptions relating to risk, production rates, materials sources, etc. may be too preliminary to secure a reliable price. The use of BV procurement was found to pose a risk to innovation and increase negotiation efforts. Qualitative trends from the project data,

interviews and literature point to agencies using QBS for the majority of CM/GC project and BV on CM/GC projects with lesser complexity or more highly developed designs at the time of selection.

Altamirano, M., & Herder, P. (2006). System dynamics modeling for road contracting. In Greener, Safer, and Smarter Road Transport for Europe (pp. 1–9). Göteborg, Sweden: Swedish Road Administration. Retrieved from https://trid.trb.org/view/862634
This paper addresses alternative project delivery methods and contract administration procedures in an effort to align with current demand for reconstruction and growth. It highlights trends in highway management that supply information to create innovative solutions to keep up with changing needs of transportation. The material discusses the use of economics to engineering-design theory to create a model for contracting practices that will assist in project delivery success, using international case studies to validate results.

American Association of State Highway and Transportation Officials (AASHTO). (2007). Transportation - Invest In Our Future: Accelerating Project Delivery (No. TIF7-1). Retrieved from https://downloads.transportation.org/TIF7-1.pdf
This report presents recommendations supporting efforts to reduce transportation project delivery time by 50%. It discusses elements such as environmental stewardship, collaborative activities, innovative contracting, advanced construction techniques and materials, public-private partnerships and partnership opportunities between sectors.

AASHTO. (2016). Fundamental Capabilities of Effective All-Hazards Infrastructure Protection, Resilience, and Emergency Management for State Departments of Transportation (No. HAZ-1-UL). Washington, D.C.: AASHTO. Retrieved from https://transportationops.org/publications/fundamental-capabilities-effective-all-hazards-infrastructure-protection-resilience-0
A Guide prepared to assist State DOTs understand the fundamentals of preventing incidents within their control, protect transportation users, supporting other responders, recover from incidents and evaluate responses. It also introduces concepts supporting resilience programs. This is an update to the 2007 publication Fundamentals of Effective All-Hazards Security Management for State DOTs.

AASHTO. (2018). Resiliency Case Studies: State DOT Lessons Learned (pp. 1–58). Washington, D.C.: AASHTO Resilient and Sustainable Transportation Systems Program. Retrieved from https://environment.transportation.org/pdf/rsts/aashto_resiliency%20_case_studies.pdf
This report provides lessons learned from the most impactful extreme weather events over a six year-year period and identifies how DOTs can become more resilient in anticipating and responding to future events, especially given the realities of a changing climate and the potential for changing storm patterns. The case studies describe lessons learned from the following extreme events: Vermont – Tropical Storm Irene, 2011; Louisiana – 500 and 1,000-Year Flooding Events, 2016; Colorado – Flooding and Rock Falls, 2013/2016; North Carolina – Hurricane Matthew, 2016; Georgia – Atlanta Ice Storm, 2014; Oklahoma – Moore Tornado, 2013; California –

Coastal Landslides, 2017; Florida – Hurricanes Hermine and Matthew, 2016. Interview findings from these eight state DOTs and the summarized cross-cutting lessons learned are categorized into three subject areas: planning and design, policies and regulations, and emergency response.

Ang-Olson, J., & Latoski, S. (2006). Simplified Guide to the Incident Command System for Transportation Professionals (HOP No. 06–004; pp. 1–64). Retrieved from Federal Highway Administration website: https://ops.fhwa.dot.gov/publications/ics_guide/ics_guide.pdf

The purpose of this Guide is to introduce ICS to stakeholders who may be called upon to provide specific expertise, assistance, or material during highway incidents but who may be largely unfamiliar with ICS organization and operations. These stakeholders include professionals at transportation agencies, companies involved in towing and recovery, as well as elected officials and government agency managers at all levels.

Atkinson, C. L., & Sapat, A. K. (2012). After Katrina: Comparisons of post-disaster public procurement approaches and outcomes in the new Orleans area. Journal of Public Procurement, 12(3), 356–385. https://doi.org/10.1108/JOPP-12-03-2012-B003

Hurricane Katrina remains the "most destructive disaster in U.S. history" (Farber & Chen, 2006). The purpose of this article is to examine the public procurement practices followed by local government officials in and around New Orleans within the context of Hurricane Katrina and define impacts of disaster on procurement processes. Original and primary data drawn from interviews with officials working in and with public procurement are used to examine the role of institutional culture and practices which encourage or constrain active, responsible behavior. We find that this behavior influences the quality, including the transparency and fairness, of purchasing responses.

Bagloee, Saeed Asadi, Majid Sarvi, Brian Wolshon, and Vinayak Dixit. "Identifying Critical Disruption Scenarios and a Global Robustness Index Tailored to Real Life Road Networks." Transportation Research Part E: Logistics and Transportation Review 98 (February 2017): 60–81.

The ability to maintain functionality in transport infrastructure is critical during disruptions. To ensure operational robustness in transportation networks, it is necessary to identify the most vital or critical roads (or links), then reinforce them to increase their resilience. In the literature, conventional approaches to analyze road network robustness have involved efforts to first remove selected road segments (one by one, not collectively), then measure the impact of these changes. Based on these results, the levels of impact are ranked and links that demonstrate the most significant impacts are deemed to be the most critical. One of the most significant limitations of such approaches, however, is that they disregard the combined effect of road connectivity. This study advances the state of knowledge in transportation-based resilience analysis through the development of an approach to assess the impact of "critical combination scenarios". The methodology involves a two-phase process. The first phase is based on the sensor (loop detector) location problem, within which, a selected number of high demand roads are identified as "candidate" critical links. Then, the second phase employs a series of discrete network design problem (DNDP) to find a variety of critical combination scenarios. The DNDPs are solved based

on a system optimal relaxation method using Bender's Decomposition. Building further from these results, the extent to which a road network is robust (or fragile) is analyzed. The results of the DNDP solutions are demonstrated to be similar to a Lorenz Curve in which the area under the Lorenz Curve (in percentage) can be viewed as a global robustness index. This index can be used to compare and assess the robustness of different road networks and mitigation scenarios. To illustrate the practical utility of this method, this research applied the methodology to the Winnipeg, Canada road network.

Beamon, B. M., & Balcik, B. (2008). Performance measure in humanitarian relief chains. International Journal of Public Sector Management, 21(1), 4–25. https://doi.org/10.1108/09513550810846087
Purpose– The purpose of this paper is to compare performance measurement in the humanitarian relief chain with performance measurement in the commercial supply chain, develop performance metrics for the humanitarian relief chain, and present a framework that can be used as a basis for a performance measurement system in the relief sector. Design/methodology/approach– The performance measurement analysis is developed through extensions on an existing performance measurement framework. Details regarding relief chain system were obtained through off-site and on-site interviews with relief professionals from World Vision International. Findings– The paper finds that this work yielded: a comparison of performance measurement in the humanitarian relief chain with performance measurement in the commercial supply chain, new performance metrics for the humanitarian relief chain, and a performance measurement framework for the relief chain. Research limitations/implications– The paper shows that future work includes performance measurement in community involvement and empowerment, performance measurement in community development, performance measurement in the combined relief and development mission, and understanding the role and impacts of cooperation and coordination in the relief chain. Practical implications– This paper provides a practical procedure for developing effective performance measurement systems for relief logistics processes. Originality/value– The paper presents to humanitarian relief professionals a new approach to performance measurement for relief logistics and to researchers in supply chain performance a comparison and contrast between performance measurement for relief and performance measurement in the commercial chain, new performance metrics for the relief chain, and implications for modern, quick-response supply chains.

Beck, K. (2017). Smart Security? Evaluating Security Resiliency in the United States Department of Transportation's Smart City Challenge. Transportation Research Record: Journal of the Transportation Research Board, (2604), 37–43.
Smart city initiatives, which involve the connection and automation of city systems and services through the use of information and communication technology, offer significant opportunities to improve efficiency and address many environmental, economic, and social issues faced by U.S. cities. However, as systems become increasingly connected and automated, these systems and the people whom they serve become more vulnerable to an array of security threats, including cybersecurity attacks and attacks on the physical infrastructure and human lives. This paper focuses on how U.S. cities plan to mitigate and respond to the security risks that may arise from

the integration of technology into transportation systems and connecting transportation system databases. After examining the U.S. Department of Transportation's recent competition Beyond Traffic: Smart City Challenge, this paper evaluates 32 of the 77 first-round applications to the Smart City Challenge submitted by midsize American cities. The paper provides a set of criteria to evaluate the resiliency of the applicants' transportation systems, that is, the ability of the cities to withstand and respond to security threats and changing conditions. These criteria include the responses of cities to a range of security risks, the response to unknown risks, plans to accommodate risks, and whether cities plan to work with private or public partners to develop security mitigation and response strategies. The paper concludes that only 19 of the 32 first-round applications to the Smart City Challenge evaluated in this paper address security concerns related to the development of smart transportation systems, and the majority of cities with security plans focus only on mass cybersecurity risks.

Blandford, B., Schurman, S., Wallace, C., & McCormack, S. (2016). Transportation System Vulnerability and Resilience to Extreme Weather Events and Other Natural Hazards Report for Pilot Project - KYTC District 1 (Report for Pilot Project — KYTC District 1 No. KTC-16-20/SPR16-524-1F) (pp. 1–104). Lexington, Kentucky: Kentucky Transportation Center. Retrieved from https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=2562&context=ktc_researchreports This research is intended to aid efforts in strategy development to deal with natural hazard vulnerabilities and improve resiliency for Kentucky's transportation infrastructure by assessing vulnerabilities. It considers federal requirements related to risk-based asset management plans, as well as FHWA's request for transportation agencies to plan for extreme weather events and climate change.

Boothman-Shepard, N., Torriente, S., & Swan, L. (2019). Rapid Response Essentials: Guide to PRE-planning for a Resilient POST-Disaster (pp. 1–60). Resilient 305: Greater Miami & the Beaches.

Botha, P. S., & Scheepbouwer, E. (2015). Relationship Between Early Contractor Involvement and Financial Performance in the Rebuilding of Infrastructure in Christchurch, New Zealand. Journal of the Transportation Research Board, 2504(1), 66–72. https://doi.org/10.3141%2F2504-08 Alliance contracting is a partnering project or program delivery method in which all parties work collaboratively to share risks. The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) alliance has been set up to manage the high risk of the unknown scopes of work associated with disaster recovery projects after the 2011 earthquakes in Christ-church, New Zealand. SCIRT uses early contractor involvement (ECI) as a key measure of risk mitigation and to offer value for money. ECI provides constructability input during the design process to ensure that any issues and construction risks are identified early and taken into consideration. Because there has been considerable pressure to start the rebuilding, not all SCIRT projects have had the benefit of ECI. With the objective of quantifying the positive effect that ECI has on financial outcomes, 288 projects that were in construction or had been finished by the end of February 2014 were compared. The comparison was based on whether ECI had been used both during the design phase of a project and in the cost estimation of the project. The results clearly showed that across

the alliance program there was significant improvement in cost performance and cost accuracy of reconstruction projects that received early contractor input.

Bypaneni, S. P. K., & Tran, D. (2017). Empirical Documentation of Project Delivery Risks for Highway Design and Construction. In TRB committee AFH15 Standing Committee on Project Delivery Methods. (pp. 1–16). Washington, D.C. Retrieved from https://trid.trb.org/view/1439582
This paper discusses a two tier approach to project delivery uncertainties, with an emphasis on dealing with risk. The material presents eight delivery risk factors, based on an analysis of 274 completed highway projects across 26 different agencies that can be used as considerations for effective implementation of project delivery efforts.

Caltrans. (2007). Innovative Procurement Practices: Alternative Procurement and Contracting Methods (Contract No. 53A0104) (pp. 1–65). California Department of Transportation. Retrieved from http://www.dot.ca.gov/design/idd/InnovativeProcurementPractices.pdf
This report evaluates selected innovative contracting strategies. Each evaluation consists of a description, objective, summary of past and ongoing DOT experience, performance outcomes to the extent documented in the literature, and project selection criteria. A qualitative assessment of the advantages and disadvantages of each particular method is also provided. The advantages and disadvantages are based in part on reported performance outcomes, which are supplemented by the perceptions of agencies, contractors, and other experienced practitioners. To provide a baseline for comparison, an evaluation of the advantages and disadvantages of the traditional design-bid-build approach has been prepared as well

Campo, M., Mayer, H., & Rovito, J. (2012). Supporting Secure and Resilient Inland Waterways: Evaluating Off-Loading Capabilities at Terminals During Sudden Catastrophic Closures. Journal of the Transportation Research Board, 2273(1), 10–17. https://doi.org/10.3141%2F2273-02
The U.S. Department of Homeland Security's National Infrastructure Protection Program presents sector-specific planning objectives for protecting the nation's critical infrastructure and key resources. In concert with this objective, researchers at the University of Arkansas and Rutgers University are developing a prototype decision support system that integrates geographic information systems and freight movement models to provide a framework for cargo prioritization and off-loading during a sudden catastrophic closure of the national inland waterway. The project seeks to develop (a) a fundamental understanding of the resiliency of inland waterway transportation systems and the interdependence within and between transportation system components and (b) a decision system that will allow public and private parties to respond quickly to catastrophic waterway events. Researchers reviewed public data, published literature, and aerial imagery to ascertain terminal characteristics indicative of a potential for transferring barge cargo from the inland waterway to freight rail systems. A preliminary framework for assessing terminal suitability for intermodal transfer during a sudden catastrophic closure was developed. Findings suggest that the geographic dispersion of terminals and their commodity-specific nature often limit off-loading operations at certain terminals to their designated commercial purpose only. Other configurations could allow for the off-loading of additional commodities at these terminals. Consideration of alternative terminal uses during a

sudden catastrophic closure requires a detailed understanding of terminal capabilities beyond historical commercial use. An investigation of alternative capabilities should be undertaken at each link in the interdependent inland marine and surface transportation systems to develop an effective decision-making framework.

Chandler, K. L., & Sutherland, P. J. (2013). Response and Recovery for Declared Emergencies and Disasters (No. OMB No. 0704-0188) (pp. 1–74). Washington, D.C.: Federal Transit Administration's (FTA) Office of Safety and Security. Retrieved from https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/Response_and_Recovery_for_Declared_Emergencies_and_Disasters_062813.pdf
This document addresses response and recovery actions that transit agencies can take, including securing funding and reimbursement for restoring services following a declared emergency or disaster. It is written specifically for transit agencies that are either affected by a declared emergency or disaster or that offer services to an affected community or region. Section 3 identifies non DOT resources that can assist with recovery.

Choate, A., Dix, B., Rodehorst, B., Wong, A., Jaglom, W., Keller, J., … Douglas, S. (2017). Synthesis of Approaches for Addressing Resilience in Project Development (No. FHWA-HEP-17-082) (pp. 1–224). Washington, D.C.: Federal Highway Administration. Retrieved from https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/synthesis/index.cfm
This report synthesizes lessons learned and innovations from recent FHWA studies and pilots to help transportation agencies address changing climate conditions and extreme weather events at the asset level. The report is designed to provide needed information to a range of engineering disciplines to integrate climate considerations into transportation project development, including: (1) Information on why, where, and how to integrate climate considerations into the project development process (2) Basic, practical information in related disciplines such as climate science and economics (3)Lessons learned for various engineering disciplines from project-level studies that address how to assess project exposure and vulnerability to climate change stressors, and how to evaluate and select appropriate adaptation strategies. This report presents climate sensitivities, FHWA guidance, lessons learned, adaptation options, and knowledge gaps for four engineering disciplines: coastal hydraulics; riverine flooding; pavement and soils; and mechanical and electrical systems.

Chung, R. M., Ballantyne, D. B., Comeau, E., Holzer, T. L., Madrzykowski, D. M., Schiff, A. J., Stone, W. C., Wilcoski, J., Borcherdt, R. D., Cooper, J. D., Lew, H. S., Moehle, J. P., Sheng, L. H., Taylor, A. W., Bucker, I., Hayes Jr., J. (Jack) R., Leyendecker, E. V., O'Rourke, T., Singh, M. P., & Whitney, M. (1996). January 17, 1995 Hyogoken-Nanbu (Kobe) Earthquake: Performance of Structures, Lifelines, and Fire Protection Systems (NIST SP 901) (Special Publication No. 901). NIST. https://www.nist.gov/publications/january-17-1995-hyogoken-nanbu-kobe-earthquake-performance-structures-lifelines-and

The January 17, 1995 Hyogoken-Nanbu earthquake of magnitude 7.2 in JMA scale (Mw = 6.9), which struck Kobe, Japan and its surrounding area was the most severe earthquake to affect that region this century. The earthquake resulted in more than 6,000 deaths and over 30,000 injuries. Fires following the earthquake incinerated the equivalent of 70 U.S. city blocks. They together destroyed over 150,000 buildings and left about 300,000 people homeless. The economic loss as a result of this earthquake is estimated to reach $200 billion. An investigation was conducted under the auspices of the Panel on Wind and Seismic Effects of the U.S.-Japan Program in Natural Resources to observe, document, and summarize important lessons from this earthquake that can be used to mitigate the potentially tragic impact of future earthquakes on modern urbanized communities. An 18-member team was in Japan from February 12 to February 18, 1995 to study seismology, geology, and geotechnical effects; as well as the performance of buildings, lifelines, and fire safety systems. This document summarizes the information collected during as well as following this investigation. Key findings of the investigation include needs for research and for improvements in practices to achieve earthquake loss reduction in the United States.

Code of Federal Regulations. Title 48 Federal Acquisition Regulation, 48 CFR §.

Code of Federal Regulations. Title 2 Grants and Agreements, 2 CFR § General procurement standards.

Colorado Department of Transportation (CDOT). (2015). 2013 Flood Event Lessons Learned and Best Practices - Action Summary (pp. 1–18).

This Action Summary translates 2013 Flood Best Practices and Lessons Learned into a set of concrete and actionable recommendations for CDOT to meet aggressive performance goals in a future flood event. As a learning organization, CDOT is committed to continuous improvement. Taking the recommended action steps will advance efficiencies in emergency response and recovery operations, support robust financial stewardship, and make significant gains in building a resilient statewide transportation infrastructure.

Contract Services Association. (2007). The Time is Now: Contracting in Emergencies (pp. 1–14). Retrieved from https://www.govexec.com/pdfs/EmergencyContracting_FINAL_1-31-07.pdf This paper identified new ways for Governments to perform its functions in emergencies. It focuses on having a set of functional contracting guidelines for extreme events and emergencies.

Community Resilience Program NIST. (2016a). Community Resilience Planning Guide - Volume 1 (NIST Special Publication No. 1190–1; pp. 1–126). National Institute of Standards and Technology. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190v1.pdf

Community Resilience Program NIST. (2016b). Community Resilience Planning Guide - Volume 2 (NIST Special Publication No. 1190–2; pp. 1–274). National Institute of Standards and Technology. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190v2.pdf

Community Resilience Program NIST. (2016c). Guide Brief 1 - Characterize the Population (Special Publication (NIST SP) - 1190GB-1 No. 1190GB-1; pp. 1–14). National Institute of Standards and Technology. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190GB-1.pdf

Community Resilience Program NIST. (2016d). Guide Brief 2 - Identify Social Institutions (Special Publication (NIST SP) - 1190GB-2 No. 1190GB-2; pp. 1–10). National Institute of Standards and Technology. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190GB-2.pdf

Community Resilience Program NIST. (2019). Guide Brief 14 - Forming a Collaborative Planning Team and Engaging the Community (Special Publication (NIST SP) - 1190GB-14 No. 1190GB-14; pp. 1–16). National Institute of Standards and Technology. https://doi.org/10.6028/NIST.SP.1190GB-14

The purpose of this Guide Brief is to provide information that communities may use to accomplish the first step of the Guide: forming a collaborative planning team and engaging the community. Identifying and engaging appropriate planning team partners and beginning community outreach and engagement early in the process will inform needs and priorities for community resilience. The planning process is more effective when communities identify leaders with vested authority and include key stakeholders who will help develop the community resilience plan and shepherd it though local approval/adoption. This Guide Brief includes best practices, elements of FEMA's Local Mitigation Planning Handbook [FEMA 2013], as well as lessons learned from FEMA's Building Resilience with Diverse Communities Program [FEMA 2014]. It also offers resources to assist community leaders in forming their collaborative planning teams and engaging the community at large.

Cooper, D. E. (2005). Hurricanes Katrina and Rita: Contracting for Response and Recovery Efforts (Testimony Before the House Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina No. GAO-06-235T,). Washington, D.C.: United States Government Accountability Office. Retrieved from https://www.govinfo.gov/content/pkg/GAOREPORTS-GAO-06-235T/pdf/GAOREPORTS-GAO-06-235T.pdf

In response to Hurricane Katrina and Rita, GAO was asked to provide an overview of (1) its role in evaluating the contracting community with regard to disaster preparedness and response; (2) GAO's plans for reviewing the performance of the federal government and its contractors in preparing for and responding to the hurricanes; and (3) what GAO has learned so far about the performance of the federal government and its contractors in preparing for and responding to the hurricanes.

Cray, C. (2005, October). Disaster Profiteering: The Flood of Crony Contracting Following Hurricane Katrina. Multinational Monitor, 26(9). Retrieved from https://www.multinationalmonitor.org/mm2005/092005/cray.html

This article reviews the potential for profiteering among contractors in the event of an emergency.

Culmo, P.E., M. P. (2011). Accelerated Bridge Construction - Experience in Design, Fabrication and Erection of Prefabricated Bridge Elements and Systems (Technical Report No. FHWA-HIF-12-013) (p. 346). Washington, D.C.: Federal Highway Administration. Retrieved from https://www.fhwa.dot.gov/bridge/abc/docs/abcmanual.pdf

This document represents the "State of the Practice" with respect to all aspects of accelerated

bridge construction (ABC). The intent of this manual is to fill in the gaps left by publication of the previous manuals. The manual covers ABC techniques, project planning and scoping, implementing ABC in a Transportation Agency, prefabricated elements, long-term performance of prefabricated elements, construction and design. The manual can be used by transportation agencies to establish a successful accelerated bridge construction program.

Cutter, S. L., & Derakhshan, S. (2018). Temporal and spatial change in disaster resilience in US counties, 2010–2015. Environmental Hazards, 1–20. https://doi.org/10.1080/17477891.2018.1511405

Davis, D., & Davis, N. (2011). Mississippi's Recovery (Public Roads No. FHWA-HRT-11-004). Federal Highway Administration Research and Technology. Retrieved from https://www.fhwa.dot.gov/publications/publicroads/11mayjun/02.cfm
This publication discusses the Mississippi DOT's process in the face of Hurricane Katrina. It presents preparations the organization took as Katrina was approaching, and how they applied accelerated procedures to deal with the destruction from the storm.

DeCorla-Souza, P. (2013, August). Introduction to Public-Private Partnerships(P3s). PowerPoint presented at the Federal Highway Administration, Center for Innovative Finance Support Academy, Webinar. Retrieved from https://www.fhwa.dot.gov/ipd/p3/p3_training/webinars/intro_p3s/
Course material provides an introduction to P3s. Enables participants to identify instances where different P3 arrangements have been used for highway projects, understand the benefits of P3s and challenges to their use.

DeCorla-Souza, P., & Douglass, L. B. (2017). Evaluating the Potential Economic Efficiency of Project Delivery Options. Transportation Research Board: Journal of the Transportation Research Board, 2606(1), 115–121. https://doi.org/10.3141/2606-15
This paper illustrates a comparison of the incremental costs and benefits of alternative delivery options for highway projects that used the FHWA's P3-VALUE analytic tool for much of the computation. The hypothetical example project consists of (a) upgrading an urban freeway with added express toll lanes, (b) possibly delivering the project via a public–private partnership concession, (c) possibly transferring the revenue risk back to the public agency via availability payments (APs), and (d) possibly substituting a hybrid payment mechanism that compensates the operator with a fixed AP plus shadow tolls paid on the basis of person throughput. Under the hybrid payment mechanism, the concessionaire would continue to set toll rates to ensure efficient operations (as under a normal toll concession), but all toll revenue would go to the public agency, as in an AP concession. The multipart payment strategy would potentially restore incentives for ensuring optimal utilization of the facility. The goal is to maximize economic efficiency, which is assessed by using benefit– cost analysis. The evaluation explores the conditions under which the features considered would be incrementally beneficial.

del Puerto, C. L., Scheepbouwer, E., Gransberg, D. D., & Loulakis, M. C. (2017). Emergency Megaproject Case Study Protest: The Interstate Highway 35 West Bridge. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 9(3).

https://doi.org/10.1061/(ASCE)LA.1943-4170.0000216
After a disaster, traditional contracting can be insufficient to restore vital infrastructure in the shortest practical schedule. Emergency contracting procedures can be used to emphasize schedule. Such procedures were used by the Minnesota Department of Transportation (MnDOT) following the collapse of the I-35W highway bridge in 2007. They used a streamlined design-build process with a best value award that included extensive confidential one-on-one meetings with each design-builder to discuss questions and allowing for innovation via alternative technical concepts (ATC). A key factor in MnDOT success with the relatively quick procurement process and later against the lawsuit brought was their extensive experience with design-build (best value award was allowed via legislation in 2001). Major incentives and disincentives were used to encourage minimized construction time. They also strove to "build the largest project possible with the smallest environmental process" and minimize permitting via a "categorical exclusion" request. An award protest was later lodged, with the winner submitting the highest proposed price. Recommendations for future include:

- Use two-step right-of-way acquisition with right of entry easement for immediate access to the construction site with guaranteed timeline for each parcel's financial closure
- Coordinate single points of contact in each agency for all permit communication and a commitment to expedite project permit issuance
- Keep tight control of project scope to avoid delays from exceeding permit constraints
- Encourage a very interactive preproposal period with frequent one-on-one meetings with each bidder
- Accept confidential ATC before proposal submission for review and decision
- Make a transparent evaluation plan/award method to defend against future lawsuits
- Use incentives directly tied to timely/early completion

Design Build Institute of America (DBIA). (2018). 2018 Design-Build State Authorization Maps. Retrieved from https://dbia.org/wp-content/uploads/2018/06/design_build_maps.pdf
Presentation features images of Design-Build Authorization Maps.

Echevarria, A., Zaghi, A. E., Christenson, R., & Accorsi, M. (2016). CFFT Bridge Columns for Multi-hazard Resilience. Journal of Structural Engineering, 142(8). https://doi.org/10.1061/(ASCE)ST.1943-541X.0001292
This study, summarizing the findings of an experiment performed on bridge columns - specifically concrete-filled fiber reinforced polymer (FRP) tube (CFFT) system elements - is in response to the need to understand impacts to infrastructure as a result of extreme events. This study is expected to promote the application of lightly reinforced CFFT columns to enhance the multi-hazard resilience of bridge infrastructure.

Federal Emergency Management Agency. (2011). FEMA Mitigation Best Practices: Public and Private Sector Best Practice Stories for all Activity/Project Types in All States and Territories Relating to all Hazards (pp. 1–757). Washington D.C. Retrieved from https://www.hsdl.org/?abstract&did=683132
This is a collection of all best practices from FEMA for a variety of project types and locations.

Federal Emergency Management Agency. (2016). National Disaster Recovery Framework (pp. 1–59). Retrieved from Homeland Security website: https://www.fema.gov/media-library-data/1466014998123-4bec8550930f774269e0c5968b120ba2/National_Disaster_Recovery_Framework2nd.pdf

The National Disaster Recovery Framework is a guide that enables effective recovery support to disaster-impacted States, Tribes, Territorial and local jurisdictions. It provides a flexible structure that enables disaster recovery managers to operate in a unified and collaborative manner. It also focuses on how best to restore, redevelop and revitalize the health, social, economic, natural and environmental fabric of the community and build a more resilient Nation.

Federal Emergency Management Agency. (2018). Disaster Declarations by Year. Retrieved from https://www.fema.gov/disasters/year
This website provides an overview of FEMA disasters per year from 1953 to present.

Federal Highway Administration. (nd). Vulnerability Assessment Scoring Tool. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/vast_users_guide.pdf

Spreadsheet tool that guides the user through conducting a quantitative, indicator-based vulnerability screen. Intended for agencies assessing how components of their transportation system may be vulnerable to climate stressors.

Federal Highway Administration. (1980). Development and Use of Price Adjustment Contract Provisions (Technical Advisory No. T 5080.3). Retrieved from https://www.fhwa.dot.gov/programadmin/contracts/ta50803.pdf

A procedure for development and use of price adjustment contract provisions to minimize the cost effects of price uncertainty for materials used in construction and to present sample wording successfully used in specifications by various States.

Federal Highway Administration. (2011a). FAQ: Emergency Relief Program and Resilience. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/er_faq/fhwahep17029.pdf

Explains that FHWA emergency relief funds may be used to rebuild damaged highways to be more resilient to future extreme weather events if cost effective or consistent with current design standards.

Federal Highway Administration. (2011b). Assessing Criticality in Transportation Adaptation Planning (FHWA-HEP-11-034). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/assessing_criticality/cta092111.pdf

This memo discusses approaches for narrowing the universe of transportation assets to study in a climate change vulnerability and risk assessment by assessing their "criticality" and otherwise narrowing study scope. It identifies common challenges and draws on examples from the FHWA Adaptation Conceptual Model Pilots and the ongoing USDOT Gulf Coast Phase 2 study.

Federal Highway Administration. (2013). Risk -Based Transportation Asset Management: Building Resilience into Transportation Assets (Report 5: Managing External Threats Through Risk-Based Asset Management). U.S. Department of Transportation. https://www.fhwa.dot.gov/asset/pubs/hif13018.pdf
Explains how risk-based asset management serves as a climate adaptation strategy.

Federal Highway Administration. (2014). Hydraulic Engineering Circular No. 25 – Volume 2 (FHWA-NHI-14-006). U.S. Department of Transportation. https://www.fhwa.dot.gov/engineering/hydraulics/pubs/nhi14006/nhi14006.pdf

Manual provides guidance and methods for assessing the vulnerability of coastal transportation facilities to extreme events and climate change.

Federal Highway Administration. (2015a). Guide to Assessing Criticality in Transportation Adaptation Planning. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/criticality_guidance/criticality_guidance.pdf

Discusses common challenges associated with assessing criticality, options for defining criticality and identifying scope, and the process of applying criteria and ranking assets.

Federal Highway Administration. (2015b). Sensitivity Matrix. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/ tools/sensitivity_matrix.xlsm
Spreadsheet tool that documents the sensitivity of roads, bridges, airports, ports, pipelines, and rail to 11 climate impacts.

Federal Highway Administration. (2015c). Transportation Engineering Approaches to Climate Resiliency (TEACR) Study. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/index.cfm
The objective of this project is to develop recommended engineering practices for identifying and evaluating project-level vulnerabilities from future extreme weather events and climate change, and designing solutions to respond and adapt to those vulnerabilities. Engineering analyses of a diverse set of transportation assets around the country were performed in order to identify best practices for improving the resiliency of the transportation system to extreme weather and climate change. The result will be a cross-cutting set of recommendations for engineering practice to cover a wide range of facility types and locations.

Federal Highway Administration (FHWA); U.S. Department of Transportation (DOT). Procurement, Management, and Administration of Engineering and Design Related Services., Pub. L. No. RIN 2125–AF44; FHWA–2012–0043, § 66, 50 23 CFR Part 172 29908 (2015d).

This rule updates the regulations governing the procurement, management, and administration of engineering and design related services directly related to a highway construction project and reimbursed with Federal-aid highway program (FAHP) funding. In issuing the final rule, FHWA revises the regulations to conform to changes in legislation and other applicable regulations [including the DOT's recent adoption of the revised '"Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards,"' and removal of outdated references] and addresses certain findings and recommendations for the oversight of consultant services contained in national review and audit reports.

Federal Highway Administration. (2016a). CMIP Climate Data Processing Tool. U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/user_guide/cmip_user_guide.pdf

Spreadsheet tool that processes downscaled climate projections from the World Climate Research Programme's Coupled Model Intercomparison Project (CMIP) CMIP3 and CMIP5 databases into relevant statistics for transportation planners, including changes in the frequency of very hot days and extreme precipitation events that may affect transportation infrastructure and services by the middle and end of the century.

Federal Highway Administration. (2016b). Highways in the River Environment-Floodplains, Extreme Events, Risk, and Resilience (FHWA-HIF-16-018). U.S. House of Representatives. https://www.fhwa.dot.gov/engineering/hydraulics/pubs/hif16018.pdf

Provides technical guidance and methods for assessing the vulnerability of transportation facilities to extreme events and climate change in riverine environments.

Federal Highway Administration. (2016c). 2013-2015 Climate Resilience Pilot Program: Outcomes, Lessons Learned, and Recommendations (FHWA-HEP-16-079; pp. 1–58). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/final_report/index.cfm

The Federal Highway Administration's (FHWA)'s Climate Resilience Pilot Program sought to assist state Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Federal Land Management Agencies (FLMAs) in enhancing resilience of transportation systems to extreme weather and climate change. From 2013 to 2015, nineteen pilot teams partnered with FHWA to assess transportation vulnerability and evaluate options for improving resilience. This report synthesizes lessons learned, needs identified, and recommended next steps from the pilot program. Illustrative project findings, outcomes, and examples are distributed throughout the report.

Federal Highway Administration. (2016d). Hydraulic Engineering Circular No. 17, 2nd Edition (FHWA-HIF-16-018). U.S. Department of Transportation. https://www.fhwa.dot.gov/engineering/hydraulics/pubs/nhi14006/nhi14006.pdf

This manual provides technical guidance and methods for assessing the vulnerability of transportation facilities to extreme events and climate change in riverine environments. The focus is quantifying exposure to extreme flood events considering climate change and other sources of nonstationarity. It is anticipated that there will be multiple uses for this guidance including risk and vulnerability assessments, planning activities, and design procedure development.

Federal Highway Administration. (2017a). INVEST Tool. U.S. Department of Transportation. https://www.sustainablehighways.org/

The Tool allows transportation agencies to evaluate the sustainability of their agency practices and projects across the entire transportation lifecycle, by self-assigning points based on how well they have met requirements set out for each particular criterion. Criteria specific for infrastructure resiliency are incorporated into the Tool's categories (called "modules") for planning at the state and regional level, and for project development. These resiliency criteria help agencies plan and design for current and future hazards, including climate change. The Tool notes that planning and designing for infrastructure resiliency supports all of the triple bottom line principles of sustainability (environmental, social, and economic) as it provides energy savings, improves safety and security of the transportation system and users, and reduces future spending on infrastructure replacement.

Federal Highway Administration. (2017b). Resilience and Transportation Planning (FHWA-HEP-17-028; p. 2). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/ratp/fhwahep17028.pdf

The nation's transportation system is essential to the economic prosperity and quality of life of communities. In order to play this critical role infrastructure must be secure and resilient to a myriad of hazards. Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. The Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, requires agencies to take resiliency into consideration during transportation planning processes.

Federal Highway Administration. (2017c). Texas Resilience and Planning Workshop: Summary Report (FHWA-HEP-17-095; pp. 1–18). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/workshops_and_peer_exchanges/texas_06_2017/fhwahep17095.pdf

This report summarizes a Federal Highway Administration (FHWA) workshop that was held on June 21, 2017 at the Texas Department of Transportation (TxDOT) in Austin, Texas. The purpose of the workshop was to identify opportunities for metropolitan planning organizations (MPOs) and other transportation agencies in Texas to assess and address their vulnerabilities to climate change and extreme weather, and incorporate resilience into the transportation planning process. The FHWA Office of Natural Environment, FHWA Office of Planning, FHWA Texas Division, and the FHWA Resource Center planned the workshop.

Presentations and discussions at the workshop focused on actions that MPOs and other transportation agencies in Texas can take to meet new requirements in the Fixing America's Surface Transportation (FAST) Act and increase their resilience to climate change and extreme weather. Appendix A includes the workshop agenda. 47 people attended the workshop, representing 10 MPOs, TxDOT, FHWA, the Federal Transit Administration (FTA), universities, and consultants. Appendix B lists the workshop participants.

Federal Highway Administration. (2017d). Synthesis of Approaches for Addressing Resilience in Project Development (FHWA-HEP-17-082). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/tea cr/synthesis/fhwahep17082.pdf

This report synthesizes lessons learned and innovations from a variety of recent FHWA studies and pilots to help transportation agencies address resilience concerns at the asset level in engineering-informed adaptation studies.

Federal Highway Administration. (2017e). Vulnerability Assessment and Adaptation Framework, 3rd Edition (FHWA-HEP-18-020). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/

The Federal Highway Administration's (FHWA's) Vulnerability Assessment and Adaptation Framework (the Framework), third edition, is a manual to help transportation agencies and their partners assess the vulnerability of transportation infrastructure and systems to extreme weather and climate effects. It also can help agencies integrate climate adaptation considerations into transportation decision-making. The Framework provides an in-depth and structured process for conducting a vulnerability assessment. The Framework describes the primary steps involved in conducting a vulnerability assessment. For each step the Framework features examples from assessments conducted nationwide between 2010 and 2017 and includes links to related resources that practitioners can access for additional information.

The information presented in the Framework is geared toward State departments of transportation (DOTs), metropolitan planning organizations (MPOs), and other agencies involved in planning, building, maintaining, or operating transportation infrastructure.

Federal Highway Administration. (2018). Integrating Resilience into the Transportation Planning Process: White Paper on Literature Review Findings (No. FHWA-HEP-18-050) (pp. 1–53). Washington, D.C.: Federal Highway Administration. Retrieved from https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/pl anning/integrating_resilience.cfm

This white paper on the efforts of State Departments of Transportation (DOTs) and Metropolitan Planning Organizations (MPOs) to integrate resilience into the transportation planning process builds on the findings of a literature review assessing the planning documents for 52 State DOTs and a selection of 101 MPOs. Key research questions sought to understand how these agencies are considering resilience in their transportation planning process, including their motivation for

such considerations, how they are assessing hazards posing a threat to their transportation networks, how they are addressing such threats and vulnerabilities, and their projections for future plans and events. This report includes examples of agencies' efforts in order to better understand the current state of practice for resilience planning.

Federal Highway Administration. (2019a). Indefinite Delivery/Indefinite Quantity Contracting for Low-Cost Federal-Aid Construction Contracts (Notice No. N5060.2). Retrieved from USDOT website: https://www.fhwa.dot.gov/legsregs/directives/notices/n5060-2.cfm

This Notice provides the Federal Highway Administration (FHWA) policy for the use of indefinite delivery/ indefinite quantity (ID/IQ) contracting for low-cost Federal-aid construction contracts. This Notice clarifies under what conditions ID/IQ contracts are allowed for Federal-aid construction.

Federal Highway Administration. (2019b). Construction Program Guide. Retrieved from https://www.fhwa.dot.gov/construction/cqit/

The Construction Program Guide is intended to provide fast, easy access to Federal-aid construction program regulations, policy, guidance, and training. All construction related information is consolidated under key subject areas, with links to related information. The web site provides a consolidated source for Federal and State construction personnel to find updated information about FHWA's construction program.

Federal Highway Administration. (2019c). A Guide to Federal-Aid Programs and Projects (pp. 48–53). U.S. Department of Transportation. https://www.fhwa.dot.gov/federalaid/projects.pdf

This guide provides basic information about the Federal-Aid programs, projects, and other program characteristics. Much of the information provided in this guide was included in the FHWA's 1999 edition of the same publication. This publication updates information from the past document and includes information resulting from the latest multi-year Federal-Aid authorizing legislative act, Fixing America's Surface Transportation Act (FAST Act) (P.L.114-94). As new or updated information becomes available, the electronic version of this guide will be updated.

Federal Highway Administration. (2019d). Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (FHWA-HEP-19-042; pp. 1–229). U.S. Department of Transportation. https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/

The Implementation Guide is designed to help transportation practitioners understand how and where nature-based solutions can be used to improve the resilience of coastal roads and bridges. Upfront, it summarizes the potential flood-reduction benefits and co-benefits of these strategies. From there, the guide follows the steps in the project delivery process, providing guidance on how to consider nature-based solutions in the planning process, how to conduct a site assessment to determine whether nature-based solutions are appropriate, key engineering and ecological design considerations, permitting approaches, construction considerations, and monitoring and maintenance strategies.

Federal Schedules, Inc. (2018). GSA Schedule Disaster Purchasing. Retrieved from https://gsa.federalschedules.com/resources/gsa-schedule-disaster-purchasing/
This website reviews GSA disaster purchasing at the state and local scales. Disaster Purchasing is a program that allows state and local government to purchase from any GSA Schedule in the event of a disaster. Disasters must be declared by the President under the Stafford Act and can include natural disasters or man-made disasters, such as terrorism or nuclear, biological, chemical, or radiological attacks. Disaster Purchasing must be in relation to preparing for, responding to, or recovering from a disaster.

Federal Transit Administration. (2006). Disaster Response and Recovery for Transit Agencies (pp. 1–43). Washington, D.C.: FTA. Retrieved from https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/Response_and_Recovery_for_Declared_Emergencies_and_Disasters_062813.pdf
This document focuses on immediate response and recovery to a disaster. The introductory section is structured as a basic Q&A format. Section 2.5 focuses on funding. Additional sections focus on the role of various federal agencies, local agencies, and MPOs. A list identifies additional resources in the transit industry to assist in response and recovery.

Fletcher, D. R., & Ekern, D. S. (2016). Understanding Transportation Resilience: A 2016-2018 Roadmap. In Special Committee on Transportation Security and Emergency Management (SCOTSEM). Tucson, AZ: American Association of State Highway and Transportation Officials. Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-59(14)C_UnderstandingTransportationResilience-Roadmap.pdf
The transportation community is engaged in a conversation focused on a new challenge facing the nation's transportation systems. The challenge is preparing for severe weather events and responding to system vulnerabilities and emergencies while ensuring the resilience of the system. Resilience is working to plan, prepare, and respond in order to return to normal as quickly as possible after an emergency. Critical infrastructure, risk management, establishing protection approaches, and dealing with extreme weather events emerge at the heart of our challenge as the four foundational concepts critical to shaping a more resilient approach. From the DOTs' perspective, there are three distinct viewpoints: planning (severe weather events/sustainability), engineering (infrastructure protection), and operations (traffic management/emergency management/security).

Gibbs, L., Bryant, R., Harms, L., Forbes, D., Block, K., Gallagher, H., Ireton, G., Richardson, J., Pattison, P., MacDougall, C., Lusher, D., Baker, E., Kellett, C., Pirrone, A., Molyneaux, R., Kosta, L., Brady, K., Lok, M., Van Kessell, G., & Waters, E. (2016). Beyond Bushfires: Community Resilience and Recovery Final Report. University of Melbourne. https://www.preventionweb.net/files/51160_webbeyondbushfiresfinalreport2016co.pdf

Gransberg, D. D. (2013). Early Contractor Design Involvement to Expedite Delivery of Emergency Highway Projects: Case Studies from Six States. Journal of the Transportation Research Board, 2347(1), 19–26. https://doi.org/10.3141%2F2347-03

Events such as Hurricanes Katrina and Irene and the sudden collapse of the I-35W bridge in Minnesota forced state departments of transportation (DOTs) to step into the public spotlight and implement expedited procurement procedures to restore vital links in the transportation network as the media scrutinized their work every night on the evening news. This paper presents the results of case studies from Florida, Maine, Minnesota, Missouri, New York, and Utah where the DOT brought the construction contractor into the design process as the primary means to expedite the delivery of emergency projects. The case studies include the use of design–bid–build, indefinite delivery and indefinite quantity (IDIQ), construction manager–general contractor (CMGC), and design–build (DB) contracts as mechanisms to gain substantive contractor input on materials, means, and methods during design. The paper concludes that completing the design is the first obstacle to surmount in emergency procurements and that the surest tool to expedite emergency project delivery is to design around immediately available materials, equipment, and proven accelerated construction methods—information that is best developed by the contractor that will eventually complete the construction. The paper recommends that agencies develop expedited procurement procedures for IDIQ, CMGC, and DB contracts before emergencies occur and furnishes case study information for specific methods used to streamline routine procurement procedures.

Gransberg, D. D., Scheepbouwer, E., & Lopez del Puerto, C. (2017). A Framework for Objectively Determine Alternative Contracting Best Practices. Transportation Research Record: Journal of the Transportation Research Board, 2630(1), 51–58. https://doi.org/10.3141/2630-07
Alternative contracting method (ACM) usage has grown to the point where the industry has sufficient experience to provide a definitive set of best practices both to promote consistency in the nation's procurement system and to leverage the lessons learned by early ACM adopters. The barrier to achieving this goal is that there is no uniform agreement on the definition of what constitutes a best practice. Both an objective definition and a framework for identifying and analyzing ACM practices are proposed that have been found to be effective by peer-reviewed research to determine whether a given practice deserves to be termed as a best practice. The framework is based on a series of indexes that are used to rank candidate practices in order of their importance and their effectiveness. The 24 ACM practices evaluated were identified from six NCHRP Synthesis reports on ACM topics. It was found that only four of the 24 candidates met the objective criteria to be termed a best practice. These candidates were formalizing and institutionalizing agency ACM procedures, using two-step best-value award procedures, appointing an agency ACM champion, and offering stipends for unsuccessful competitors.

Gransberg, Douglas, Jacob Kovel, Jane Stahl, and Bin (Brenda) Zhou. "Strategies for Improving Transportation Project Delivery Performance." Rocky Hill, CT: The Connecticut Academy of Science and Engineering, September 14, 2016. http://www.ctcase.org/reports/Project-Deliverability/ProjectDeliverability.pdf.
The objective of this study was to identity practices for improving transportation project delivery performance for the various contracting methods that are applicable for CTDOT's use. The report is structured in two parts. Part A covers overall project deliverability and Part B is focused on

environmental review processes and permitting. An overview of the study's recommendations is as follows: CTDOT leadership should articulate the department's vision and objectives for project delivery performance and continue to foster and improve internal relations to instill a shared production culture and team orientation among designers, engineers, environmental regulators, and associated construction entities; to achieve the goals as set forth in the state's transportation capital program plans, it is expected that CTDOT and the Connecticut Department of Energy and Environmental Protection will require additional staffing and flexibility to engage consultants to fill staffing gaps, especially to meet short-term needs; establish key project delivery performance measures to monitor processes using data-driven analysis to identify areas for improvement, and justify needed funding and staffing levels; a useful strategy for improving constructability and ensuring the success of all projects, regardless of the project delivery method used, is early and continuous contractor and regulator involvement to enable design and constructability to be considered concurrently; to enhance environmental benefits and minimize environmental impacts of a project, a holistic design approach should be used that includes early and collaborative discussions between designers, construction managers, and environmental regulators. The practice of sequential design reviews for environmental considerations should be replaced with over-the-shoulder reviews where environmental considerations are integrated into overall project design; use the project delivery method and contractor selection method that best fits a project's challenges and objectives to achieve potential benefits; a consultant should be engaged to guide the development and implementation of alternative contracting methods (ACMs) processes, and for training CTDOT staff in all aspects of scoping, procurement and contracting, and managing the relationships between CTDOT and design and construction project teams in the use of ACMs.

Han, Y., Zegras, P. C., Rocco, V., Dowd, M., & Murga, M. (2017). When the Tides Come, Where Will We Go? Modeling the Impacts of Sea-Level Rise on Greater Boston's Transport and Land Use System (p. 22). Presented at the Transportation Research Board 2017 Annual Meeting. Retrieved from http://hdl.handle.net/1721.1/112778

This paper outlines a scenario specific to how a land use transport model can help forecast impacts of a sea-level rise in the Greater Boston community, and illustrates potential response to transport system impacts.

Hitchcock, W. A., Nunez, S., & Watson, S. V. (2008). Emergency Reconstruction of Critical Transportation Infrastructure (Management and Safety of Transportation Systems Emergency Reconstruction of Critical Transportation Infrastructure No. 06211) (pp. 1–99). Tuscaloosa, AL: University Transportation Center for Alabama. Retrieved from https://rosap.ntl.bts.gov/view/dot/17006

This paper focuses on the viability of contingency planning in Alabama in the face of terrorist attacks or natural disasters. It presents an approach to assessing the processes and practices in preparation of these events. It provides a 3 phased approach including: the existing recovery and reconstruction information, potential recovery processes and recommended contingency processes.

Holleman, Wim. “Efficiency in Road Public Procurement,” 1–58. CEDR’s Secretariat-General, 2016. https://www.cedr.eu/download/Publications/2016/Efficiency-in-Road-Public-Procurement.pdf.

Holsinger, H. (2017). Preparing for Change (FHWA-HRT-17-002). Federal Highway Administration. https://www.fhwa.dot.gov/publications/publicroads/17janfeb/05.cfm
To better understand the risks of climate change, FHWA is working with its international, State, and local partners. The purpose is to develop tools and approaches to address these risks during all aspects of transportation decision-making--from planning and project design to construction, maintenance, and operations. This includes highlights of this ongoing work and some anticipated next steps.

Houston, N. (2006). Best Practices in Emergency Transportation Operations Preparedness and Response: Results of the FHWA Workshop Series (Results of the FHWA Workshop Series No. FHWA-HOP-07-076) (pp. 1–24). Washington, D.C.: Federal Highway Administration. Retrieved from https://ops.fhwa.dot.gov/publications/etopr/best_practices/etopr_best_practices.pdf
This report consolidates the best practices identified during the 30 workshops. Practices grouped in common categories as follows:

- Interagency Coordination and Communication
- Emergency Operations
- Equipment
- Intelligent Transportation Systems
- Mutual Aid
- Threat Notification, Awareness, and Information Sharing
- Policy

Houston, N. (2007). Common Issues in Emergency Transportation Operations Preparedness and Response – Results of the FHWA Workshop Series (Emergency Transportation Operations Preparedness and Response No. FHWA-HOP-07-090) (p. 16). Washington, D.C.: Federal Highway Administration. Retrieved from https://ops.fhwa.dot.gov/publications/etopr/common_issues/etopr_common_issues.pdf
Summarizes the results of 30 workshops conducted between 2002 and 2005 on Transportation Operations Preparedness and Response in 30 regions across the US.

Houston, N., Wiegmann, J., Marshall, R., Kandarpa, R., Korsak, J., Baldwin, C., … Vann Easton, A. (2010). Information Sharing Guidebook for Transportation Management Centers, Emergency Operations Centers, and Fusion Centers (No. FHWA-HOP-09-003) (pp. 1–144). Washington, D.C.: Federal Highway Administration. Retrieved from https://ops.fhwa.dot.gov/publications/fhwahop09003/tmc_eoc_guidebook.pdf
This Guidebook provides an overview of the mission and functions of Transportation Management Centers, Emergency Operations Centers, and Fusion Centers. The Guidebook is focused on the types of information these centers produce and manage and how the sharing of such information among the centers can be beneficial to both the day-to-day and emergency operations of all the centers. There are some challenges to the ability to share information and these challenges and some options for addressing them are addressed in the Guidebook. The

Guidebook also provides some lessons learned and best practices identified from a literature search and interviews/site visits with center operators.

Hu, B., Hu, H., & Chai, Y. (2012). An Emergency Procurement Decision Support System Integrating Case-Based and Rule-Based Reasoning. Presented at the International Conference of Logistics Engineering and Management 2012, Chengdu, China. https://doi.org/10.1061/9780784412602.0141
Under emergency conditions, procurements must be responsive and effective. In order to make up for the scarcity of relevant information needed for timely procurement decisions, this paper proposes an emergency procurement decision support system, which uses a hybrid case-based and rule based reasoning approach to determine the varieties and quantities of supplies. On the basis of the discussion of key technologies such as case representation, case retrieval algorithm, hybrid reasoning mechanism, the framework for this emergency procurement decision support system(EPDSS) is constructed. The study aims at expediting procurement procedures during emergency situations and is of great significance.

Hurst, D., Sharpe, S., & Yeager, V. A. (2017). Administrative Preparedness Strategies: Expediting Procurement and Contracting Cycle Times During an Emergency. Public Health Reports, 132(3), 294–297. https://doi.org/10.1177%2F0033354917698131
We assessed whether administrative preparedness processes that were intended to expedite the acquisition of goods and services during a public health emergency affect estimated procurement and contracting cycle times. We obtained data from 2014-2015 applications to the Hospital Preparedness Program and Public Health Emergency Preparedness (HPP-PHEP) cooperative agreements. We compared the estimated procurement and contracting cycle times of 61 HPP-PHEP awardees that did and did not have certain administrative processes in place. Certain processes, such as statutes allowing for procuring and contracting on the open market, had an effect on reducing the estimated cycle times for obtaining goods and services. Other processes, such as cooperative purchasing agreements, also had an effect on estimated procurement time. For example, awardees with statutes that permitted them to obtain goods and services in the open market had an average procurement cycle time of 6 days; those without such statutes had a cycle time of 17 days (P = .04). PHEP awardees should consider adopting these or similar processes in an effort to reduce cycle times.

ICF International. (2008). DOT Approaches to Implementing Cost Estimate Management Process Improvements (No. NCHRP 8-36(72)). Retrieved from NCHRP website: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(72)_FR.pdf

Ip, W. H., & Wang, D. (2009). Resilience Evaluation Approach of Transportation Networks (Vol. 2, pp. 618–622). Presented at the Second International Joint Conference on Computational Sciences and Optimization, Sanya, Hainan, China. http://dx.doi.org/10.1109/CSO.2009.294
To analyze the resilience of transportation networks, it is proposed to use a quantificational resilience evaluation approach. First, we represent transportation networks by an undirected graph with the nodes as cities and edges as traffic roads. Because the survival ability of transportation of

a pair of cities depends on the number of independent paths between them, the resilience of a city node can be evaluated by the weighted average number of reliable independent paths with all other city nodes in the networks. The network resilience can then be calculated by the weighted sum of all node resilience. Based on the recommended approaches, the resilience of a transportation network is evaluated and analyzed. Several interesting conclusions are drawn from the computational results.

Jabbarzadeh, A., Fahimnia, B., Sheu, J.-B., & Hani Shahmoradi, M. (2016). Designing a supply chain resilient to major disruptions and supply/demand interruptions. Transportation Research Part B: Methodological, 94, 121–149. https://doi.org/10.1016/j.trb.2016.09.004
This paper presents a solution to the problem of reduced supply capacity or total facility shutdown. The material lays out a model and method approach designed to establish a supply chain that is resilient to supply/demand interruptions and facility disruptions. The analysis in this report focuses on supply chain design decisions and the factors that influence them.

Jeffrey, J. T., & Menches, C. L. (2008). Emergency Contracting Strategies for Federal Projects. Journal of Professional Issues in Engineering Education and Practice, 134(4). https://doi.org/10.1061/(ASCE)1052-3928(2008)134:4(371)
During the past decade, government agencies have struggled to adequately respond to emergency events that require labor, materials, equipment, and services provided by construction contractors. In fact, the criticism directed at government agencies during their response to, and recovery after, recent events is a testament to the insufficient contracting strategies that were implemented. Countless media headlines highlighted the fragmented approach used to hire contractors expeditiously, and several agencies were criticized for their inconsistent contracting methods. As a result, a study was initiated to investigate the differences between normal federal contracting procedures, as outlined in the Federal Acquisition Regulation (FAR), and emergency acquisition procedures that are permitted by the FAR. The study found six examples of waivers to the usual regulations or expedited contracting techniques permitted by the FAR. Furthermore, the study highlighted five emergency contract strategies that are available to the Navy (as one example of a government agency with contracting authority) and may be available to other governmental contracting authorities as well. Consequently, the purpose of this paper is to identify emergency contract strategies that can be used by government agencies and to outline the criteria that must be met to use each strategy.

King, J. A., & McKay, J. H. (2006). Disaster Response Contracting in a Post-Katrina World: Analyzing Current Disaster Response Strategies and Exploring Alternatives to Improve Processes for Rapid Reaction to Large Scale Disasters within the United States (MBA Professional Report). Naval Postgraduate School, Monterey, CA. Retrieved from https://apps.dtic.mil/dtic/tr/fulltext/u2/a460411.pdf
Considerable public scrutiny has been focused on the Federal Government's, especially the Federal Emergency Management Agency's (FEMA) supposed inadequate, misdirected, and slow response to the acquisition needs required for responding to the aftermath of hurricane Katrina. This seemingly failed response quite possibly cost the Federal Government billions in wasted

taxpayer dollars and has affected the livelihood of thousands. Analyzing what went wrong and examining available acquisition concepts, organizations, processes, and technologies that could be leveraged for future disaster responses is the focus of our MBA project. The project's product provides some proposed solutions to assist FEMA's acquisition mission, along with some recommended technologies for executing these solutions.

Kirk, R. S., & Mallett, W. J. (2018). Emergency Relief for Disaster-Damaged Roads and Public Transportation Systems (Congressional Research Service No. R45298; pp. 1–19). Retrieved from https://fas.org/sgp/crs/homesec/R45298.pdf

Major roads and bridges are part of the federal-aid highway system and are therefore eligible for assistance under the Emergency Relief Program (ER) of the Federal Highway Administration (FHWA). Following a natural disaster (such as Hurricane Sandy in 2012 or the West Virginia flooding of 2016), or catastrophic failure (such as the 2013 collapse of the Skagit River Bridge in Washington State) ER funds are made available for both emergency repairs and restoration of federal-aid highway facilities to conditions comparable to those before the disaster. State departments of transportation typically have close ongoing relationships with FHWA's division offices in each state, which facilitate a quick, coordinated response to disasters. Although ER is a federal program, the decision to seek ER funding is made by the state, not by the federal government.

Lam, J. S. L., & Lassa, J. A. (2017). Risk Assessment Framework for Exposure of Cargo and Ports to Natural Hazards and Climate Extremes. Maritime Policy and Management, 44(1), 1–15. http://dx.doi.org/10.1080/03088839.2016.1245877

This paper discusses gaps in transportation research associated to maritime transport, including ports and cargo. It examines the theoretical framework of risk and exposure to natural disasters, and recommended an assessment framework that can guide future risk assessment processes.

Le Mazurier, J., Wilkinson, S., & Shestakova, Y. (2006). An analysis of the alliancing procurement method for reconstruction following an earthquake. Presented at the 8th U.S. National Conference on Earthquake Engineering, San Francisco, California. Retrieved from https://www.researchgate.net/publication/228544250_An_analysis_of_the_alliancing_procurement_method_for_reconstruction_following_an_earthquake

Reconstruction following an earthquake disaster requires a different response to ordinary construction. One of the key factors to consider is the development of a fast and efficient contractual framework for rebuilding following a disaster event. The objective of this paper is to explore the effectiveness of the alliancing system for the procurement of construction projects following such an event. The methodology for this research consists of analyzing international literature on the alliancing procurement system and then assessing this for usefulness following an earthquake. Comparisons of this system with more common procurement systems will be made. The paper will then discuss how the construction industry in New Zealand, and internationally, can facilitate the adoption of pre-disaster reconstruction procurement plans. This

will include a discussion on what such a plan might include, with particular focus on the adoption of the alliancing system of procurement for reconstruction following an earthquake.

Lessons Learned Information Sharing. (n.d.). Mutual Aid Agreements: Developing Agreements (pp. 1–6). Washington, D.C.: US Department of Homeland Security/Federal Emergency Management Agency. Retrieved from http://www.homelandplanning.unl.edu/Documents/radioconference/moreusefulmaterials/Best%20Practice-Mutual%20Aid%20Agreements-Developing%20Agreements.pdf
Guidance on developing written agreements, contracts, memoranda, and legislation that will guide aid during an emergency. Six sample agreements are included.

Luckey, J. R. (2005). Emergency Contracting Authorities (CRS Report for Congress No. RS22273). The Library of Congress. Retrieved from https://www.everycrsreport.com/files/20050920_RS22273_108a8e4c720031340d55b10f2082f534a639d9bf.pdf
Hurricane Katrina has given rise to many emergency contracting situations. This report will attempt to identify and summarize the primary emergency contracting authorities which might be available to facilitate response to these situations. Generally, these authorities may be divided into two categories, general emergency authority, and emergency (or national interest) exceptions to general procurement statutes or regulations.

MacKenzie, C. A., Santos, J. R., & Barker, K. (2012). Measuring changes in international productions from a disruption: Case Study of the Japanese earthquake and tsunami. International Journal of Production Economics, 138(2), 293–302. https://doi.org/10.1016/j.ijpe.2012.03.032
The earthquake in Japan disrupted the global supply chain in addition to the loss of life and property. By using the input-output model to conceptualize a supply chain, they present a unique method for calculating indirect production losses caused by disabled production facilities. Methods for calculating the possible transfer of demand to industries in other countries are also discussed.

Manzella, M. J. (2016). Upping the Emergency Management Ante: The Role of Private Sector Collaboration in Emergency Management and whether State Procurement and Emergency Management Laws are Built to Collaborate. Naval Postgraduate School, Monterey, California. Retrieved from https://www.hsaj.org/articles/10952
The benefits of public-private collaborations for enhanced emergency management purposes are widely acknowledged, but the questions of when and how such collaborations would be most beneficial have been the subject of much debate. Arguably, it is at the preparedness stage that the private sector's resources, innovative technologies and business continuity expertise can best be used to create more robust risk reduction and preparedness plans. Collaborations at this stage also provide for the identification and proper competitive procurement of all reasonably foreseeable emergency-related goods and services, rather than overuse of the emergency "no-bid" exception to competitive procurement, which can result in contractor fraud and government abuse. But, do the appropriate legal mechanisms exist to support increased collaborations? Given that the

discussion surrounding such collaborations is still current, the assumption was that legal reform would be necessary. Using the Best Practice Research methodology, a review of the states' procurement and emergency management laws actually reveals that they generally contain the necessary language to support increased public-private collaborations. But some are more explicitly supportive of such collaborations than others. Accordingly, this thesis offers a statutory policy framework for agencies to consider making greater use of private resources for better emergency management practices.

Maxwell, K. S., Julius, S., Grambsch, A., Kosmal, A., Larson, L., & Sonti, N. (2018). Built Environment, Urban Systems, and Cities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment (Volume II; pp. 438–478). U.S. Global Change Research Program. https://nca2018.globalchange.gov/chapter/11/

Recent extreme weather events reveal the vulnerability of the built environment (infrastructure, such as residential and commercial buildings, transportation, communications, energy, water systems, parks, streets, and landscaping) and its importance to how people live, study, recreate, and work in cities. This chapter builds on previous assessments of urban social vulnerability and climate change impacts on urban systems.1,2,3 It discusses recent science on urban social and ecological systems underlying vulnerability, impacts on urban quality of life and well-being, and urban adaptation. It also reviews the increase in urban adaptation activities, including investment, design, and institutional practices to manage risk. Examples of climate impacts and responses from five cities (Charleston, South Carolina; Dubuque, Iowa; Fort Collins, Colorado; Phoenix, Arizona; and Pittsburgh, Pennsylvania) illustrate the diversity of American cities and the climate risks they face.

McKinnon, A. (2014). Building Supply Chain Resilience. OECD/ITF Joint Transport Research Centre Discussion Papers, 25. https://doi.org/10.1787/2223439X

The International Transport Forum at the OECD is an intergovernmental organization with 54 member countries. It acts as a strategic think-tank, with the objective of helping shape the transport policy agenda on a global level and ensuring that it contributes to economic growth, environmental protection, social inclusion and the preservation of human life and well-being. The International Transport Forum organizes an annual summit of Ministers along with leading representatives from industry, civil society and academia

Merrill, S. B., Gates, J., & Gray, A. (2017). Integrating Assets Vulnerable to Sea Level Rise and Extreme Weather Events into Ongoing Structural Review Decisions at Maine DOT (pp. 1–12). Presented at the Transportation Research Board 96th Annual Meeting, Washington, D.C.: TRB committee ABC40 Standing Committee on Transportation Asset Management. Retrieved from https://trid.trb.org/view/1438900

Maine Department of Transportation (Maine DOT) has identified coastal bridge and culvert features along its coastal assets that are vulnerable, sensitive, and critical according to a range of technical, environmental, bureaucratic, and economic risk metrics. For the most critical assets it has then identified which engineering designs would be good investments given extreme weather scenarios in both coastal and inland areas, across possible environmental futures. The current

project goes farther, using geographic information systems (GIS) to incorporate lessons from these efforts into ongoing asset management so that similar benefits can accrue to larger numbers of vulnerable assets on an ongoing basis. The authors report on (1) a GIS overlay method developed to be easily communicable between DOT programs and replicable each year as part of developing the next work plan iteration and (2) efforts to use results from the method to identify immediate and longer term actions to enhance resiliency of vulnerable road segments, bridges, and culverts. Lessons are drawn about fitting such targets into existing agency processes, satisfying federal requirements for risk-based asset management, and taking advantage of existing expertise.

Migliaccio, G. C., Gibson, G. E., & O'Connor, J. T. (2009). Procurement of Design-Build Services: Two-Phase Selection for Highway Projects. Journal of Management in Engineering, 25(1). https://doi.org/10.1061/(ASCE)0742-597X(2009)25:1(29)

In the United States, public agencies are adopting the design-build (DB) delivery method for delivering highway projects after having used the traditional design-bid-build method for generations. In the 2002 design-build contracting final rule, the Federal Highway Administration (FHWA) strongly encourages the use of two-phase selection procedures for DB procurement. This paper takes a case study approach to investigating the use of a two-phase process for selecting providers of highway design-build services. Using two DB projects in central Texas as case studies, the writers have analyzed project documentation and performed interviews with 37 project participants involved in procurement, including owner representatives and legal consultants. For the first case, the writers selected the $1.3 billion SH-130 tolled expressway project in central Texas. Procurement of the SH-130 DB contract was performed before the FHWA rule on DB contracting was released. In addition, the writers examined procurement activities for the $154 million DB contract for the SH-45 SE tolled expressway, which was procured by the same owner in 2004 following procedures identified in the FHWA rule. As a result, a process was developed that included activities to be performed between the delivery method decision and the contract execution. This process model tracks the differences between the SH-130 and the SH-45 SE processes that are attributable to the latter's adoption of the FHWA Rule.

Molenaar, K., Harper, C., & Yugar-Arias, I. (2014). Guidebook for Selecting Alternative Contracting Methods for Roadway Projects: Project Delivery Methods, Procurement Procedures, and Payment Provisions (Guidebook No. TPF-5(260) Project No. 1) (p. 410). Retrieved from https://www.colorado.edu/tcm/sites/default/files/attached-files/TPF-5(260)%20Project%20No%201%20-%20Guidebook%20for%20selecting%20contracting%20methods%20-%20DRAFT%20FOR%20REVIEW_0.pdf

The guidebook provides an exhaustive and comprehensive list of the contracting strategies in use today by STAs across the United States and describes each strategy in an effort to educate STAs on strategies they have not used before. Also, the decision-support tools included in the guidebook provide STAs with an approach for selecting from the various contracting strategies available based on the known specifics of a highway or road project. Some contracting strategies

help to accelerate the time to complete a project, while others help to alleviate or better allocate the risks involved in a project. In general, this guidebook does not specify the "right" or "wrong" contracting strategy, rather a way to determine the most "optimal" contracting strategy based on a variety of factors including the attributes, goals, and constraints of a project.

Moradi, S., Vazandrani, V., & Nejat, A. (2019). A Review of Resilience Variables in the Context of Disasters. Journal of Emergency Management, 17(5). https://doi.org/10.5055/jem.2019.0431

The increasing impacts of disasters, caused by more frequent extreme events coupled with the growth of adverse anthropogenic activities, has raised the importance of fostering more resilient communities. Measuring resilience is a vital step in the process of building and strengthening a community's resilience as it helps with identifying the priorities and monitoring the progress. The objective of the current research is to catalog variables proposed in the literature as measures of households' resilience to disasters. Searching the literature through content analysis and applying three selection criteria resulted in a list of 149 variables. These criteria required the variables to be influential on disaster resilience of households, to be quantitatively measurable, and to be obtainable from publicly available data sources. Additionally, a selection of resilience and vulnerability assessment models suggested in the literature were reviewed to highlight the importance of resilience variables in addressing their planned objectives. The variables were classified into five categories titled demographic, socioeconomic, infrastructural, environmental, and institutional. Further analysis of the variables led to identification of the most prevalent variables and commonalities among the categories, aimed to provide a more integrated approach toward resilience planning. This research can serve as an initial yet relatively extensive inventory for selecting variables that are deemed to be influential on households' resilience to extreme events. Further, quantifying a community's resilience using resilience variables can help with identifying and prioritizing the resilience needs, monitoring the progress, and justifying the costs of resilience programs.

National Academies of Sciences, Engineering, and Medicine. (2005). Guide for Emergency Transportation Operations (Surface Transportation Security, Volume 6 No. 525) (pp. 1–56). Washington, D.C.: The National Academies Press. Retrieved from http://www.trb.org/Publications/Blurbs/156212.aspx
TRB's National Cooperative Highway Research Program (NCHRP) Report 525: Surface Transportation Security, Volume 6: Guide for Emergency Transportation Operations supports development of a formal program for the improved management of traffic incidents, natural disasters, security events, and other emergencies on the highway system. It outlines a coordinated, performance-oriented, all-hazard approach called "Emergency Transportation Operations" (ETO). The guide focuses on an enhanced role for state departments of transportation as participants with the public safety community in an interagency process.

National Academies of Sciences, Engineering, and Medicine. (2007). Emergency Contracting Flexibilities in Contracting Procedures During an Emergency (p. 27). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/catalog/23115/emergency-contracting-

flexibilities-in-contracting-procedures-during-an-emergency
This material presents a summary of practices, procedures, and laws related to state procurement processes; discusses flexibility in federal procurement and identifies limitations of grant agreements. This information is key for transportation agencies in an effort to keep up-to-date of practices and law affects operations.

National Academies of Sciences, Engineering, and Medicine. (2008). Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion. The National Academies Press. https://doi.org/10.17226/23075
TRB's National Cooperative Highway Research Program (NCHRP) Synthesis 379: Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion explores the process for selection of alternative contracting methods that can potentially accelerate project completion. The report also examines factors associated with selecting one type of alternative contracting technique over another.

National Academies of Sciences, Engineering, and Medicine. (2009). Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) (Surface Transportation Security, Volume 15 No. 525) (pp. 1–126). Washington, D.C.: The National Academies Press. Retrieved from http://www.trb.org/Publications/Blurbs/160337.aspx
TRB's National Cooperative Highway Research Program (NCHRP) Report 525: Surface Transportation Security, Volume 15: Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) is designed as a planning tool for top-down estimation of both capital and operating budget implications of measures intended to reduce risks to locally acceptable levels. CAPTA supports mainstreaming an integrated, high-level, all-hazards, national incident management system-responsive, multimodal, consequence-driven risk management process into transportation agency programs and activities.

National Academies of Science, Engineering, and Medicine. (2009). A Guide to Planning Resources on Transportation and Hazards. Transportation Research Board. http://www.trb.org/Main/Blurbs/162332.aspx

TRB's National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP) have jointly released A Guide to Planning Resources on Transportation and Hazards. The report was published as NCHRP Research Results Digest (RRD) 333 and as TCRP RRD 90. The report highlights a framework for thinking about the stages of a disaster, and identifies some of the most current and innovative hazard-related research.

National Academies of Sciences, Engineering, and Medicine. (2010). A Guide to Emergency Response Planning at State Transportation Agencies (Surface Transportation Security No. 525) (pp. 1–158). Washington, D.C.: TRB's National Cooperative Highway Research Program (NCHRP). Retrieved from https://www.nap.edu/catalog/14469/a-guide-to-emergency-response-planning-at-state-transportation-agencies
TRB's National Cooperative Highway Research Program (NCHRP) Report 525: Surface Transportation Security, Volume 16: A Guide to Emergency Response Planning at State

Transportation Agencies is designed to help executive management and emergency response planners at state transportation agencies as they and their local and regional counterparts assess their respective emergency response plans and identify areas needing improvement.

National Academies of Science, Engineering, and Medicine. (2011). Guidebook for Sustainability Performance Measurement for Transportation Agencies (Guidebook No. 708; pp. 1–203). The National Academies Press. https://ssti.us/wp/wp-content/uploads/2011/11/nchrp_rpt_708.pdf

The guidebook provides resources for state departments of transportation (DOTs) and other agencies to tailor a performance measurement program for sustainability that is relevant to their specific needs and contexts. Agencies can adapt and use the generally applicable framework in ongoing performance measurement programs or as a part of a new sustainability initiative. The recently enacted transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21), emphasizes performance measurement.

National Academies of Sciences, Engineering, and Medicine. (2012). Expedited Procurement Procedures for Emergency Construction Services (Synthesis No. 438) (pp. 1–106). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/catalog/22691/expedited-procurement-procedures-for-emergency-construction-services

3 distinct parts of procurement process to be defined: Contract payment provision – How designers and contractors will be paid. Common payments provisions are lump sum, GMP (Guaranteed Maximum Price), unit price and cost reimbursable - Project delivery method – Process by which designers, contractors and consultants provides services to deliver a complete project. Common project delivery methods are Design-Bid-Build (DBB), Construction Manager/General Contractor (CMGC) or CM At-Risk, and Design Build (DB). Procurement procedure – Process of getting services and materials for a project. Common procedures are low bid, best value, qualification based and sole source procurement. Touran et al 2009 surveyed DOTs on most effective method for addressing risks and the clear preference was for CMGC due to early contractor involvement. The contractor could help prepare more realistic plans and schedule. However, DB was judged to be better for accelerated schedule. Respondent DOTs showed a distinct preference for lump sum, sticking with routine procedures. Design and constructions contracts tend to be different. Designers are familiar with qualification based selection since the passage of the Brooks Act in 1972 permitted it along with sole source. Contractors, in contrast, are accustomed to lowest bid, open competitions. The most often used method for emergency contract awards was low bid for prequalified contractors. They require the lowest administrative oversight, and literature without exception found the requirement to have a notable impact on success of project. Six state DOTs who replied to the survey faced protests to their emergency contract awards. All but one (MN) had their cases dropped before going to court while Minnesota successfully defended the process. Perry and Hines (2007) discussed 4 best practices for insulating DOTs to protests: careful adherence to laws/regulations, emergency contracts only to supply the immediate need before returning to mandated procedures, prohibit emergency contract renewal without competitive bidding, and use a list of prequalified bidders.

The study and literature recommend that DOTs should maintain a list of prequalified emergency consultants and contractors also to manage risk.

National Academies of Sciences, Engineering, and Medicine. (2013a). A Pre-Event Recovery Planning Guide for Transportation (National Cooperative Highway Research Program No. 753) (pp. 1–197). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/download/22527
This report identified steps to prepare for recovery of transportation infrastructure. It contains numerous appendices addressing case studies, damage assessment, pre-event recovery planning, funding and other topics.

National Academies of Sciences, Engineering, and Medicine. (2013b). Operational and Business Continuity Planning for Prolonged Airport Disruptions. The National Academies Press. https://doi.org/10.17226/22531
TRB's Airport Cooperative Research Program (ACRP) Report 93: Operational and Business Continuity Planning for Prolonged Airport Disruptions provides a guidebook and software tool for airport operators to assist, plan, and prepare for disruptive and catastrophic events that have the potential for causing prolonged airport closure resulting in adverse impacts to the airport and to the local, regional, and national economy.

National Academies of Sciences, Engineering, and Medicine. (2013c, August). Logistics of Disaster Response. Transportation Research News, pp. 1–64.
This issue of the TR News focuses on logistics of disaster response and business continuity by examining supply chain performance challenges in a crisis, the role of the private sector in maintaining supply chains for relief efforts, recent lessons learned for post-disaster relief logistics, and a state department of transportation's emergency management program—plus reports on the effect of gasoline shortages after a disaster, the role of ferries in rescue efforts, applications of social media in disaster preparation and in response and recovery, contingency planning for airport irregular operations, and more.

National Academies of Sciences, Engineering, and Medicine. (2014a). Managing Catastrophic Transportation Emergencies: A Guide for Transportation Executives (Web-Only Document No. 206) (pp. 1–53). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/download/22304#
TRB's National Cooperative Highway Research Program (NCHRP) Web-Only Document 206: Managing Catastrophic Transportation Emergencies: A Guide for Transportation Executives provides guidance to new chief executive officers (CEOs) about the roles and actions that CEOs take during emergency events.

National Academies of Sciences, Engineering, and Medicine. (2014b). Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report (National Cooperative Highway Research Program (NCHRP) No. 750) (pp. 1–204). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/download/22473

TRB's National Cooperative Highway Research Program (NCHRP) Report 750: Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report provides guidance on adaptation strategies to the likely impacts of climate change through 2050 in the planning, design, construction, operation, and maintenance of infrastructure assets in the United States (and through 2100 for sea-level rise).National Academies of Sciences, Engineering, and Medicine. (2015). Alliance Contracting - Evolving Alternative Project Delivery (Synthesis No. 466; pp. 1–82). Retrieved from National Cooperative Highway Research Program (NCHRP) website: http://www.trb.org/Publications/Blurbs/172113.aspx

TRB's National Cooperative Highway Research Program (NCHRP) Synthesis 466: Alliance Contracting—Evolving Alternative Project Delivery synthesizes current practices related to the use of alliance contracts around the world, and explores the procurement procedures that have been used to successfully implement alliance contracting on typical transportation projects.

National Academies of Science, Engineering, and Medicine. (2014c). A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events (No. Report 777) (pp. 1–147). Washington D.C.: The National Academies Press. Retrieved from http://www.trb.org/Publications/Blurbs/171087.aspx

TRB's National Cooperative Highway Research Program (NCHRP) Report 777: A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events uses foundational planning principles, case studies, tips, and tools to explain implementation of transportation planning for possible multijurisdictional disasters, emergencies, and other major events. In addition to the guide, there is a contractor's final research report and a PowerPoint presentation describing the entire project.

National Academies of Sciences, Engineering, and Medicine. (2015a). Indefinite Delivery/Indefinite Quantity Contracting Practices (Synthesis No. 473; pp. 1–617). Retrieved from The National Academies Press website: https://www.researchgate.net/profile/Douglas_Gransberg/publication/280610335_Indefinite_DeliveryIndefinite_Quantity_Contracting_Practices/links/55be2ba308aed621de120e0c/Indefinite-Delivery-Indefinite-Quantity-Contracting-Practices.pdf

The synthesis covers multiple aspects of IDIQ practice, including contracting techniques, terminology used by transportation agencies, contract advertising and award practices, successful contracting procedures, pricing methods, risk management issues, and effective contract administration practices.

National Academies of Sciences, Engineering, and Medicine. (2015b). Legal Aspect of Environmental Permitting in the Emergency Response Environment (Legal Research Digest No. 64) (pp. 1–71). Washington, D.C.: The National Academies Press. Retrieved from https://www.nap.edu/catalog/22186/legal-aspect-of-environmental-permitting-in-the-emergency-response-environment

TRB's National Cooperative Highway Research Program (NCHRP) Legal Research Digest 64:

Legal Aspect of Environmental Permitting in the Emergency Response Environment explores processes used by governmental entities to attain compliance with environmental laws and regulations in emergencies.

National Academies of Science, Engineering, and Medicine. (2016a). Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects (No. 787). Transportation Research Board. http://www.trb.org/Publications/Blurbs/171479.aspx

TRB's National Cooperative Highway Research Program (NCHRP) Report 787: Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects presents guidance for transportation agencies on design management under construction manager/general contractor and design-build project delivery. The guidance includes case studies of projects successfully developed using these alternative procurement strategies.

National Academies of Sciences, Engineering, and Medicine. (2016b). Transportation Resilience: Adaptation to Climate Change. The National Academies Press. https://doi.org/10.17226/24648. Transportation Resilience: Adaptation to Climate Change and Extreme Weather Events summarizes a symposium held June 16–17, 2016 in Brussels, Belgium. The fourth annual symposium promotes common understanding, efficiencies, and trans-Atlantic cooperation within the international transportation research community while accelerating transport-sector innovation in the European Union (EU) and the United States. The two-day, invitation-only symposium brought together high-level experts to share their views on disruptions to the transportation system resulting from climate change and extreme weather events. With the goal of fostering trans-Atlantic collaboration in research and deployment, symposium participants discussed the technical, financial, and policy challenges to better plan, design, and operate the transportation network before, during, and after extreme and/or long-term climate events.

National Academies of Science, Engineering, and Medicine. (2017a). Alternative Design/Alternate Bid Process for Pavement-Type Selection. The National Academies Press, 1–77. https://doi.org/10.17226/24674
This document presents the state of the practice for alternate design and bid selection processes using state DOT survey information, case study examples, DOT pavement design and procurement documentation and other pertinent publications. The literature offers discussion on topics including life-cycle cost analysis (LCCA), procurement activities, and administration considerations.

National Academies of Sciences, Engineering, and Medicine. (2017b). Improving the Resilience of Transit Systems Threatened by Natural Disasters, Volume 3 Literature Review and Case Studies (TCRP) (pp. 1–447). Washington, D.C.: The National Academies Press. Retrieved from http://www.trb.org/Main/Blurbs/177009.aspx
TRB's Transit Cooperative Research Program (TCRP) Web Only Document 70: Improving the Resilience of Transit Systems Threatened by Natural Disasters, Volume 3: Literature Review and Case Studies includes appendices that outline the literature reviewed and 17 case studies that explore how transit agencies absorb the impacts of disaster, recover quickly, and return rapidly to

providing the services that customers rely on to meet their travel needs. The report is accompanied by Volume 1: A Guide, Volume 2: Research Overview, and a database called resilienttransit.org to help practitioners search for and identify tools to help plan for natural disasters.

National Academies of Sciences, Engineering, and Medicine. (2018). Resilience in Transportation Planning, Engineering, Management, Policy, and Administration (Synthesis No. 527) (pp. 1–82). Washington, D.C.: The National Academies Press. Retrieved from http://www.trb.org/NCHRP/Blurbs/177737.aspx

TRB's National Cooperative Highway Research Program (NCHRP) Synthesis Report 527: Resilience in Transportation Planning, Engineering, Management, Policy, and Administration documents resilience efforts and how they are organized, understood, and implemented within transportation agencies' core functions and services. Core functions and services include planning, engineering, construction, maintenance, operations, and administration. The information gathered details the motivations behind the policies that promote highway resilience, definitions of risk and resilience, and the relationship between these two fields. The report also explores how agencies are incorporating resilience practices through project development, policy, and design.

National Academies of Sciences, Engineering, and Medicine. (2019). Building and Measuring Community Resilience: Actions for Communities and the Gulf Research Program. The National Academies Press, 1–152. https://doi.org/10.17226/25383.

National Research Council. (2012). Disaster Resilience: A National Imperative. The National Academies Press.

No person or place is immune from disasters or disaster-related losses. Infectious disease outbreaks, acts of terrorism, social unrest, or financial disasters in addition to natural hazards can all lead to large-scale consequences for the nation and its communities. Communities and the nation thus face difficult fiscal, social, cultural, and environmental choices about the best ways to ensure basic security and quality of life against hazards, deliberate attacks, and disasters. Beyond the unquantifiable costs of injury and loss of life from disasters, statistics for 2011 alone indicate economic damages from natural disasters in the United States exceeded $55 billion, with 14 events costing more than a billion dollars in damages each.

NOAA National Centers for Environmental Information (NCEI). (2020). Billion-Dollar Weather and Climate Disasters: Overview. National Oceanic and Atmospheric Administration (NOAA). https://www.ncdc.noaa.gov/billions/

The National Centers for Environmental Information (NCEI) is the Nation's Scorekeeper in terms of addressing severe weather and climate events in their historical perspective. As part of its responsibility of monitoring and assessing the climate, NCEI tracks and evaluates climate events in the U.S. and globally that have great economic and societal impacts. NCEI is frequently called upon to provide summaries of global and U.S. temperature and precipitation trends, extremes, and

comparisons in their historical perspective. Found here are the weather and climate events that have had the greatest economic impact from 1980 to 2019. The U.S. has sustained 258 weather and climate disasters since 1980 where overall damages/costs reached or exceeded $1 billion (including CPI adjustment to 2019). The total cost of these 258 events exceeds $1.75 trillion.

Noland, R. B., Weiner, M. D., & Greenberg, M. R. (2016). Funding Resilient Infrastructure in New Jersey: Attitudes Following a Natural Disaster. Mineta Transportation Institute Publications. Retrieved from https://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=1205&context=mti_publications
Recent major natural disasters in New Jersey have demonstrated the need to increase the resilience of transportation infrastructure. This research examines public attitudes toward revenue sources that can be dedicated to protecting vulnerable areas, most notably the transportation linkages on which the state depends. A statewide survey was conducted to gather data approximately four months following Superstorm Sandy, the costliest natural disaster in the state's history. The authors' objective was to sample public attitudes while the impacts of the disaster were still fresh. They found little support for temporary tax increases to improve resiliency, with the most positive support for taxing visitors (i.e., a hotel and recreational tax) and for a 30-year bond measure (i.e., taxing the future). This observation seemingly contradicts broad support for investing in new infrastructure, as well as maintaining and protecting existing infrastructure. Multivariate analysis to understand the underlying attitudes toward raising revenue found that more left-leaning or communitarian attitudes are associated with more support for gasoline, income, or sales taxes devoted to mitigating vulnerability. Those who supported investment in transit and protecting infrastructure also were more likely to support these taxes. There was no parallel finding of factors associated with taxing visitors or issuing bonds.

Office of Federal Procurement Policy. (2011). Emergency Acquisitions Guide (Memorandum for Chief Acquisition Officers, Senior Procurement Executives). Washington, D.C.: Office of Management and Budget. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/procurement_guides/emergency_acquisitions_guide.pdf
The guide describes strategies for effective acquisition planning and provides a list of flexibilities available when contracting during emergencies. The guide also incorporates a number of management and operational best practices that agencies developed in response to natural disasters and other emergency situations. These practices should be considered in planning related to contingency operations, antiterrorism activities, and national emergencies

Office of the Inspector General. (2010). Assessment of Federal Emergency Management Agency's Emergency Support Function Roles and Responsibilities (No. OIG-11-08) (pp. 1–73). Washington, D.C.: U.S. Department of Homeland Security. Retrieved from https://www.oig.dhs.gov/assets/Mgmt/OIG_11-08_Nov10.pdf
This report assesses the effectiveness of FEMA to fulfill its responsibilities under the National Response Framework to coordinate eight Emergency Support Functions. It identifies 11 recommendations for FEMA to improve its coordination with stakeholders and its operational

readiness. FEMA's role insects with DOT's in ESF-1 transportation, ESF-3 Public Works, ESF-7 Logistics Management, and ESF-14 Financial Management and Accountability

Office of the Inspector General. (2016). FTA Can Improve its Oversight of Hurricane Sandy Relief Funds (Audit Report No. ZA-2016-077). Federal Transit Administration. Retrieved from https://www.oig.dot.gov/sites/default/files/FTA%20Oversight%20of%20Hurricane%20Sandy%20Relief%20Funds_Final%20Report%5E7-21-16.pdf
In October 2012, Hurricane Sandy caused widespread damage to the transportation infrastructure in the mid-Atlantic and northeastern United States. In response, the President signed the Disaster Relief Appropriations Act (DRAA) in January 2013, which appropriated $10.9 billion to the Federal Transit Administration's (FTA) Public Transportation Emergency Relief Program (ERP) for Sandy-related recovery, relief, and resiliency programs. As of November 30, 2015, FTA had obligated nearly $4.6 billion and disbursed $1.16 billion. FTA's top four grantees1 received $1.14 billion of the $1.16 billion in disbursed funds. The Metropolitan Transportation Authority (MTA) received $821 million, or 70 percent, of those funds. Of MTA's subsidiaries, New York City Transit (NYCT) holds the majority of MTA's DRAA-funded contracts. DRAA directs our office to support oversight of FTA's Hurricane Sandy relief funds. Accordingly, we conducted this audit to determine whether FTA provides effective oversight of grantees' contracting practices using DRAA funds. We focused our review on NYCT because it was one of the largest recipients of MTA's Hurricane Sandy relief funds. We conducted this audit according to generally accepted Government auditing standards. To conduct our work, we used a risk-based approach to select 9 out of 37 DRAA-funded NYCT contracts to review NYCT's procurement practices and FTA's oversight.3 These 9 contracts represented $190 million—or 86 percent—of the 37 NYCT contracts, valued at $220 million. We reviewed Federal requirements, FTA guidance, and MTA and NYCT policies and procedures. We also interviewed FTA, MTA, and NYCT personnel. Exhibit A further details our scope and methodology.

Oliva, M., Bank, L., & Sivak, R. (2009). Rapid Repair and Replacement Techniques for Transportation Infrastructure Damaged from Natural and Man-made Disasters. Retrieved from https://www.researchgate.net/publication/234095024_Rapid_Repair_and_Replacement_Techniques_for_Transportation_Infrastructure_Damaged_from_Natural_and_Man-made_Disasters
Highways and railways move the major volume of freight tonnage in the nation. The impact to the freight hauling industry created by disruption due to natural and man-made disasters is tremendous. Bridges are the most sensitive components for construction in both railroad and highway systems. While highways and rail lines can be repaired relatively quickly, bridges require special planning, engineering, materials procurement, and longer construction time. The objective of this research project is to ensure that the Wisconsin Department of Transportation (WisDOT) has the most complete list of rapid repair/replacement construction and contracting techniques for bridges readily available for use in emergency situations where the timing of response and recover actions are critical.

Oliva, S., & Lazzeretti, L. (2017). Adaptation, adaptability and resilience: the recovery of Kobe after the Great Hanshin Earthquake of 1995. European Planning Studies, 25(1), 67–87. https://doi.org/10.1080/09654313.2016.1260093

In the past few years, the concept of resilience has captured the attention of academics, politicians and public opinion and has been identified as the source of recovery policies of local, regional and national economies. As a result, searching for the so-called resilient factor has led governments to manage territories and resources, combining sustainability and adaptation in an increasingly risky world. The purpose of this paper is to investigate resilience in response to natural disasters through the analysis of the recovery process of the city of Kobe destroyed by the Great Hanshin-Awaji Earthquake in 1995. Japanese regions have always coexisted with significant external pressures often leading to environmental disasters and consequent relevant economic and social damage. Kobe has been an emblematic case because of its rapidity in urban reconstruction and speeding of economic recovery. Kobe and the Great Hanshin Earthquake of 1995 represent a successful case of resilient city able to adapt to changing circumstances and to foster local development proposing a renewed image of a creative city.

Oregon Seismic Safety Policy Advisory Commission (OSSPAC). (2013). The Oregon Resiliency Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami (Report to the. 77th Legislative Assembly) (pp. 1–341). Salem, Oregon. Retrieved from https://www.oregon.gov/oem/documents/oregon_resilience_plan_final.pdf
Oregon Resilience Plan reviews policy options, summarizes relevant reports and studies by state agencies, and makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia earthquake and tsunami.

Perry, J. L., & Hines, M. L. (2007). Emergency Contracting: Flexibilities in Contracting Procedures During an Emergency (Legal Research Digest 49) (pp. 3–27). Washington, D.C.: Transportation Research Board of the National Academies. Retrieved from https://www.nap.edu/read/23115/chapter/15#27
This legal research digest reviews available flexibilities within emergency contracting procedures.

Peterson, S., Braun, S., Salazar, J., & Balmaseda, M. S. (2017). Accelerating Pre-construction Project Delivery (p. 11). Presented at the Transportation Research Board 96th Annual Meeting, Washington, D.C.: Transportation Research Board. Retrieved from https://trid.trb.org/view/1438960
Using formal process reviews, the Florida DOT presents a report that offers guidance for streamlining opportunities to underscore the importance of innovation and efficiency. The results outline targeted process improvements focusing on accelerated project delivery.

Pitera, K. A., & Goodchild, A. V. (2009). Interpreting Resilience: An Examination of the Use of Resiliency Strategies within the Supply Chain and Consequences for the Freight Transportation System (Vol. 1, pp. 492–509). Presented at the 50th Annual Transportation Research Forum, Portland, Oregon: Transportation Research Forum. Retrieved from https://ageconsearch.umn.edu/record/207814/files/2009_93_InterpretingResilience_paper.pdf

With continued increases in trade volumes, lengthening of supply chains due to globalization, and an increased focus on disruptions, resiliency has become an issue of concern within the supply chain community. Resiliency is formally defined as the ability to recover from or adjust easily to change or disruption. For this research and within the supply chain community, resiliency also includes the ability to avoid disruptions. In the past, resiliency has been discussed in nebulous terms, typically focusing on the overall concept of resiliency, past resiliency successes and failures, and generalized frameworks and flowcharts to help assess risk and mitigate for it. Absent is the discussion of how companies perceive resiliency and by what methods are they currently integrating resiliency strategies into supply chain and goods movement policies. This research explores and evaluates resiliency efforts, focusing on the goods movement within the supply chain, currently being used in practice by importing companies. Additionally, the information gathered in this research may be utilized to improve resiliency within freight transportation systems. Through a series of eleven interviews with personnel responsible for transportation and supply chain activities and operations, information was gathered to understand how companies are attempting to improve the resiliency within their supply chain in the face of increasing vulnerabilities. Responses to questions about resiliency, vulnerabilities, disruptions, and disruption procedures were used to identify fifteen resiliency strategies which were categorized as enablers or strategic resiliency strategies. Enablers, such as communication, relationships, and use of information and technology, were identified as ways to increase the effectiveness of other resiliency efforts and are often an integral part of supply chain operations prior to concerns about resiliency. Strategic resiliency strategies, including using expedited transportation, using multiple ports and/or carriers to move goods, becoming C-TPAT certified, and delivering during off-peak hours, are typically part of a long term plan of action, but are often implemented on a day to day or as needed basis. Both enablers and strategic resiliency strategies result in the reduction of exposure to supply chain disruptions and/or the mitigation of disruption impacts. Relationships between the strategies are revealed, highlighting the importance of enablers as a means of promoting the success of many other reported resiliency strategies. The strategies used by a given company are often a reflection of the company's current exposure to risk, and therefore experience with resiliency. For example, companies with existing supply uncertainty have already implemented resiliency strategies to mitigate the impact of sourcing difficulty. Examination of resiliency strategies as a means to reduce exposure to supply chain disruptions has shown that the use of these strategies helps spread the risk of disruptions, either geographically, temporally, or across personnel. In addition to improving resiliency, many identified strategies can provide an added value to supply chains, improving operations and efficiency on a daily basis. This research provides a summary of existing strategies, but also presents a framework for discussing resilience in terms of enablers and strategies. Enablers, which allow a company to improve resilience, are the nebulous concepts often associated with resilience such as flexibility and communication. The strategies are specific actions that can have a measurable impact on an enterprise's ability to tolerate disruptions. Understanding the implications of employing various resiliency strategies can assist companies in making strategic decisions which are in the best interest of a resilient and successful supply chain. The research also discusses how knowledge of these strategies can assist

freight transportation system planners, designers, and managers in improving system resilience for the benefit of all users.

Python, G. C., & Wakeman, T. H. (2016). Decision Making Guidelines to Enhance Port Supply Chain Resilience (pp. 1–11). Presented at the Transportation Research Board 95th Annual Meeting, Washington, D.C.: TRB committee AW010 Standing Committee on Ports and Channels. Retrieved from https://trid.trb.org/view/1393416

The high value and volume of commercial goods moved into and out of the United States on the water make maritime ports indispensable, not only for economic reasons but also for citizens to have access to necessary cargo. The location and nature of coastal ports make them susceptible to both natural and human-made disasters. Seaports inherently have some level of vulnerability to disruptions because of their location (adjacent to waterways) and their interdependencies (industrial and societal), but the impact can generally be managed. However, the impact of Hurricane Sandy on the Eastern seaboard, combined with future trends of sea-level rise and storm severity, has demonstrated that reducing the impact of flooding on port supply chain activities is an economic necessity. The development of organizational guidelines formulated from lessons learned from disasters was undertaken to aid personnel in making decisions to reduce the impact of flooding on the freight transportation system (i.e., supply chain). These guidelines allow for ports around the country to incorporate standardized steps and methods, while also allowing personnel to use best professional judgment for any particular event. When all ports use the same guidelines, it allows for ports to come to each other's aid during a disruption, creating a more resilient port and enhancing national resilience. This paper incorporates lessons learned from Sandy into a composite set of guidelines to help direct decision makers with potential port operational and landside logistics problems that they may face due to a disruptive event.

Rabbani, M., Arani, H. V., & Rafiei, H. (n.d.). Option contract application in emergency supply chains. International Journal of Services and Operations Management, 20(4). https://doi.org/10.1504/IJSOM.2015.068523

Emergencies, such as natural and man–made disasters, might impose great amount of uncertainties on companies in supply chains, especially supply chain of relief materials. Risk hedging procedures such as risk–sharing contracts help the firms to survive from these uncertainties. In this study, an option contract application in relief material supply chains is considered within which a buyer purchase some options from a supplier and has a right, not obligation, to exercise it according to special conditions. In emergencies, condition for option exercising is disaster occurrence which is probabilistic. Our study takes disaster intensity into account via a disaster intensity probability density function, upon which the buyer can exercise a portion of the option contract. In order to motivate both parties to participate in the option contract, an option pricing model based on binomial trees is presented, which optimizes option and exercise prices in four different conditions. Also, it is assumed that both parties of the supply chain can negotiate on the obtained prices. In order to validate the model, a numerical example is presented, whose obtained results demonstrate a feasible region for option and exercise price.

Ritchie, L., Tierney, K., & Gilbert, B. (2011). Disaster Preparedness among Community-Based Organizations in the City and County of San Francisco: Serving The Most Vulnerable. In D. S. Miller & J. D. Rivera (Eds.), Community Disaster Recovery and Resiliency: Exploring Global Opportunities and Challenges (pp. 3–39). Taylor and Francis.

Rueda-Benavides, J. A., & Gransberg, D. D. (2014). Fundamentals of Indefinite Delivery/Indefinite Quantity Contracting: A Primer for Public Transportation Agencies. In TRB committee AFH15 Project Delivery Methods. (p. 15). Washington, D.C.: National Academies of Sciences, Engineering, and Medicine. Retrieved from https://trid.trb.org/view/1287416
Indefinite delivery/indefinite quantity (IDIQ) contracts are linked to the creation of the General Services Administration (GSA) in 1949, but has only become popular among nonfederal agencies during the last few years. Hence many state departments of transportation (DOT) still consider IDIQ as an alternative contracting method. The paper discusses the fundamentals of IDIQ contracting and proposes three generic models that were synthesized from both the literature and a content analysis of IDIQ procurement documents. The paper finds that IDIQ contracting has a number of distinct advantages for small, repetitive construction and/or maintenance projects by literally creating a capacity through an on-call contractor that can be mobilized and working in a much shorter period than traditional project delivery methods. It also finds that once the IDIQ contract is awarded the agency is able to utilize the contractor to furnish a number of preconstruction services in much the same manner as Construction Manager/General Contractor (CMGC) projects, which results in better pricing due to more constructible designs. Additionally, the repetitive nature of the IDIQ work orders also offers the contractor the ability to leverage the learning curve on its means and methods to the benefit of the owner. Finally, IDIQ contracts provide a vehicle to rapidly obligate available year-end funding without the need to execute an expedited procurement process.

Ruparathna, R. (2013). Emergency Based Procurement Framework to Improve Sustainability Performance in Construction (Master of Applied Science). The University of British Columbia, Okanagan. Retrieved from https://open.library.ubc.ca/media/download/pdf/24/1.0074139/1
Thesis reviews the sustainability of traditional procurement practices.

Ruparathna, R., & Hewage, K. (2015). Review of Contemporary Construction Procurement Practices. Journal of Management in Engineering, 31(3). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000279
Procurement is a key process in a construction project that creates and manages contacts. Procurement activities span from identification of requirements to project closeout, making it a perfect mode for integrating organizational strategic directions. Lately, the strategic importance of procurement has been widely acknowledged by academics as well as industry professionals. Construction procurement is a complex process with a large number of available options and directions. Ad hoc statistics show that modern initiatives such as sustainability, life-cycle costing, and standardization are getting integrated with procurement. However, there is no unified view in the construction industry on procurement as a project process. This paper presents a comprehensive review of traditional and emerging procurement practices in the construction

industry. The current procurement practices are analyzed by separating into three segments; processes, methods, and policies. Furthermore, strengths and weaknesses of the traditional procurement methods are reviewed in detail. As the final section, contemporary developments in construction procurement are investigated. This article consolidates detailed knowledge of construction procurement that is identified as a knowledge gap in the literature.

Schexnayder, C., & Anderson, S. (2010). Emergency Accelerated Construction. Presented at the Construction Research Congress 2010, American Society of Civil Engineers. https://doi.org/10.1061/41109(373)84
There are a number of transportation agencies that have experience with accelerated construction strategies. California and Alabama have in the last several years completed major accelerated construction projects. These projects served as the proving ground for acceleration approaches and methods. When on two occasions a fuel truck collision damaged a bridge at the I-65/I-59 interchange in Birmingham, the Alabama Department of Transportation dedicated the necessary staff resources to accelerated project delivery under emergency conditions. Caltrans has had similar emergency projects both in rural and urban settings. This paper identifies, through a set of project case studies, construction operational and management practices that support accelerated project delivery. From this study it is evident that successful project acceleration is achieved through a partnering atmosphere and contracting methods such as design-build plus incentive/disincentive clauses that encourage a contractor to expend the planning effort and resources necessary to reduce construction time.

Scott, S., Klei, H., & Ferragut, T. (2006). Innovative Contracting for Major Transportation Projects (NCHRP Project 20-24(43)) (p. 22). National Cooperative Highway Research Program Transportation Research Board National Research Council. Retrieved from http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/20-24(43)_FR.pdf
This report summarizes the development and delivery of a workshop for state highway agency CEOs and senior managers responsible for highway construction contracting. The workshop was held at the AASHTO 2005 annual meeting in Nashville, Tennessee. It provided information concerning innovative contracting practices for transportation projects, focusing specifically on design-build delivery, best-value procurement, and construction warranties. It discussed recent trends in the industry, and provided state highway agency CEOs and managers with information needed to identify projects and implement innovative contracting methods to reduce construction time and life-cycle costs, improve quality, and enhance customer satisfaction

Soltani-Sobh, A., Heaslip, K., Scarlatos, P., & Kaisar, E. (2016). Reliability based pre-positioning of recovery centers for resilient transportation infrastructure. International Journal of Disaster Risk Reduction, 19, 324–333. https://doi.org/10.1016/j.ijdrr.2016.09.004
This material provides a methodology used to establish a resilient and effective transportation infrastructure when unpredictable disruptions occur. The paper focuses on restoration of bridges by creating clustered recovery centers to help manage cost and system reliability. The methodology scenario in this paper is applied to the Sioux Falls real transportation network.

Stamos, I., Mitsakis, E., & Grau, J. M. S. (2015). Roadmaps for Adaptation Measures of Transportation to Climate Change. Journal of the Transportation Research Board, 2532(1), 1–12. https://doi.org/10.3141/2532-01

No strangers to the phenomenon of climate change, transport-related authorities responsible for managing its impacts have lately turned their attention to exploring ways to address the increasing frequency and intensity of extreme weather events and natural hazards, often referred to as "the face of climate change." In the quest to identify optimal alternatives that will reduce the effects of climate change on human ecosystems, these authorities find themselves presented with a series of options. Nonetheless, transportation authorities have no assurances that their choices will best deal with the challenges and therefore substantially contribute to the minimization of negative climate change impacts. Following a detailed literature review of both research efforts and actual case-study experience, adaptation measures for road, rail, air, and water transportation are consolidated and related to the extreme weather events, natural hazards, or both that they mostly address. The review is concluded in the form of a measure and policy database, which is then evaluated through a series of performance indicators. These indicators include the extent to which each measure contributes to the enhancement of transport system resilience as well as the temporal and financial resources required for its implementation. The evaluation is conducted by using an expert group survey covering multiple sectors and disciplines (academia, research, industry, and government). Findings are formulated in the form of roadmaps for climate change adaptation measures for the transport sector; these roadmaps can serve as a useful tool and basis for an improved decision-making approach for different end users to address climate change.

Stopka, Ondrej, Mária Chovancová, Ján Ližbetin, and Vladimír Klapita. "Proposal for Optimization of the Inventory Level Using the Appropriate Method for Its Procurement," 2016. https://hrcak.srce.hr/file/239695.

This paper deals with the optimization of the inventory level through determining and applying the appropriate way for the procurement of the inventory. It is important to determine the optimization criteria which are proposed on the basis of defining the factors affecting the determination of the procurement method. The criteria are proposed in such way in order the costs are optimized, and at the same time, the risk of the inventory deficiency is reduced. The paper also contains the algorithm regarding the determination of the appropriate procurement method. This algorithm takes into account the particular set of criteria and the proposal of multi-criteria model of the inventory management. Subsequently, the specific cases of costs reduction and reduction of risk of the inventory deficiency when applying the proposed model in comparison with the application of existing models are presented.

Storsjö, I., Kovács, G., Forss, L., & Haavisto, I. (2016). Innovation in public procurement for emergencies. In Purchasing and Supply Management. Orlando, FL: HUMLOG Institute. Retrieved from https://www.pomsmeetings.org/ConfPapers/065/065-1237.pdf

According to the European Commission, buying innovative products and services plays a key role in improving the efficiency and quality of public services while addressing major societal

challenges. In this study, we investigate how Finnish agencies integrate the performance objective of innovation in public procurement processes while dealing with emergencies.

Ta, C., Goodchild, A. V., & Ivanov, B. (2010). Building Resilience into Freight Transportation Systems: Actions for State Departments of Transportation. Journal of the Transportation Research Board, 2168(1), 129–135. https://doi.org/10.3141%2F2168-15
The management of transportation systems for resilience has received significant attention in recent years. Resilience planning concerns the actions of an organization that reduce the consequences of a disruption to the system the organization manages. Little exploration has been made into the connections between resilience planning and the actions of a state department of transportation (DOT) that contribute to resilience of a freight transportation system. Conclusions are presented from collaborative research between the Washington State DOT Freight Systems Division (WSDOT FSD) and researchers at the University of Washington. Activities of the WSDOT FSD that contribute to resilience are identified, and one such activity undertaken by WSDOT to improve communication with system users is described. This and other activities can be undertaken by other DOTs that want to improve the resilience of their freight transportation systems at relatively low cost.

Tai, Y. M. (2017). Role of management capability and web-enables direct procurement in creating competitive direct procurement advantage. International Journal of Logistics Systems and Management, 26(1). https://doi.org/10.1504/IJLSM.2017.080634
Using a sample of 101 manufacturing companies in Taiwan, this document presents management competencies and web-enabled procurement process that can enhance an agency's ability to generate competitive procurement opportunities. The results show there are a number of elements that contribute to procurement advantages including process management and coordination efforts.

Taylor, M., & Susilawati. (2012). Remoteness and accessibility in the vulnerability analysis of regional road networks. Transportation Research Part A: Policy and Practice, 46(5), 761–771. https://doi.org/10.1016/j.tra.2012.02.008
This paper considers the development of a method for network vulnerability analysis which considers the socio-economic impacts of network degradation and seeks to determine the most critical locations in the network. The method compares the levels of remoteness (or its inverse, accessibility) of localities within the study region, on the basis of the impacts of degradation of the road network on a recognized accessibility/remoteness index that can be applied to each and every location within the region. It thus extends the earlier work on accessibility-based vulnerability analysis which was limited to assessment of impacts on selected nodes in a network. The new method allows study of impacts on both specified locations (which do not have to be represented as network nodes) and the region as a whole. The accessibility/remoteness index is defined so that an accessibility surface can be calculated for the region, and the volume under this surface provides an overall measure of accessibility. Changes in the volume under different network states thus reflect the overall impacts. The method is applied to a rural region in south east Australia.

Transportation Systems Resilience Section. (2017). Transportation Systems Resilience: Preparation, Recovery, and Adaptation (Circular No. E-C226). Washington, D.C.: Transportation Research Board. Retrieved from http://onlinepubs.trb.org/onlinepubs/circulars/ec226.pdf
TRB's E-Circular 226: Transportation System Resilience: Preparation, Recovery, and Adaptation explores research issues related to implementing transportation systems resilience, and explores themes of a whole system approach to resilience, weather and advances in forecasting, an integrated approach to cyber-physical security for transportation, a European perspective on research for resilient road infrastructure, training and recruiting qualified employees who can assist during adverse events, and improving the resilience of transit systems threatened by natural disasters.

Trauner Consulting Services. (2007). CONSTRUCTION PROJECT DELIVERY SYSTEMS AND PROCUREMENT PRACTICES: Considerations, alternatives, advantages and disadvantages. Retrieved from http://www.fefpa.org/pdf/summer2007/Pros-Cons-handout.pdf
This report reviews types of project delivery systems and procurement practices.

United Nations General Assembly. (2016). Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction (Seventy-First Session, pp. 1–47). https://www.preventionweb.net/files/50683_oiewgreportenglish.pdf

This report presents recommended indicators to monitor the global targets of the Sendai Framework, the follow-up to and operationalization of the indicators and recommended terminology relating to disaster risk reduction. The open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction was established by the General Assembly in its resolution 69/284 for the development of a set of possible indicators to measure global progress in the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030, coherent with the work of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators, and the update of the publication entitled "2009 UNISDR Terminology on Disaster Risk Reduction".

U.S. Department of Homeland Security. (2015). Transportation Systems - Critical Infrastructure and Key Resources Sector-Specific Plan as input to the National Infrastructure Protection Plan (pp. 1–38). Washington, D.C.: U.S. Department of Homeland Security (DHS). Retrieved from https://www.dhs.gov/sites/default/files/publications/nipp-ssp-transportation-systems-2015-508.pdf
The Transportation Systems Sector - a sector that comprises all modes of transportation (Aviation, Maritime, Mass Transit, Highway, Freight Rail, and Pipeline) - is a vast, open, interdependent networked system that moves millions of passengers and millions of tons of goods. The transportation network is critical to the Nation's way of life and economic vitality. Ensuring its security is the mission charged to all sector partners, including government (Federal, State, regional, local, and tribal) and private industry stakeholders. Every day, the transportation network connects cities, manufacturers, and retailers, moving large volumes of goods and individuals through a complex network of approximately 4 million miles of roads and highways,

more than 100,000 miles of rail, 600,000 bridges, more than 300 tunnels and numerous sea ports, 2 million miles of pipeline, 500,000 train stations, and 500 public-use airports. The sector's security risks are evident by attacks either using or against the global transportation network, including not only the September 11, 2001, attacks on the World Trade Center and the Pentagon, but also more recent attacks on transportation targets such as the 2005 London bombings, the coordinated attack on four commuter trains in Madrid in 2004, and the 2006 plot uncovered in the United Kingdom targeting airlines bound for the United States. These recent attacks are a sobering reminder that the transportation system remains an attractive target for terrorists post-September 11. Hurricane Katrina and other disasters (natural and industrial) also highlight the risk to the sector that is not directly related to terrorism. Taken together, the risk from terrorism and other hazards demands a coordinated approach involving all sector stakeholders.

U.S. Government Accountability Office. (2006). Hurricane Katrina: Better Plans and Exercises Needed to Guide the Military's Response to Catastrophic Natural Disasters (Report to the Congressional Committee No. GAO-06-643; pp. 1–72). Retrieved from https://www.gao.gov/new.items/d06643.pdf

Hurricane Katrina was one of the largest natural disasters in U.S. history. Despite a large deployment of resources at all levels, many have regarded the federal response as inadequate. GAO has a body of ongoing work that covers the federal government's preparedness and response to hurricanes Katrina and Rita. Due to widespread congressional interest, this review was performed under the Comptroller General's authority. It examined (1) the extent to which pre-Katrina plans and training exercises reflected the military assistance that might be required during a catastrophic, domestic, natural disaster, (2) the military support provided in response to Katrina and factors that affected that response, and (3) the actions the military is taking to address lessons learned from Katrina and to prepare for the next catastrophe.

U.S. House of Representatives. (2006). A Failure of Initiative: Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina (Final Report No. 000–000) (pp. 0–520). Washington, D.C.: U.S. House of Representatives. Retrieved from https://www.npr.org/documents/2006/feb/katrina/house_report/katrina_report_full.pdf
This report, authored by a bi-partisan committee of the U.S. Congress, outlines the lessons learned from Hurricane Katrina. It analyzes the effectiveness of collaboration between all levels of government, and identifies areas where failures occurred that impacted the effectiveness of the overall response efforts. This study list extensive learnings that can be used to improve future response efforts to natural disasters.

Utah Technology Transfer Center. (2010). Innovative Contracting Techniques. PowerPoint. Retrieved from http://www.ic.usu.edu/UtahLTAP_Innovative-Contracting-overview.ppt
PowerPoint reviewing innovative contracting techniques centered on partnering with industry to create a better roadway. This reviews Design-Build, Lane Rental, A+B Bidding, Warranty, and Job Order Contracting.

Vu M.P.H., L., VanLangingham Ph.D., M. J., Do Dr. P.H., M., & Bankston III. Ph.D., C. L. (2009). Evacuation and Return of Vietnamese New Orleanians Affected by Hurricane Katrina. Organ Environ, 22(4), 422–436. https://doi.org/10.1177/1086026609347187

Vugrin, E. D., Turnquist, M. A., & Brown, N. J. K. (2014). Optimal Recovery Sequencing For Enhanced Resilience. International Journal of Critical Infrastructure, 10(3/4), 218–246.
This paper provides an approach for the role of recovery decisions in network resilience. It uses a project-oriented perspective to recover from the effects of a network disruption. One problem involves solving network flows, while the second problem identifies the optimal recovery modes and sequences, using tools from the literature on multi-mode project scheduling problems. Application and advantages of this method are demonstrated through two examples.

Walker, B., & Salt, D. (2006). Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press. https://islandpress.org/books/resilience-thinking

In Resilience Thinking, scientist Brian Walker and science writer David Salt present an accessible introduction to the emerging paradigm of resilience. The book arose out of appeals from colleagues in science and industry for a plainly written account of what resilience is all about and how a resilience approach differs from current practices. Rather than complicated theory, the book offers a conceptual overview along with five case studies of resilience thinking in the real world. It is an engaging and important work for anyone interested in managing risk in a complex world.

Wilkinson, K. J. (2007). More effective federal procurement response to disasters: maximizing the extraordinary flexibilities of IDIQ contracting. Air Force Law Review, 231+.
This paper reviews the benefits of IDIQ contracting and assets that the multiple-award IDIQ contract is the most valuable procurement tool for disaster and crisis response operations by federal agencies and that IDIQ contracts are ideally suited to meet the majority of contracting needs before, during, and after disasters or emergencies.

Woods, W. T. (2006). Hurricane Katrina: Improving Federal Contracting Practices in Disaster Recovery Operations (Testimony Before the Committee on Government Reform, House of Representatives No. GAO-06-714T). United States Government Accountability Office. Retrieved from https://www.gao.gov/assets/120/113786.pdf
The devastation experienced throughout the Gulf Coast region in the wake of Hurricanes Katrina and Rita has called into question the government's ability to effectively respond to such disasters. The government needs to understand what went right and what went wrong, and to apply these lessons to strengthen its disaster response and recovery operations. The federal government relies on partnerships across the public and private sectors to achieve critical results in preparing for and responding to natural disasters, with an increasing reliance on contractors to carry out specific aspects of its missions. This testimony discusses how three agencies--the General Services Administration, the Federal Emergency Management Agency (FEMA), and the U.S. Army Corps of Engineers (the Corps)--conducted oversight of 13 key contracts awarded to 12 contractors for hurricane response, as well as public and private sector practices GAO identified

that provide examples of how the federal government could better manage its disaster-related procurements.

Yongze, Y., Liu, H., Xiaozheng, H., Min, O., Srinivas, P., & Xueguang, C. (2017). Pre-disaster investment decisions for strengthening the Chinese railway system under earthquakes. Transportation Research Part E: Logistics and Transportation Review, 105, 39–59.
This study proposes a framework to determine the investment plan to strengthen a railway system which is subject to earthquake hazard. The proposed framework includes four parts: (1) Construct a two-layer (physical layer and service layer) railway network representation; (2) Generate earthquake scenarios based on historical earthquake data; (3) Formulate an investment optimization model to minimize the expected railway system service loss subjected to an investment budget constraint, where the service loss is quantified based on the affected train flow; (4) Solve the optimization model by using Genetic Algorithm. Taking the Chinese railway system (CRS) as an example, the proposed framework has been applied and the results show that the solution of the proposed framework is more responsive to the earthquake impact on railway system compared to topology-based methods. Note that the proposed framework can also be extended to identify pre-disaster investment plans for other transportation systems under natural disasters.

Zhou, Yawen, Jing Liu, Yutong Zhang, and Xiaohui Gan. “A Multi-Objective Evolutionary Algorithm for Multi-Period Dynamic Emergency Resource Scheduling Problems.” Transportation Research Part E: Logistics and Transportation Review 99 (March 2017): 77–95.

The resource distribution in post-disaster is an important part of emergency resource scheduling. In this paper, we first design a multi-objective optimization model for multi-period dynamic emergency resource scheduling (ERS) problems. Then, using the framework of multi-objective evolutionary algorithm based on decomposition (MOEA/D), an MOEA is proposed to solve this model. In the proposed algorithm, new evolutionary operators are designed with the intrinsic properties of multi-period dynamic ERS problems in mind. The experimental results show that the proposed algorithm can get a set of better candidate solutions than the non-dominated sorting genetic algorithm II (NSGA-II).

Appendix B:
Case Studies

B.1 Case Study 1: Long Beach Seismic and Tsunami Scenario and Functional Exercise Pilot

Participating Agencies:	60 WASHTO 2017 conference attendees from State DOTs and FDOT, FHWA, MPOs, and industry
Scenario:	Participants engaged in simulations responding to two potential concurrent disasters in Long Beach, California: a magnitude 6.6 earthquake at Northridge, and a maximum 42-foot run-up tsunami. Participants received HAZUS global risk reports outlining building and lifeline inventory and direct and induced damage, social impact, and economic loss. They then simulated the process of formally declaring a disaster, estimating disaster damage, identifying priority recovery activities, and initiating emergency procurement requests. To assist with the simulation, participants received the various materials to help them understand the scale and scope of the disaster and focus their decision-making activities. See Figure B-1 and Figure B-2 for visual images of the HAZUS scenarios.
Exercise Location:	Western Association of State Highway and Transportation Officials (WASHTO) conference, Juneau, Alaska
Exercise Focus:	June 2017
Exercise Location:	Pilot exercise; catastrophic response
Participant Engagement:	Participants discussed the following questions: • How can we promote cooperation between federal state and local governments in times of crisis? • What procurement and contracting methods do you think are best for rapidly restoring severely damaged highways and structures? • What design and construction methods do you think are best for rapidly restoring severely damaged highways and structures? • Sometimes air, rail and/or port facilities have damages along with roadways, how do we best gain access to the critically damaged corridors to bring in the people, equipment and materials needed to restore essential traffic? • How do we shorten or otherwise deal with long lead times on materials, component fabrication or other urgently-needed supplies? • What other problems and solutions can you see related to restoring multiple, critically damaged transportation corridors in a region?

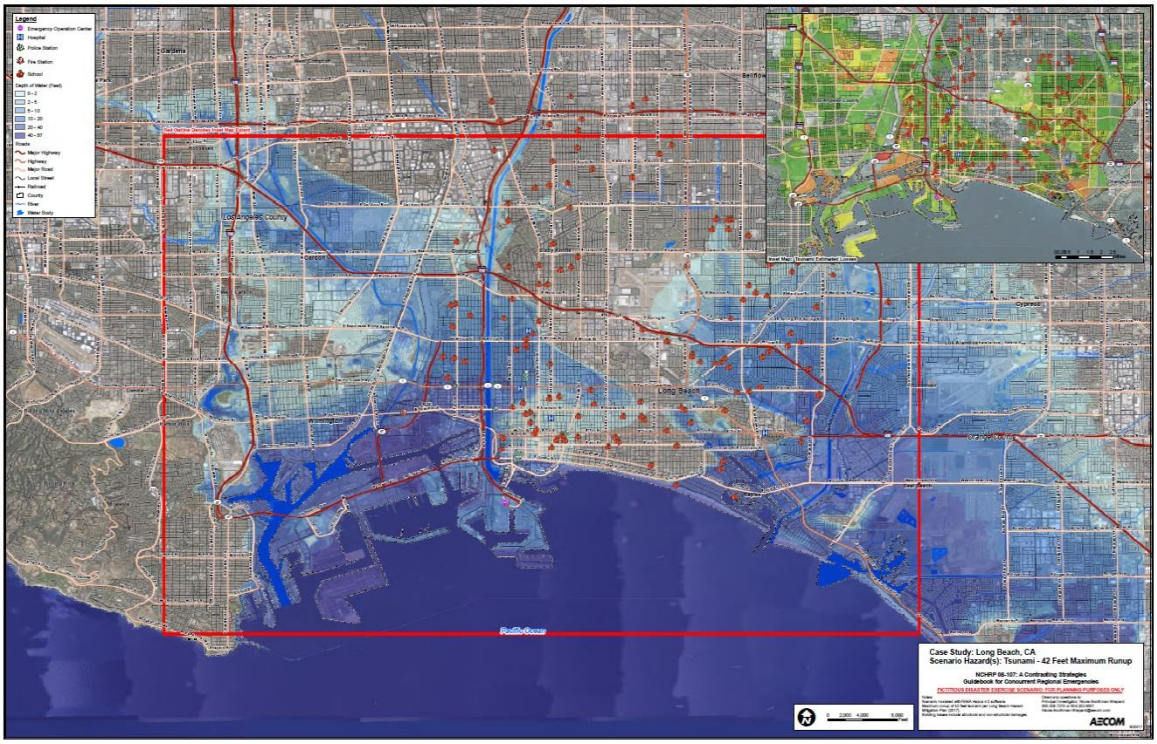

Figure B-1: HAZUS Scenario – Tsunami

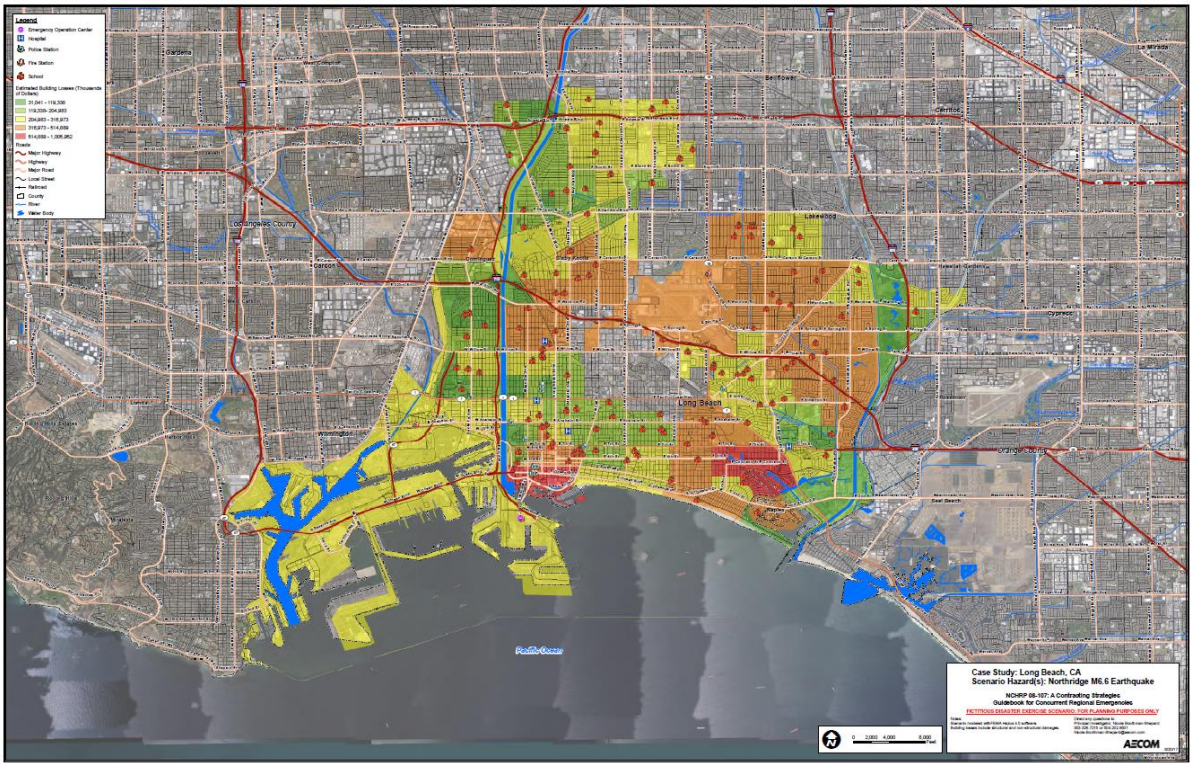

Image Credits: FEMA HAZUS Software

Figure B-2: HAZUS Scenario - Earthquake

B.2 Case Study 2: Colorado DOT 2013 Flood Best Practices

Participant Acknowledgements: FHWA: Randy Jensen (Ret. FHWA); Mike Lewis, former Deputy and Executive Director Josh Laipply, former Chief Engineer; Maria Sobota, former Chief Financial Officer; CDOT OEM: Chad Ray and Kerry Kimble; Engineering: Roselle Drahushak-Crow; Finance and Administration: Michael Krochalis, Colette DeSonier, Sam Pappas, Eric Ehrbar; Controller: Lilia Gershman; Procurement and Contracting: Scott Young (ret. CDOT), Pat O'Neil, Kyle Dilbert (formerly with CDOT); Flood Recovery Advisors and Region 4: Johnny Olson, (ret. CDOT), and Heather Paddock; Region 1: Paul Jesaitis and Richard Zamora; Region 3: David Eller and Rocky Baker; Risk Management: Julie Mileham; Maintenance: Kyle Lester (Ret. CDOT), Jessie Morehouse, BJ McElroy, Al Martinez (ret. CDOT); Traffic: Charles Meyer; Planning: Jeffery Sudmeier and Lisa Streisfeld

Participating Agencies:	Colorado DOT (CDOT) Executive Leadership Team, CDOT 2013 Flood Incident Commander and Section Chiefs, CDOT Emergency Operations Working Group, and FHWA, FEMA, and multiple local agencies
Scenario:	This case study is based on an actual disaster event. In September 2013, Colorado experienced its worst recorded flood event in modern history. Flood impacts significantly exceeded $1 billion in total damages with impacts to Federal-aid roads of approximately $595 million. Damages were widespread across Northern Colorado. The disaster impact area was unprecedented, spanning almost 200 miles (North-South) by approximately 50 miles (East-West), affecting over 400 miles of roadways and adjacent areas and impacting over 120 bridges and structures. A Major (Presidential) Disaster Declaration was issued on September 14, 2013 (DR-4145) for severe storms, flooding, landslides, and mudslides covering 24 counties. The Governor directed the Colorado Department of Transportation (CDOT) to make all roadways passable by December 1, 2013 to allow residents to return to their homes and businesses. This goal was accomplished by Thanksgiving of 2013 through an intensive Emergency Repair (ER) effort that operated 24/7 in heavy rains, cold weather and complex conditions. See Figure B-3 for a visual image of the flooding scenario.
Exercise Location:	Various cities, Colorado
Exercise Focus:	March 8, 2017 to June 25, 2018
Exercise Location:	Analysis of CDOT's 5-year maturity in resilience since 2013 flooding of the North Front Range to present day. The summary of CDOT's contributions are substantially reflected throughout the Guidebook and Appendix G and thus not expounded upon here.
Participant Engagement:	See Acknowledgements

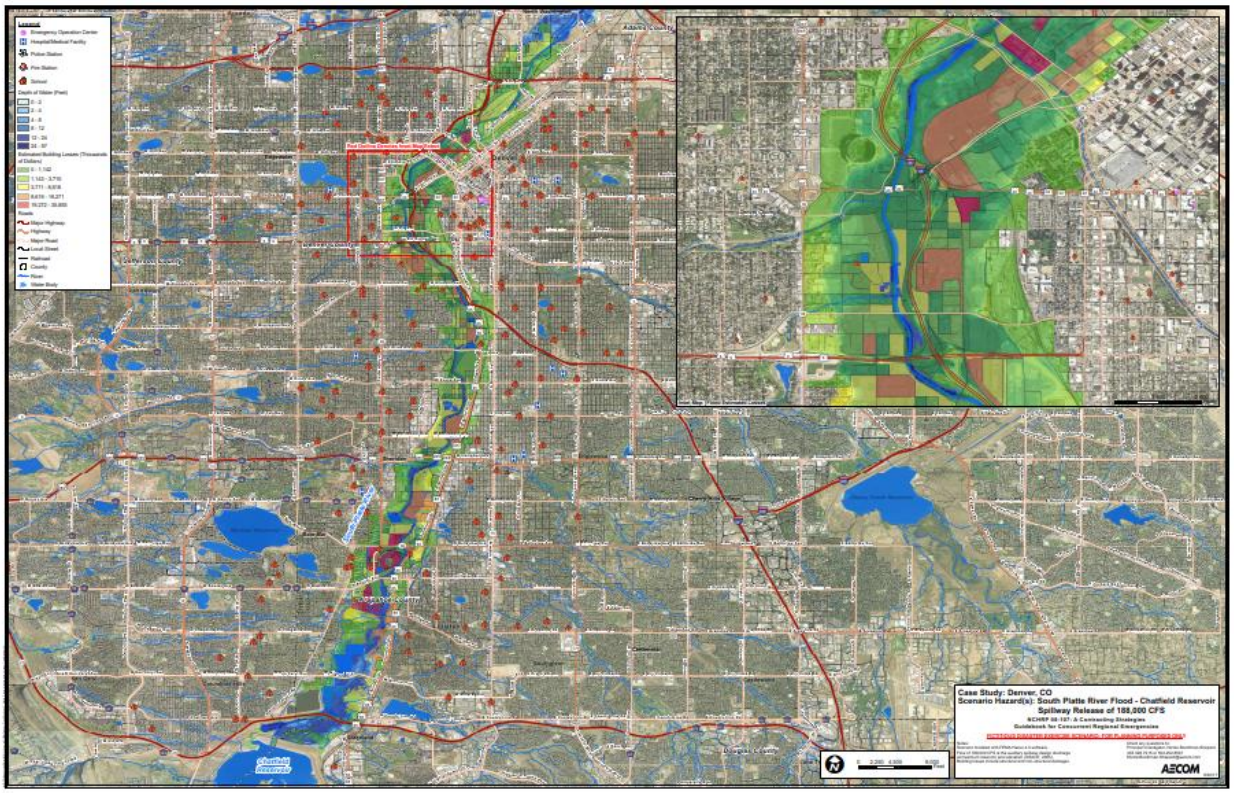

Image Credits: FEMA HAZUS Software

Figure B-3: Denver HAZUS Scenario - Flood Hazard and Losses Combined

B.3 Case Study 3: Washington State DOT Cascadia Subduction Zone After Action Analysis

Participant Acknowledgements: Washington State Department of Transportation: John Himmel; Brittany Miller; Brian Lagerberg; Jeff Pelton; Doug Vaughn; Kathleen Davis; Kevin Dayton; Elizabeth Kosa; Denys Tak; Andrea Heryford; Robin Mayhew; Keith Metcalf; Roger Millar; Dylan Counts; Jay Alexander; Chris Christopher; John Himmel; Jennifer Dahl; Dave Erickson; Lars Erickson; Pasco Baktich; Kara Larsen; David Fleckenstein; Catherine Pearce; Jeff Carpenter; Ed Barry; Joseph Hedges; Terry Meara; May Scarton; Kim Henry; Megan White; Mike North; Kerri Woehler; Craig Stone; Julie Meredith; Ron Pate; Allison Camden; Tom Baker; Ron Judd; Patty Rubstello; Barb Chamberlin; Anthoney Buckley; John Milton; Elise Greef; FHWA: Susan Wimberly

Participating Agencies:	Washington State DOT (WSDOT) executive and region leadership
Scenario:	As part of a National Level Exercise (NLE) scenario of the Cascadia Subduction Zone, participants engaged in simulations responding to two potential concurrent disasters in Seattle, Washington: a magnitude 7.2 earthquake, and a maximum 6-meter run-up tsunami. Leaders within the Department discussed critical issues shaping WSDOT strategies in two key areas: response/recovery prioritization and procurement. Based on previous after-action reviews of disasters and CSZ exercises, these areas need strengthening. See Figure B-4 and Figure B-5 for visual images of the HAZUS earthquake and tsunami scenarios.
Exercise Location:	Olympia, Washington
Exercise Date:	November 6, 2017
Exercise Focus:	Procurement and contracting strategies
Participant Engagement:	Participants addressed the following questions related to **prioritization**: • How do we prioritize asset recovery/regional? • How do we optimize inter- and intra-agency prioritizations? • Will we use the current incident structure, or create a new one with the Governor's office and counties/cities? What would that look like? • Participants discussed: Maintenance only, Construction only, Design-bid–build (DBB), Innovative contracting (e.g. design-build), Incentives (e.g. bonus for ahead-of-schedule delivery), and P3 Contractor financed, designed & delivered. Examples of special considerations include: Bulk ordering of materials for multiple jobs and Reuse of on-site materials on job. Participants addressed the following questions related to **critical assets**: • Which assets drive economic vitality? • Which corridor segments/systems have highest ADT and impact to WSDOT customers? • How do we plan for rapid restoration of ferry services? • Movement of transit-dependent riders? • Current asset performance standards – Integrated into Cap/Ex plan & asset management? • Local agency control of critical adjacencies? • Participants discussed: Force account, Unit price/low bid & economic price adjustments, Lump Sum, Innovative contracting, and Best value awards.

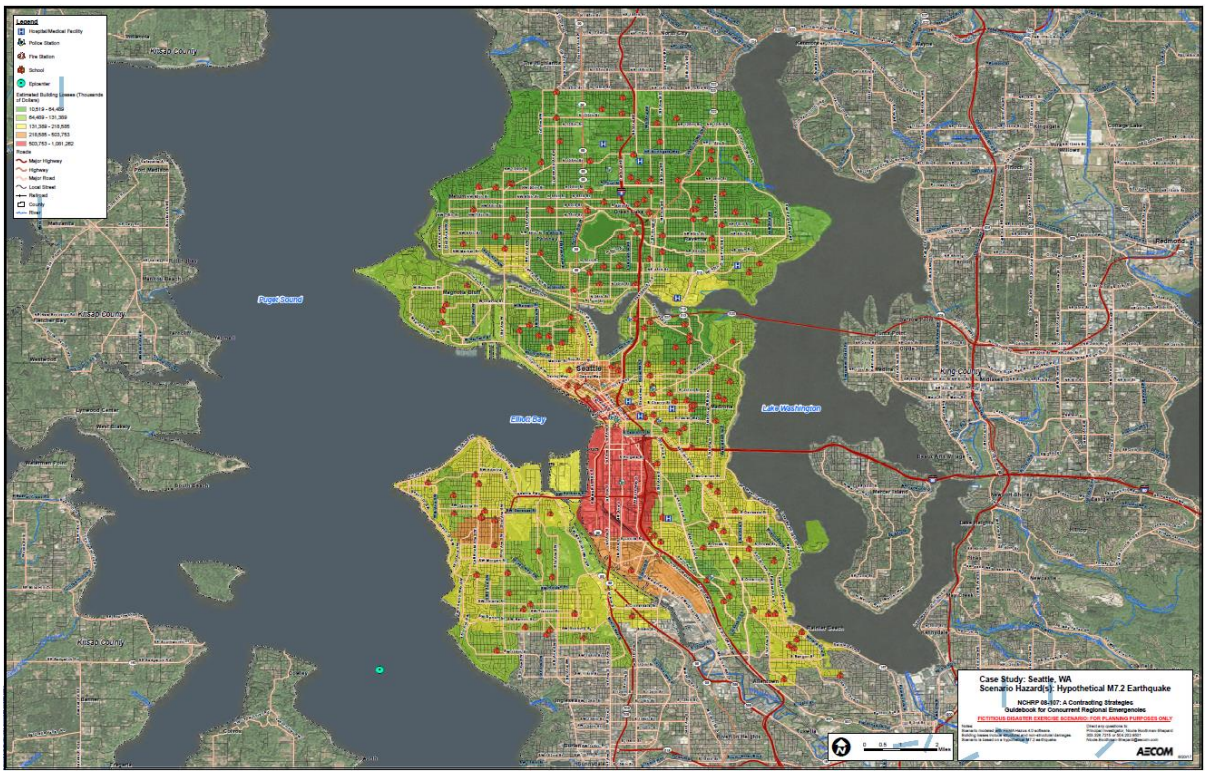

Figure B-4: Seattle HAZUS Scenario - Earthquake

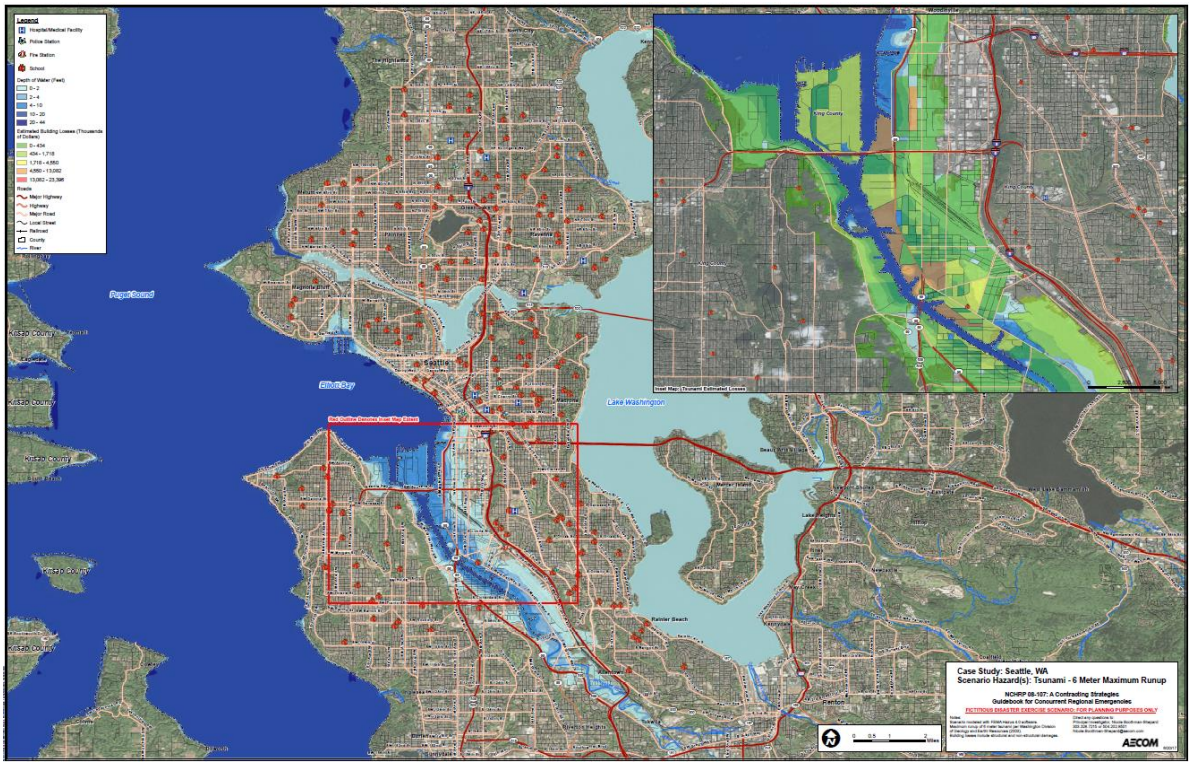

Image Credits: FEMA HAZUS Software

Figure B-5: Seattle HAZUS Scenario – Tsunami

Case Study PowerPoint

CATASTROPHE PRIORITIZATION

In support of WSDOT emergency management and NCHRP 08-107

WELCOME

- Introductions
- Agenda
  - Prioritization
  - Procurement
- Session Goals

2

BACKGROUND & ASSUMPTIONS

Background

- Context for Discussion
  - Cascadia SZ & Tsunami Scenarios
  - Damaged Assets Inventory & RRAP (in development)

Assumptions

- State & Presidential Disasters Declared
- Fiscal Rules for emergencies in force
- Primary recovery funding
  - FHWA Emergency Relief
  - FEMA Public Assistance for Debris Removal (Category A)

3

SCENARIO IMPACT SUMMARY

4

NCHRP 08-107

- Applied Research
- Purpose
- Where today's discussion fits
- Critical issue areas
- Locations
- Guidebook
- Publication timeline
- TRB Resilience Summit 10/18

5

PRIORITIZATION

Critical Questions

- How do we prioritize asset recovery/regional?
- How do we optimize inter- and intra-agency prioritizations?
- Will we use the current incident structure, or create a new one with the Governor's office and counties/cities? What would that look like?

6

PRIORITIZATION

Overarching Issues

- Critical assets recovery
- Mitigating cascading impacts
- Resource availability
- Mobilization of people, equipment, materials
- Cash flow – keeping work moving

7

CRITICAL ASSETS RECOVERY

- Which assets drive economic vitality?
- Which corridor segments/systems have highest ADT and impact to WSDOT customers?
- How do we plan for rapid restoration of ferry services?
- Movement of transit-dependent riders?
- Current asset performance standards – Integrated into Cap/Ex plan & asset management?
- Local agency control of critical adjacencies

8

CASCADING IMPACTS & CONSEQUENCE MANAGEMENT

- Lifeline systems: utilities (fuel, power), waste/potable water, fiber
- Supply lines to cut-off communities: landslides, bridge failures, liquefaction, etc.
- Protecting off-system assets with partners (police, hospitals, Guard)

9

WSDOT AVAILABLE CAPACITY

- Staff available to pivot to catastrophe and mobilization timelines
- WSDOT staff readiness for incident management, training and exercises, compensation
- Costs/impacts on other STIP'ed work if active projects paused (force majeure clause)
- Staff to manage significant number of complex projects safely and effectively
- Consultant resources and readiness

10

VENDOR BENCH STRENGTH & CAPACITY

- Adequacy of available/approved vendors in WSDOT systems
- Time to Contract: pre-qualification status
- Capabilities: project scale & complexity
- Bench-strength
  - Personnel
  - Equipment ownership, control, location
  - Materials: pits, Buy America certified steel
- Portfolio-based selection concept

11

CASH FLOW $MB

- Process and authority: Transportation Commission, OMB, legal, capital development, Congressional appropriation
  - FHWA
  - FEMA Category A Debris Removal
- FHWA quick release only $2M
- Reimbursement basis FHWA & FEMA funds
- Other instruments:
  - state bonds
  - Caution on catastrophe bonds
- Local agency cash flow challenges

12

PROCUREMENT

- WSDOT emergency procurement constraints
  - WSDOT current pre-qualified vendors
  - Standby emergency contracts
  - Professional Services
  - Construction

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Contracting & Project Delivery

Contracting

- Force account
- Unit price/low bid & economic price adjustments
- Lump Sum
- Innovative contracting
- Best value awards

Project Delivery Methods

- Maintenance only
- Construction only
- Design-bid–build (DBB)
- Innovative contracting (e.g. design-build)
- Incentives (e.g. bonus for ahead-of-schedule delivery)
- P3 Contractor financed, designed & delivered
- Special considerations:
  - Bulk ordering of materials for multiple jobs
  - Reuse of on-site materials on job

14

NEXT STEPS

- After-Action Summary by 11.22.17
- Determination on mission-critical issues to tackle
- Optional review of NCHRP 08-107 content including WSDOT case study examples and take-aways/recommendations by WSDOT

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THANK YOU

CO-FACILITATOR CONTACT

Nicole Boothman-Shepard
Principal Investigator, NCHRP 08-107

Resilience Strategist & Senior Policy Advisor
AECOM
6200 S. Quebec Street
Greenwood Village, CO 80111
303.328.7215 (mobile 1)
504.202.8501 (mobile 2)

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B.4 Case Study 4: U.S. Virgin Islands 2017 Hurricanes Irma and Maria Response Review

Participant Acknowledgements: U.S. Virgin Islands Department of Public Works, Piotr Gajewski, P.E.

Participating Agencies:	Virgin Islands Department of Public Works (DPW) includes VI Territory DOT staff
Scenario:	September 2017 landfalls of Category 5 Hurricanes Irma and Maria
Exercise Location:	St. Thomas, U.S. Virgin Islands
Exercise Date:	April 10, 2018
Exercise Focus:	Rapid response planning
Participant Engagement:	U.S. Virgin Islands Department of Public Works, Piotr Gajewski, P.E.

Image Credit: NOAA

Figure B-6: Hurricane Maria

Materials from Case Study

NCHRP 08-107 Case Study Briefing

Below please find excerpts of the case study component of our current research project for the National Cooperative Highway Research Program (NCHRP) which is the surface transportation arm of the Transportation Research Board (TRB) sponsored by the National Academy of Sciences.

The case study visioning session will extract information on current and promising practices that will build the body of knowledge for this applied research's primary deliverable, the Guidebook. The following fields of data are the key to project success:

NCHRP 08-107 CRITICAL ISSUE AREAS

1	Prioritization of DOT Plans by State, Local and Federal Agencies in Advance of Major Disruptions
2	Assurance Requirements that Emergency Contracting Methods Align to Complaint Field Documentation
3	Utilization of Accelerated Construction Techniques in Concurrent, Regional Emergencies
4	Flexible Emergency Contracting Procedures if Multiple Infrastructure Assets/Routes are Compromised and/or Affect a Broad Geographic Region
5	Optimum Procurement involving Multiple/Coordinated Stakeholders
6	Optimum Procurement for Multiple-Corridor Prioritization Related to Materials, Contractors, Route Availability, Fabricator Prioritization, and Rights of Way (ROW)
7	Alternative Contracting Methods for On-Call Design and Construction Services (e.g. IDIQs)
8	Locally-Specific Challenges & Opportunities

Task 3: Develop Case Studies

Case studies provide the research team with the opportunities to explore qualitative feedback from innovative and experienced practitioners in concurrent regional emergencies.

While we recommend substantial DOT participation in case studies, we also recommend that a number of case studies involve multi-agency engagement (1) to facilitate transfer of knowledge between agencies, (2) support inter- and intra-state relationship development, and (3) in recognition of the fact that disasters - whether in a unified Incident Command System (ICS) structure or as a result of overlap or shared oversight on elements of a disaster response or recovery program (e.g. environmental, archaeological and other clearances, administration of match funds) - require partnerships for effective practice. As is often said, disasters do not recognize geographic or political boundaries.

Concerning Prioritization

The project will contemplate the most effective strategies to get assets back on-line and permanently restored in alignment with project/corridor prioritization objectives despite complex and dynamic post-disaster conditions.

This will include consideration of the following:

- DOT leadership in regional emergencies;
- A focus on key characteristics of successful multi-agency partnerships involving both the public and private sectors in regional emergencies;
- Effective practice in project oversight in regional emergencies;
- Optimal utilization of maintenance forces;
- Procurement, contracting and utilization of professional engineering and other consulting services;
- Procurement, contracting and mobilization of contractors and oversight of construction, and

- Securing adequate resources needed for getting transportation systems back on-line including labor forces, materials transport and supply, and equipment.

Case Study Outcome

The case study involved one focused 3-hour discussion concerning procurement, contracting, and project delivery of mission-critical emergency repairs to stabilize roadways and maintain essential traffic as well as FHWA ER and FEMA PA requirements. Discussions centered around overall roadway damages across all islands and discussed the challenges of inadequate staffing to support response and recovery efforts. Of primary concern were roadway failures due to slips, slides, rockfall (St. Thomas) and roadway erosion adjacent to and under roadway bed where roadways are at grade. The challenges concerning roadway failures are complicated by the limited number of redundant public roadways in the system.

While emergency repairs were of immediate concern, resilient recovery plans were focused not only on the importance of meeting or exceeding stringent codes and standards adopted by the Territory, but also incorporating complete streets into permanent repairs. The U.S. Virgin Islands has among the highest per Capita rates of pedestrian injury and death from accidents with moving vehicles and also experiences high rates of accidents between bicyclists and vehicles. Contributing factors, in addition to inadequate availability of sidewalks and curbing outside of urban centers, include street geometry that does not conform with FHWA standards due to narrow and steep grades that join communities on St. Thomas, St. John, and to a lesser extent St., Croix.

Case study discussions were pragmatic, focused on current widespread disaster damage and associated challenges and opportunities for resilient recovery with triple bottom-line benefits (complete streets), and solutions-centric.

B.5 Case Study 5: Central U.S. Earthquake Consortium: New Madrid Functional and Visioning Exercise

Participant Acknowledgements: Central U.S. Earthquake Consortium, Brian Blake; Rik Endrulat; Ron Williams; J.D. Brooks; Shane Hall; Jeff McSpaden; Mike Callahan; Michael Kelly; Chris Engelbrecht; Herb Hendrickson Jr.; Brooke Pearson; Heath Patterson; Jim Wilkinson

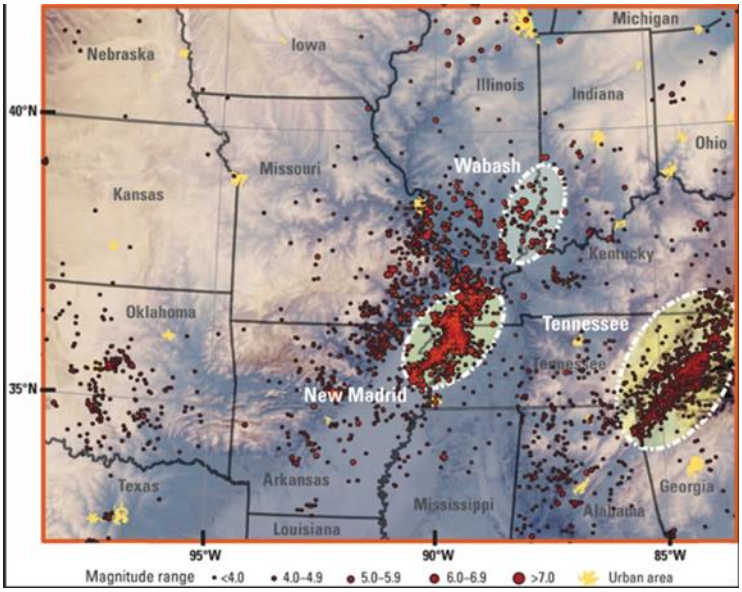


Image Credit: (United States Geological Survey, 2011)

Figure B-7: New Madrid Seismic Zone

Participating Agencies:	Central US Earthquake Consortium Transportation Committee (8 DOTs present), and USDOT, FHWA, USACE
Scenario:	HAZUS Earthquake multi-event catastrophe scenarios for New Madrid Seismic Zone (NMSZ)
Exercise Location:	New Madrid Seismic Zone 8-State Consortium, Missouri
Exercise Date:	April 24, 2018
Exercise Focus:	Contracting, supply chain, and mega-project delivery. Considered rapid response in context of continuous ground shaking
Participant Engagement:	The objective of the activity was to enable participants think through the key issues that could potentially arise during the recovery process following concurrent catastrophic events, specifically, those affecting multiple corridors across multiple jurisdictions. The exercised involved every participant being given a role and description based on a typical command post organization chart. Using the results of the HAZUS analysis on two seismic events, participants discussed various critical issue areas in catastrophic recovery of regional transportation assets. The participants found that in the absence of a unified regional plan, individual agency and state plans need to address shared regional priorities, inter and intra agency coordination, and unified command in regional events and that the executive management of stakeholder agencies and organizations need to be engaged in order to build the right political capital, which is vital to affect any lasting impact.

Case Study Notes

The New Madrid Case study was conducted during a meeting of the Central United States Earthquake Consortium (CUSEC) Transportation Taskforce organized in Southaven, MS. The consortium has eight-member states, which include Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee. there are also 10 associate states which support the organization.

The transportation taskforce meeting consisted of transportation representatives from some CUSEC member states. Representatives from the USDOT as well as other CUSEC staff were also present. Table B-1 provides a list of the case study participants.

Table B-1: New Madrid Seismic Zone Case Study Participants

Name	Organization	Role
Brian Blake	CUSEC	Associate Director
Rik Endrulat		
Ron Williams	USDOT/FHWA	Regional Emergency Transportation Representative (RETREP), Region VIII
J.D. Brooks	Indiana DOT	State Highway Maintenance Director
Shane Hall	Mississippi DOT	
Jeff McSpaden	USDOT - Chicago	Regional Emergency Transportation Representative (RETREP), RETREP Region V
Mike Callahan	USDOT HQ	Associate Director for Response and Recovery
Michael Kelly	Arkansas DOT	System Information and Research
Chris Engelbrecht	Missouri DOT	Emergency Management Liaison
Herb Hendrickson Jr.	Division of Incident Management, Kentucky Transportation Cabinet	ESF-01 Coordinator
Brooke Pearson	CUSEC	GIS/Data Analyst
Heath Patterson	Mississippi DOT	State Maintenance Engineer
Jim Wilkinson	CUSEC	Executive Director

Overview

The afternoon began with a presentation of the project overview by Nicole Boothman-Shepard. This briefed the participants on the background, purpose and objectives of the research project. Ms. Boothman-Shepard then proceeded with an overview of the activity.

The objective of the activity was to enable participants think through the key issues that could potentially arise during the recovery process following concurrent catastrophic events, specifically, those affecting multiple corridors across multiple jurisdictions. The facilitators provided information that would create an environment that would, to the extent possible, mimic the conditions of an actual event to serve as a platform for discussion.

Each participant was given a role and description for the exercise based on a typical incident command post organization chart. Detailed descriptions for each role can be found in the Appendix. The following roles were assigned[13]:

- Incident Commander: supervises command and general staff
- Liaison Officer
- Safety Officer
- Public Information Officer (PIO)
- Planning Section Chief
- Operations Section Chief:
- Technical Specialists: environmental, structures and engineering
- Corridor Division Supervisor
- Logistics Section Chief
- Finance and Administration Section Chief
- Federal Highway Administration (FHWA)
- Federal Emergency Management Agency (FEMA)
- Army Corps of Engineers

Key Tasks and Resources

The following key tasks were outlined for the activity:

- Damage assessment
- Draft of emergency repair scope and permanent repair scope (with resiliency considerations)
- Establishment of project cost estimate

Activity participants were provided the following tools to accomplish the key tasks:

- Damage Assessment Report (DAR) Template
- DDIRs/POP
- Emergency repair project decision tool
- FHWA-focused compliance checklists
- Document control file structure template
- Business process flows

[13] Some participants played more than one role.

Parameters for Exercise

A HAZUS analysis was conducted to modeled to simulate two New Madrid seismic events: a 7.4 magnitude earthquake which occurred in December 1811, and a 7.2 magnitude aftershock in February 1812. The analyses modelled expected damages and economic losses for transportation, utilities and other lifeline infrastructure. The detailed outputs of the two scenarios as well as the simulation maps can be found in the Appendix.

However, a course correction was taken during the exercise to account for models used across each of the CUSEC member states. An earthquake with magnitude 7.2 was therefore assumed.

The other parameters that were considered for the model area were as follows:

- 61,118.24 square miles
- 1,026 census tracts with over 1.6 million households
- 4.148 million people (2010 Census Bureau data)
- 1.756 million buildings with a total replacement value exceeding $424 billion
- 92% of the buildings (76% of the value) are associated with residential

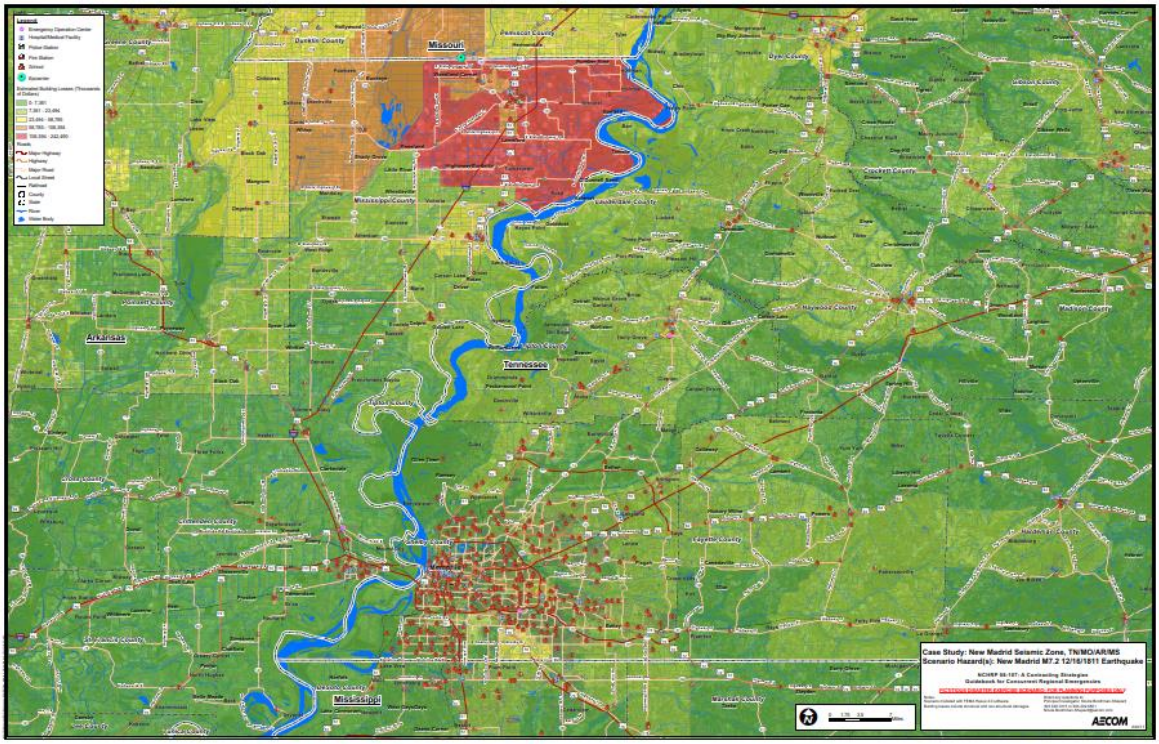


Figure B-8: New Madrid HAZUS Scenario – Earthquake

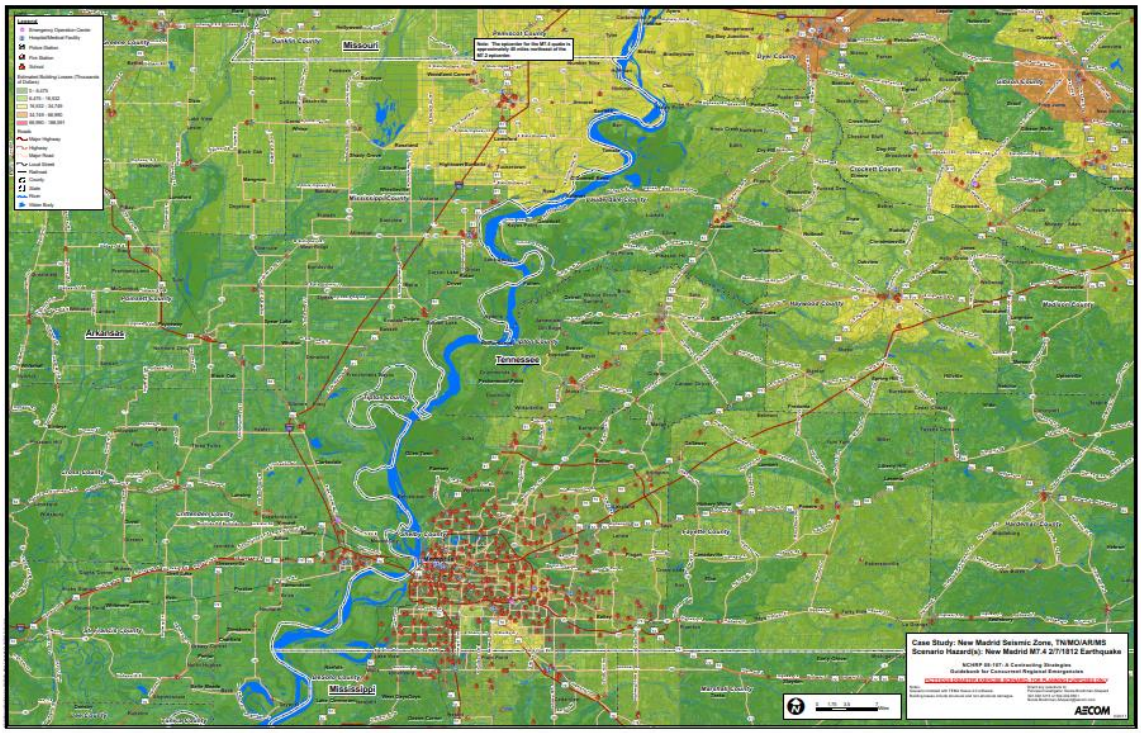


Figure B-9: New Madrid HAZUS Scenario – Earthquake (2)

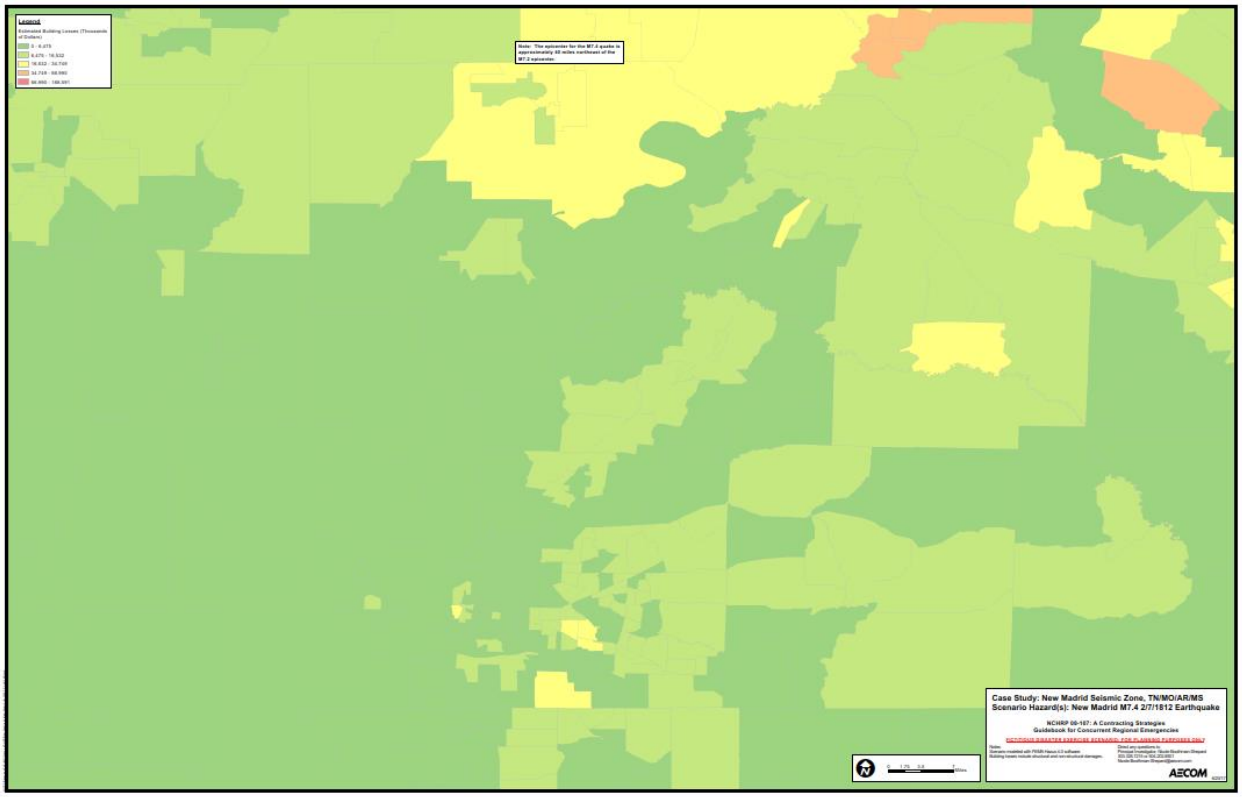


Image Credits: FEMA HAZUS Software

Figure B-10: New Madrid HAZUS Scenario – Earthquake (Mylar)

Exercise Summary and Discussion of Critical Issue Areas

Throughout the exercise, participants discussed various critical issue areas in catastrophic recovery of regional transportation assets. The issue areas are discussed below.

Command Plans

Unified Command

This issue area focuses on the establishment of a unified command. It includes: determining the chain of command between the various organizations (which own different assets) present onsite during such catastrophic events; identifying which emergency support functions (ESF) to leverage; and determining which individuals in the unified commands make key decisions.

It is also important to determine whether the scale of the event requires the federal government to take over the unified command. Command plans determine the capacity of the asset owners to handle repairs or the tipping point at which command is handed over to a higher jurisdiction. For example, the eastern federal lands operated by FHWA (cooperative program) could play a role in performing repairs for local areas or jurisdictions that don't have the capacity to do so. Individuals with the decision-making authority need to be clearly identified in such cases to ensure that local areas reach out to the appropriate federal partners for help.

Plan Harmonization

Since the New Madrid Seismic Zone is multi-jurisdictional, recovery plan harmonization was raised as an issue of interest. Following the discussion, participants decided that the best approach would be for each agency (DOT and federal) to have separate plans; however, one strategy suggested for plan integration was the creation of shared priorities. Specifically, each agency recovery plan would have an appendix that clearly articulates the region's shared priorities for its assets and resources.

Finally, participants identified owners of private critical infrastructure as key stakeholders in recovery planning. The lack of such representation in most agency recovery planning was seen as a gap that needed to be addressed.

Prioritization & Capacity

The team then proceeded to identify critical transportation corridors that were essential for recovery. Consideration was given to the following issues:

Highway and Bridge Selection

Corridor selection was an important issue. Although the participants agreed on the final corridors to be selected, they discussed the discrepancies with their own state emergency plans and priority corridors. Consensus on *regional priorities* over *state priorities* was highlighted as most critical for multi-jurisdictional events. Consequently. Two corridors were selected for consideration based on connectivity and freight movement.

The team also recognized the role of congress in the final corridor selection.

River Accessibility and Safety

The Mississippi and Ohio Rivers were identified as possible means of transporting recovery equipment and essentials. The use of barges for freight movement was also seen as essential for the local economies, particularly in the event that large portions of the region would be inaccessible by road.

Safety issues along both rivers were identified to include possible liquefaction near levies, locks and dams. Reliability of the levies, locks and dams were also discussed.

Electric Power

Three power plants along the Mississippi river were identified as having high priority for reinstatement. The three plants could supply needed power to portions of the affected region and would help with recovery options.

The influence of MISO (a non-profit member-based organization) groups on power generation and distribution was also identified as potential real-life issue.

Economic Recovery

Economic recovery was for the region was a priority consideration, with a special focus on small businesses and freight movement. Key corridors that affect the regional economy were therefore discussed and considered in the highway selection. Strategies to prevent the local population from permanently migrating to other regions or states were discussed. One such strategy was the involvement of the local labor force in recovery efforts, especially low wage workers.

Another area discussed under economic recovery was current disconnect between recovery planning and the private sector. Participants identified a need to work with employers to evaluate business recovery strategies that would support overall regional recovery.

Social Impact

Another area that arose in discussing prioritization and capacity was social impact. Particularly, the use of social science data by infrastructure owners to support recovery planning and decision making. The main issue identified concerned testing long-held beliefs and assumptions about how communities respond to catastrophic events. The participants noted that it was important to use credible social science data to guide recovery planning.

Furthermore, good sociological data on vulnerable populations within communities in the region could be used to incorporate equity considerations into recovery planning.

Environmental Impact

Finally, the group touched on possible environmental issues that could arise as a result of a seismic event. Risk of chemical spills, including hazmat materials, were considered. Impact to chemical plants in the region and the cascading impacts to the region were also briefly discussed.

Flexible Contracting

This critical issue area involved a discussion of flexible contracting procedures to be implemented in the event that multiple infrastructure assets or routes were compromised. The following related items were discussed:

Contractor Availability

It was noted that the earthquake would put a strain on the number of contractors that would be ready, willing and able to support recovery efforts. For example, bordering states such as Arkansas and Mississippi, which share many of the same contractors would be an issue. Additionally, there would be multiple states and jurisdictions that would have to compete for scarce resources and materials

Bidding

The team also recognized that the local labor force would have a diminished capacity following such an event therefore contracts for permanent repairs would have to be open bids (with free and fair competition). For example, in cases where states share contractors (e.g., bordering states – Arkansas and Mississippi), the inability of contractors to mobilize equipment and labor would have compounding effects. *Cooperative bidding* between states for shared projects was encouraged.

For emergency repairs, the bidding method adopted would depend on whether state and local agencies waive free and open competition requirements following the event. Non-competitive methods that could be adopted in such situations include rapid/limited competition, stand-by contracts (IDIQs), and preferred vendors (prequalified contractors).

Use of GSA (General Services Administration) schedules following a presidential declaration was also discussed. These could be used for both permanent and emergency repairs.

Proxy Support for Local Agencies

Local agencies that own and operate critical infrastructure have the ability to request federal support (e.g., from FEMA Mission Assignment) to perform work that they are unable to perform themselves during emergencies.

Procurement

The issue of IDIQ for debris removal was raised in the discussion. Many participants reported experience with effectively using IDIQs. The use of penalty clauses in such contracts was also discussed as a possibility for contractor non-performance.

Innovative Delivery

The use of design build, CMGC, and P3s as delivery methods for recovery work was discussed. However, feedback from the agencies suggested that these were rarely used for their regular construction projects.

Drive Down Audit Risks

Participants did not have much experience in this area. However, issues discussed for this category included prevailing wages and the eligibility of certain employee classes to receive federal funds. Particularly, employees on work visas and permanent residents.

Locally Relevant Issues

After Shocks

Participants discussed the reality of a seismic event in the New Madrid zone triggering aftershocks above 6.0 magnitude for a duration of six months. Participants were also aware that aftershock impacts across the region would be inconsistent. This combined with the knowledge that many residents would opt to shelter in place affects the entire regional approach to recovery planning. Subsequently, agencies would have to identify and prepare for the consequences of cascading impacts, particularly for recovery inaccessible areas (e.g., landlocked areas, structure failures on the river or port failures).

Social/Behavioral Issues

Participants discussed the accuracy of assumptions concerning social behavior typically made during recovery planning. For example, assumptions made during plan development for evacuation, housing, provision and others, need to be made from a social science perspective taking into consideration the sociological and equity impacts on different population groups. Thus, participants noted the need to the consider social implications of assumptions and decisions made during recovery planning.

Secondly, the use of crowd-sourced data was during emergencies and recovery was raised. Participants discussed the reliability of such data for assessing site conditions.

Practicality of Response Plans

One issue raised by the group was the practicality of response plans. Participants discussed whether there was a need for contingency plans. For example, if assumptions about earthquake impact and emergency route accessibility were to be proven false, contingency plans could prove effective.

Asset Inspection

Approaches for asset inspections were discussed. In general, people on the ground would first inspect primary routes with from all directions and then branch out onto the secondary routes.

Shelter-In-Place vs. Evacuation

Participants pointed out the general perception about mass evacuations during emergencies and discussed factors and situations that would prove otherwise. The first factor discussed was the island effect caused by catastrophic events, which usually break connectivity and isolate people, making it nearly impossible to evacuate after such events. The second was the culture of self-reliance among people that live in regions such as the New Madrid zone to take a protectionist approach to their property.

These two factors led participants to believe that mass evacuations (such as was experienced during Hurricane Katrina) in the region were unlikely to occur. Rather, movement would likely be limited to

localized movement (point-to-point) of vulnerable people (e.g., children or elderly to other family members) for safety, survival or additional comfort.

Competing Interests of Urban vs. Rural Areas

The CUSEC region consists of different types of communities which have competing interests. Participants noted the difficulty of weighing the impacts of decisions that affect communities of different population sizes. For example, recovery efforts focused on dense urban areas would affect the most people; however, equity concerns could be raised for rural communities which make up majority of the region.

Summary Observations and Recommendations

- Social science data can be used to support recovery planning
- In the absence of a unified regional plan, individual agency and state plans need to address the following:
  - Shared regional priorities
  - Inter and intra agency coordination
  - Unified command in regional events
- Task force members can have the expanded role of relaying shared regional priorities back to individual agencies.
  - Task force members may use a hub and spoke model within DOTs and other key stakeholder organizations for coordination. Task force members could serve as a single point of the contact within an agency for coordinating resilience and recovery planning across the different departments, e.g., traffic and incidence management, maintenance, debris removal, engineering, bridges and structures, finance, PIOs.
  - Task force members could also support a peer network of shared functional responsibilities across agencies to align plans, policies and procedures (to the extent possible).
- The executive management of stakeholder agencies and organizations need to be engaged in order to build the right political capital, which is vital to affect any lasting impact.

Sample ICS Position Template Distributed with NMHZ Exercise

SAMPLE POSITION TEMPLATE DISTRIBUTED WITH NMHZ EXERCISE

The following checklist should be considered as the minimum requirements for this position. Note that some of the tasks are one-time actions; others are ongoing or repetitive for the duration of the incident. Tasks may be delegated to the appropriate Unit Leader.

✓	Task
☐	1. Obtain briefing from Incident Commander: ▪ Incident objectives. ▪ Participating/coordinating agencies. ▪ Anticipated duration/complexity of incident. ▪ Determine any political considerations. ▪ Obtain the names of any agency contacts the Incident Commander knows about. ▪ Possibility of cost sharing. ▪ Work with Incident Commander and Operations Section Chief to ensure work/rest guidelines are being met, as applicable.
☐	2. Obtain briefing from agency administrator: ▪ Determine level of fiscal process required. ▪ Delegation of authority to Incident Commander, as well as for financial processes, particularly procurement. ▪ Assess potential for legal claims arising out of incident activities. ▪ Identify applicable financial guidelines and policies, constraints and limitations.

SAMPLE POSITION TEMPLATE DISTRIBUTED WITH NMHZ EXERCISE

☐ 3. Obtain briefing from agency Finance/Administration representative:

- Identify financial requirements for planned and expected operations.
- Determine agreements are in place for land use, facilities, equipment, and utilities.
- Confirm/establish procurement guidelines.
- Determine procedure for establishing charge codes.
- Important local contacts.
- Agency/local guidelines, processes.
- Copies of all incident-related agreements, activated or not.
- Determine potential for rental or contract services.
- Is an Incident Business Advisor (IBA) available, or the contact information for an agency Financial/Administration representative?
- Coordinate with Command and General Staff and agency Human Resources staff to determine the need for temporary employees.
- Ensure that proper tax documentation is completed.
- Determine whether hosting agency will maintain time records, or whether the incident will document all time for the incident, and what forms will be used.

☐ 4. Ensure all Sections and the Supply Unit are aware of charge code.

☐ 5. Attend Planning Meeting:

- Provide financial and cost-analysis input.
- Provide financial summary on labor, materials, and services.
- Prepare forecasts on costs to complete operations.
- Provide cost benefit analysis, as requested.
- Obtain information on status of incident; planned operations; changes in objectives, use of personnel, equipment, aircraft; and local agency/political concerns.

SAMPLE POSITION TEMPLATE DISTRIBUTED WITH NMHZ EXERCISE

Sample Planning Meeting Agenda

	Agenda Item	Responsible Party
1	Briefing on situation/resource status.	Planning/Operations Section Chiefs
2	Discuss safety issues.	Safety Officer
3	Set/confirm incident objectives.	Incident Commander
4	Plot control lines & Division boundaries.	Operations Section Chief
5	Specify tactics for each Division/Group.	Operations Section Chief
6	Specify resources needed for each Division/Group.	Operations/Planning Section Chiefs
7	Specify facilities and reporting locations.	Operations/Planning/Logistics Section Chiefs
8	Develop resource order.	Logistics Section Chief
9	Consider communications/medical/ transportation plans.	Logistics/Planning Section Chiefs
10	Provide financial update.	Finance/Administration Section Chief
11	Discuss interagency liaison issues.	Liaison Officer
12	Discuss information issues.	Public Information Officer
13	Finalize/approve/implement plan.	Incident Commander/All

☐ 6. Gather continuing information:

- Equipment time – Ground Support Unit Leader and Operations Section.
- Personnel time – Crew Leaders, Unit Leaders, and individual personnel.
- Accident reports – Safety Officer, Ground Support Unit Leader, and Operations Section.
- Potential and existing claims – Operations Section, Safety Officer, equipment contractors, agency representative, and Compensation/Claims Unit Leader.
- Arrival and demobilization of personnel and equipment – Planning Section.
- Daily incident status – Planning Section.
- Injury reports – Safety Officer, Medical Unit Leader, and Compensation/Claims Unit Leader.
- Status of supplies – Supply Unit Leader and Procurement Unit Leader.
- Guidelines of responsible agency – Incident Business Advisor, local administrative personnel.
- Use agreements – Procurement Unit Leader and local administrative personnel.
- What has been ordered? – Supply Unit Leader.
- Unassigned resources – Resource Unit Leader and Cost Unit Leader.

SAMPLE POSITION TEMPLATE DISTRIBUTED WITH NMHZ EXERCISE

☐ 7. Meet with assisting and cooperating agencies, as required, to determine any cost-share agreements or financial obligation.

☐ 8. Coordinate with all cooperating agencies and specifically administrative personnel in hosting agency.

☐ 9. Initiate, maintain, and ensure completeness of documentation needed to support claims for emergency funds, including auditing and documenting labor, equipment, materials, and services:

- Labor - with breakdown of work locations, hours and rates for response personnel, contract personnel, volunteers, and consultants.
- Equipment - with breakdown of work locations, hours and rates for owned and rented aircraft, heavy equipment, fleet vehicles, and other equipment.
- Materials and supplies purchased and/or rented, including equipment, communications, office and warehouse space, and expendable supplies.

☐ 10. Initiate, maintain, and ensure completeness of documentation needed to support claims for injury and property damage. (Injury information should be kept on contracted personnel formally assigned to the incident, as well as paid employees and mutual aid personnel).

☐ 11. Ensure that all personnel time records reflect incident activity and that records for non-agency personnel are transmitted to home agency or department according to policy:

- Notify incident management personnel when emergency timekeeping process is in effect and where timekeeping is taking place.
- Distribute time-keeping forms to all Sections-ensure forms are being completed correctly.

☐ 12. Ensure that all obligation documents initiated by the incident are properly prepared and completed.

☐ 13. Assist Logistics in resource procurement:

- Identify vendors for which open purchase orders or contracts must be established.
- Negotiate ad hoc contracts.

☐ 14. Ensure coordination between Finance/Administration and other Command and General Staff.

☐ 15. Coordinate Finance/Administration demobilization.

☐ 16. Provide briefing to relief on current activities and unusual events.

SAMPLE POSITION TEMPLATE DISTRIBUTED WITH NMHZ EXERCISE

☐ 17. Ensure all Logistics Units are documenting actions on Unit Log (ICS Form 214).

☐ 18. Submit all Section documentation to Documentation Unit.

B.6 Case Study 6: Greater Miami and Beaches Hurricane Exercise and After Action Analysis

Facilitator and Participant Acknowledgements:

- *AECOM:* Lauren Swan; Laura Johnson; Andres Gomez
- *Arthur J. Gallagher:* Tony Abella
- *Arup:* Louise Ellis
- *BCEPCRD:* Jennifer Juiado
- *City of Miami:* Jane Gilbert (CRO); Frank Gomez; Stephanie Tashiro
- *City of Miami Beach:* Allison Williams; Amy Knowles; Christine Rogers; Georgette Daniels; Jose R. Gonzalez; Maria Estevez; Sonia Bridges; Thomas Mooney; Susy Torriente (Former CRO)
- *CSA Group:* Edgardo N. Martinez
- *Florida International University:* Aris Papadoporias
- *Miami-Dade County:* Alex Alfonso; Cathie Perkins; Jack L. Speers, Sr.; James Murley (CRO); Steve Detweiler (Dept. of Emergency Management); Kimberly Brown (Planning); Michele Markovits (RER/OOR)
- *Miami-Dade Water and Sewer Department:* Jose Cueto, P.E.; Francisco J. Martinez; Debbie Griner; Hardeep Anand P.E.
- *The Netherlands Consulate General, Miami, FL:* Esther Van Geloven
- *Self:* Mel Meinhardt
- *Greater Miami Chamber of Commerce:* Irela Bague
- *SIWI:* James J. Leten

Participating Agencies:	City of Miami, City of Miami Beach, Miami-Dade County, Broward County, Miami-Dade Sewer and Water Board, FDOT region administrator, and other local administrative subdivision officials
Scenario:	Participants engaged in simulations responding to two potential concurrent disasters: HAZUS Category 5 Hurricane catastrophe scenarios projected for current day wind and flooding at King Tide and 2060 flood projections with 1.5-foot sea-level rise risk at King Tide.
Exercise Location:	Greater Miami and the Beaches
Exercise Date:	May 15, 2018
Exercise Focus:	Lifeline inter-operability. Coordinated with 100 Resilient Cities *Pre-Planning for Post-Disaster Activities* as well as a *Water Resilience Case Study* by 100 Resilient Cities
Participant Engagement:	This exercise involved pre-scenario planning in order to respond to key priorities for participant organizations. The Miami case study took a holistic view of catastrophic recovery (readiness) planning. As such, the work bisected a number of areas from financing, to lifeline infrastructure and community habitability, to resilient reconstruction. One tool developed as a follow-on to preparation meetings for the case study was the *Guide to Innovative Disaster Financing* which was developed by AECOM and SuissRe. The purpose of this guide was to offer a simple resource to cities as part of the Greater Miami and the Beaches Resilience Strategy. The guide provides an approach to think through funding option alternatives to traditional insurance that can be used after a disaster such as a shock like storms or health crisis like Zika. It is organized in 3-parts: Part 1: 5-Steps to Innovative Disaster Recovery Funding Part 2: At a Glance Options for Hurricane Recovery Funding Part 3: Q&A- Understanding Parametric Insurance

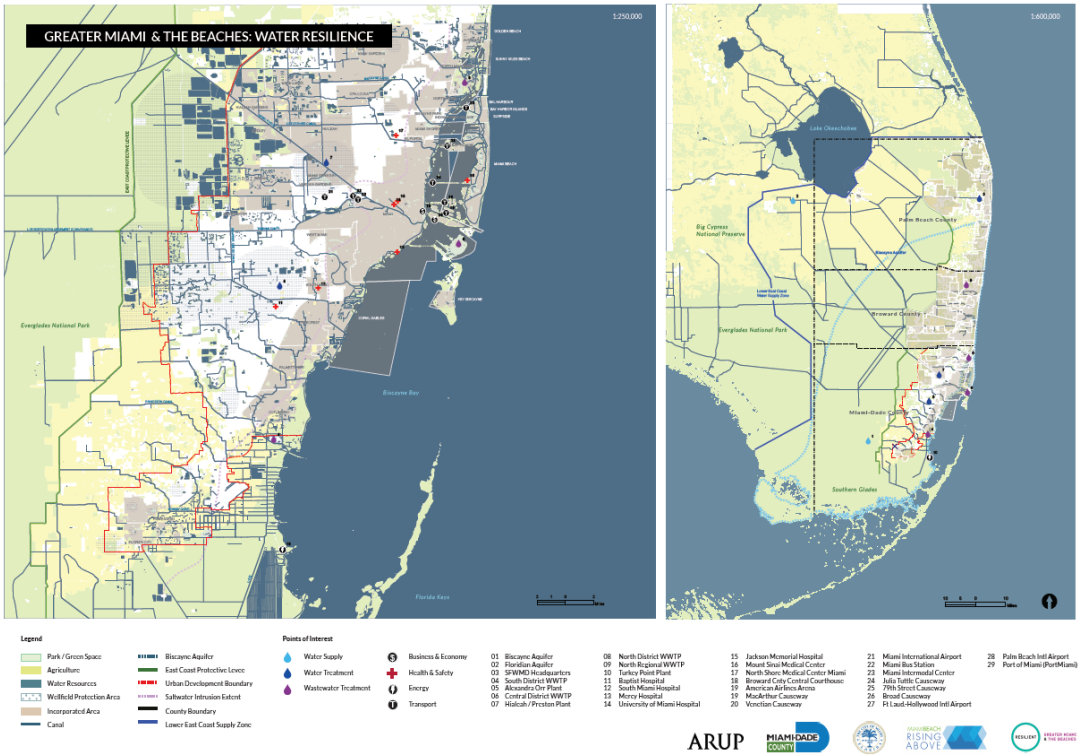


Figure B-11: Greater Miami Scenario

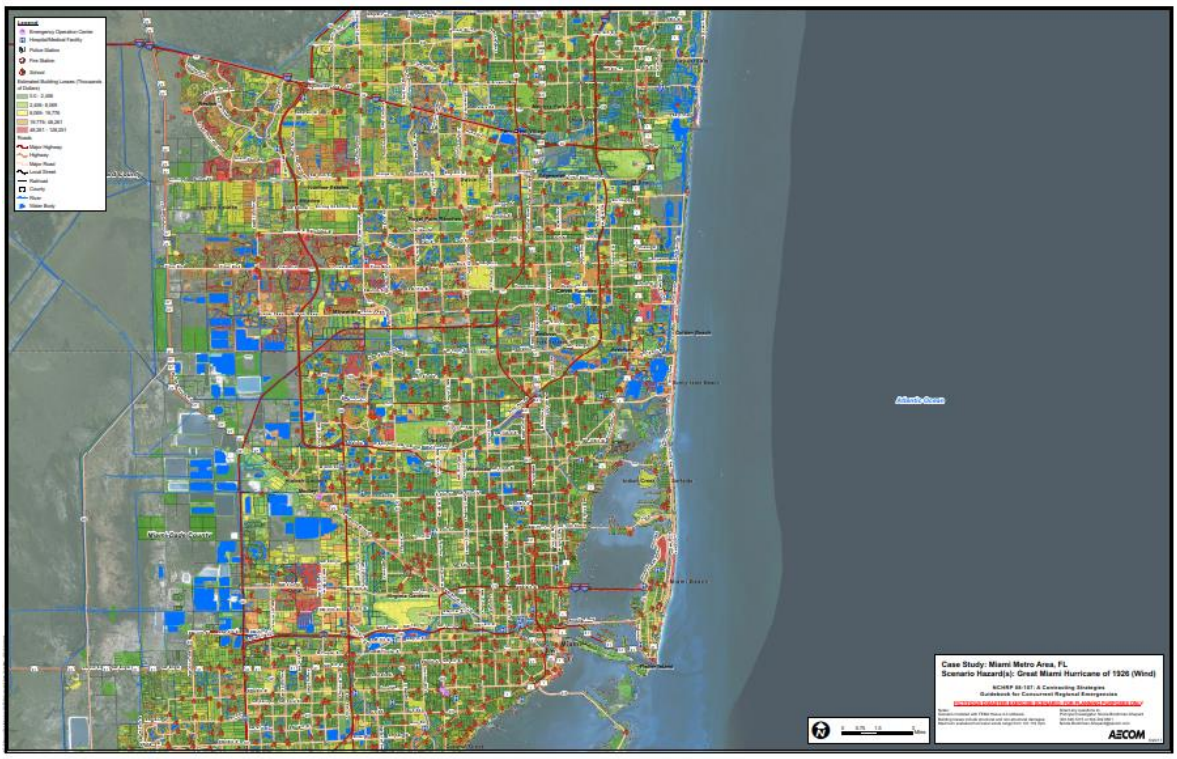


Figure B-12: Miami HAZUS Scenario - 1926 Hurricane

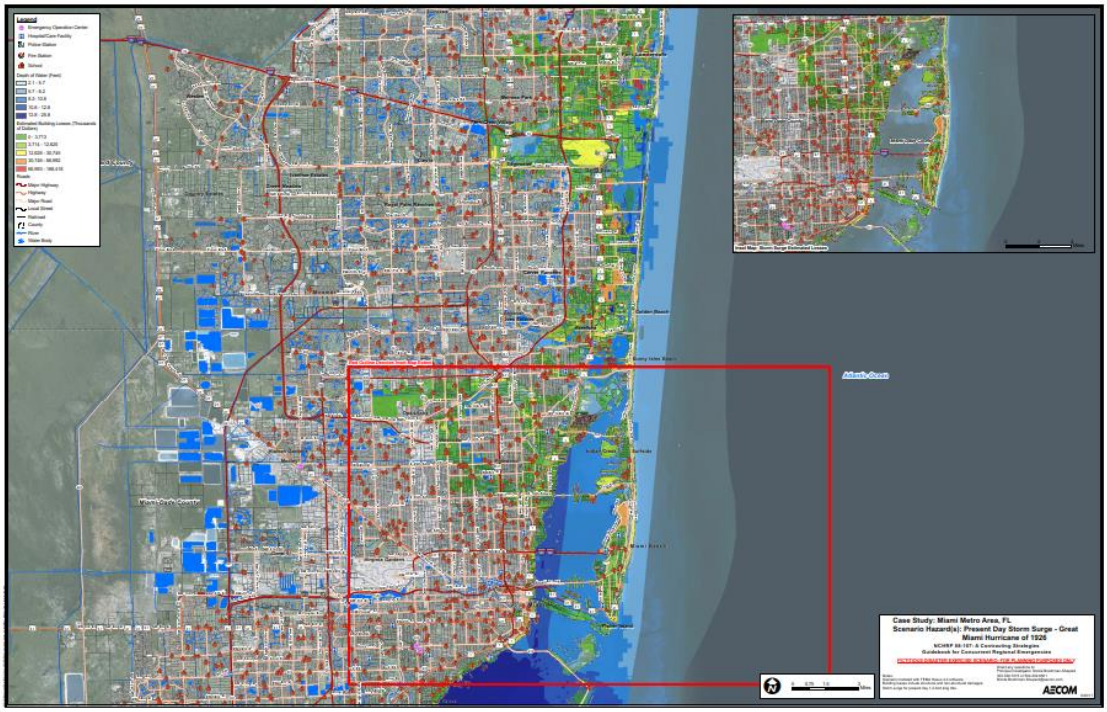


Figure B-13: Miami HAZUS Scenario - Present Day Storm Surge

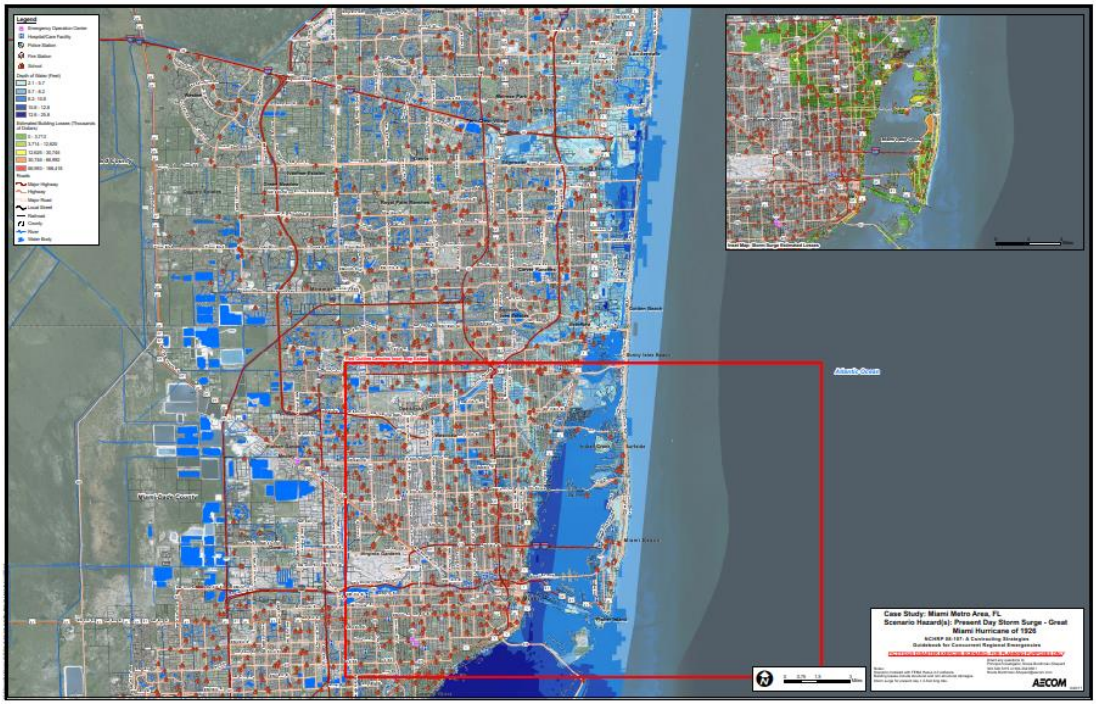


Figure B-14: Miami HAZUS Scenario - Storm Surge (Damaged Infrastructure Excluded)

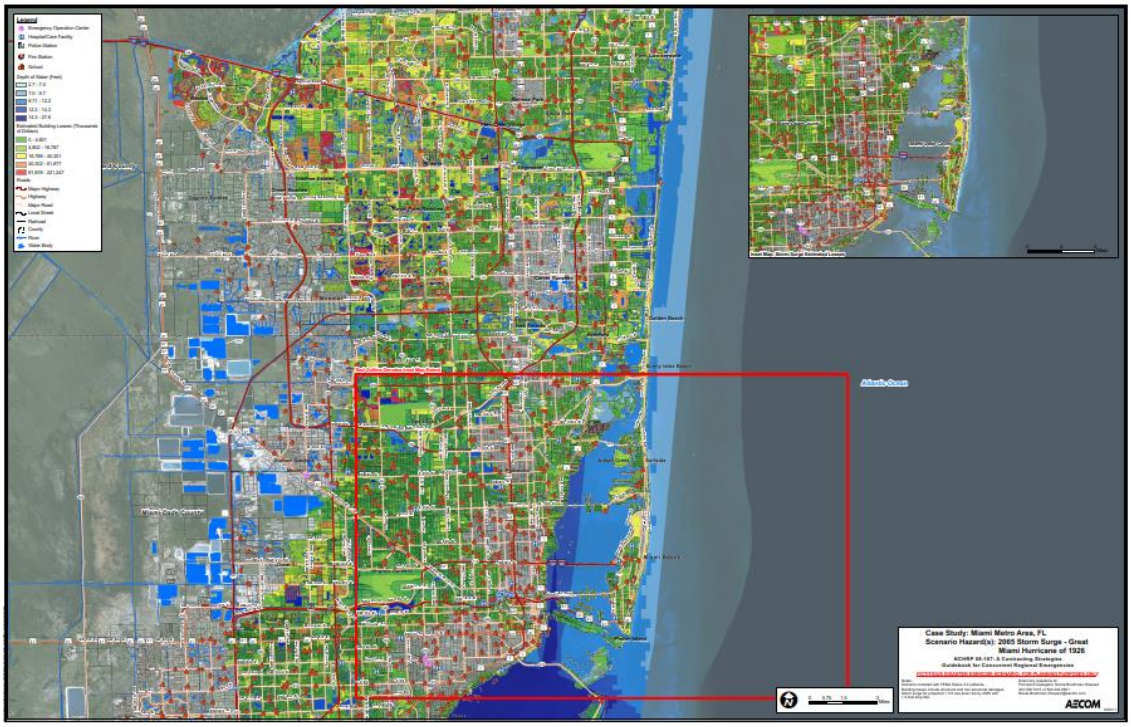


Figure B-15: Miami HAZUS Scenario - SLR and Storm Surge

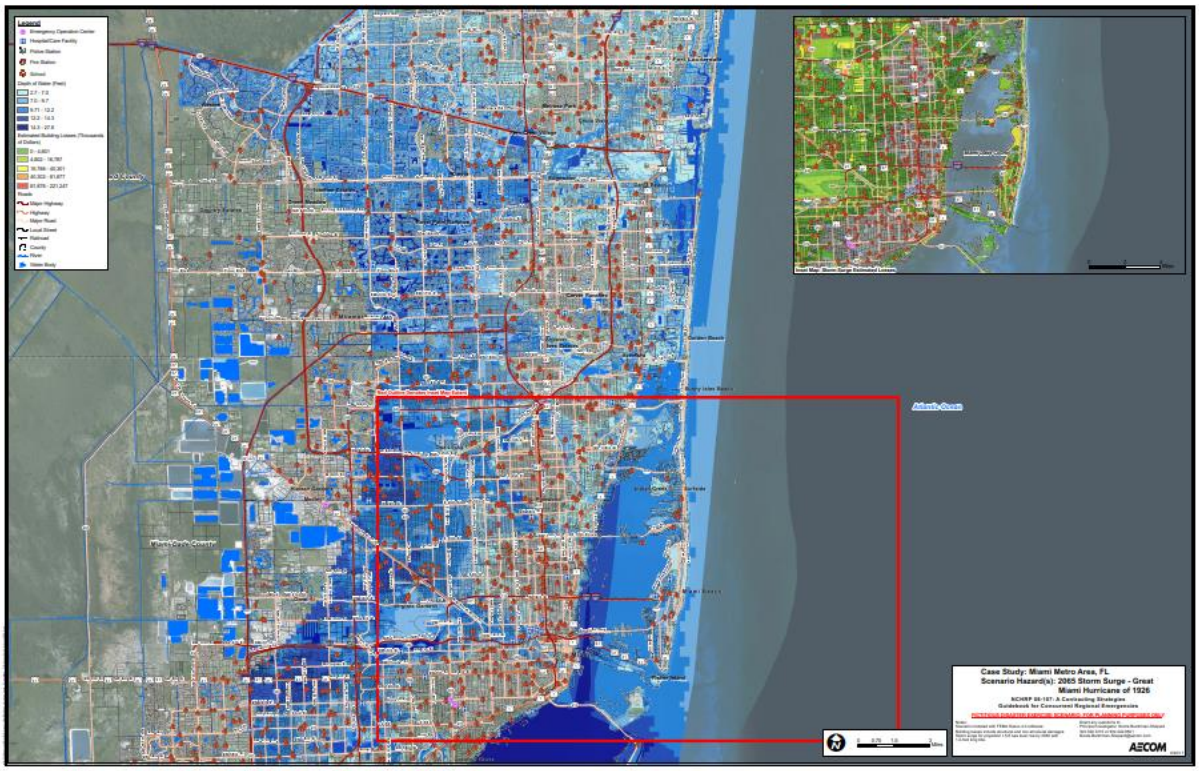


Image Credits: FEMA HAZUS Software

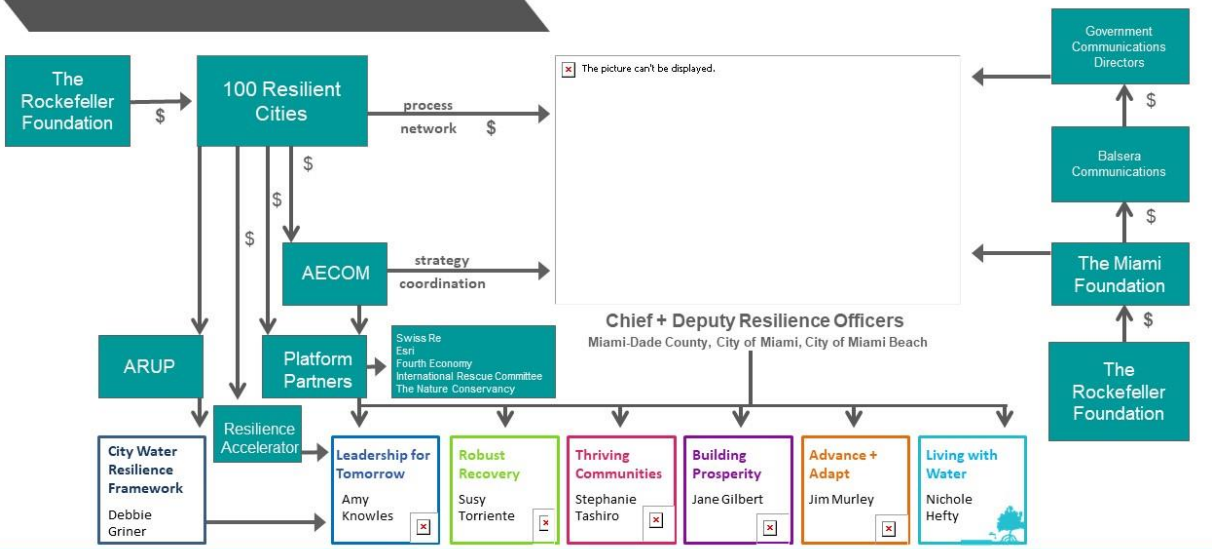
Figure B-16: Miami HAZUS Scenario - SLR and Storm Surge (Damaged Infrastructure Excluded)

Case Study PowerPoint


Robust Recovery
PREPlanning for POSTDisaster
SITUATION: We are vulnerable to hurricanes and flooding but well-known throughout the Nation for our advanced emergency management
INTENT: This discovery area focuses on how to change our culture and policies, systems, and insurance structures now for faster, more affordable, and smarter recovery in the event of a disaster
The picture can't be displayed.
Disaster Financial Literacy Agenda
10:30 Welcome + Introductions
• Disaster Recovery Funding
• Risk Transfer
• Cash Management
• Plenary Q + A
12:00 Adjourn + Lunch

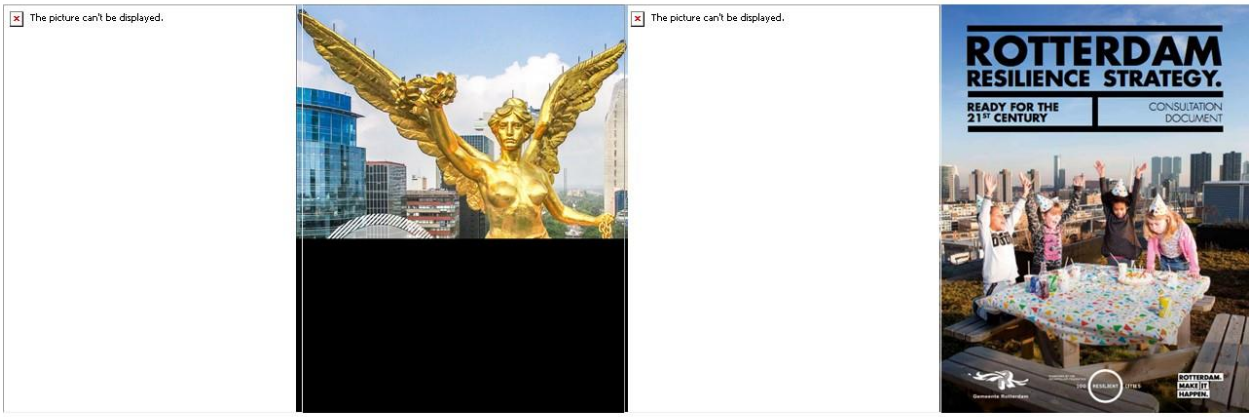
Introduction
Greater Miami & the Beaches

Our Process



What is
A Resilient Strategy?

Developing our Resilience Strategy



37 urban resilience strategies have been released; 11 within the USA

Robust Recovery
PREPlanning for POSTDisaster

INTRODUCTION: Susanne M. Torriente

DISASTER FINANCIAL LITERACY AGENDA

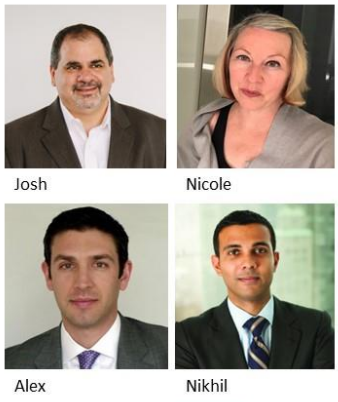
- RECOVERY FUNDING: Post-catastrophe disaster funding mix, eligibility & emerging trends
- RISK TRANSFER: Innovative financial instruments available in the marketplace to buy down risks
- CASH MANAGEMENT: Revenue sources, reserves and cash flow post-catastrophe
- PLENARY Q + A

Robust Recovery
PREPlanning for POSTDisaster

INTRODUCTION: Susanne M. Torriente

PANELISTS

- Josh Sawislak, Global Director for Resilience, AECOM
- Nicole Boothman-Shepard, Resilience Strategist & Senior Policy Advisor, AECOM
- Alex Kaplan, Head, North America, Senior Vice President, Global Partnerships, Swiss Re Management (US) Corporation
- Nikhil da Victoria Lobo, Managing Director, Global Partnerships (Americas), Swiss Re



Robust Recovery
PREPlanning for POSTDisaster

RECOVERY FUNDING

- Post-catastrophe disaster funding mix + eligibility + emerging trends with Nicole Boothman-Shepard
- FAQs

(20 mins)

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DISASTER FUNDING MIX

- FEMA Public Assistance (Categories A-G)
- FEMA Hazard Mitigation (404 + 406)
- FEMA Individual Assistance + STEP + Permanent Housing
- FEMA Community Disaster Loan (CDL)
- FHWA Emergency Relief: Federal-aid roads
- HUD Community Development
- Block Grants – Disaster Recovery (CDBG-DR
- FEMA ESF Support + Mission Assignments

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ELIGIBILITY + EMERGING TRENDS

- Gubernatorial + Presidential Disaster Declarations
- FEMA
  - Eligible County + Applicant + Work
  - Houses of Worship Now Eligible

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PREPlanning for POSTDisaster

ELIGIBILITY + EMERGING TRENDS

- Congressional Relief: CDL + CDBG-DR + Cost Shares
- Trends
  - FEMA Preliminary Damage Assessment (PDA)
  - More Local/State Responsibility
  - Warming up to Resilience
  - New FEMA Fund Award Process (FL Irma)
  - FEMA Pilot Programs

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ELIGIBILITY + EMERGING TRENDS

- Optimization Strategies
  - Defining Damages + Costs
  - Project Procurement + Delivery + Resilience Standards
- Congressional Relief: CDL + CDBG-DR + Cost Shares

FAQs

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PREPlanning for POSTDisaster

RISK TRANSFER

- Innovative financial instruments available in the marketplace to buy down risks with Alex Kaplan + Nikhil da Victoria Lobo
- FAQs
  (25 mins)

Solutions Beyond Facilities

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Options for the Public Sector

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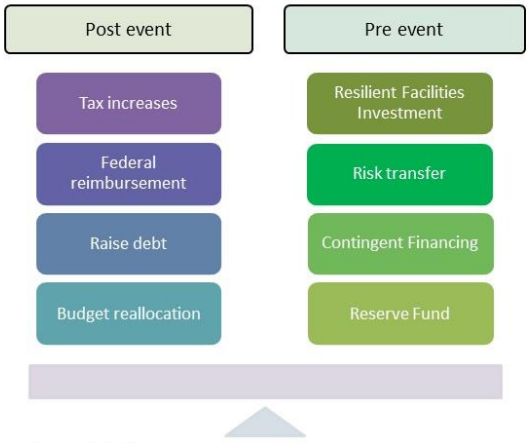

Source: Swiss Re

"From an ex-post perspective, the availability of insurance offers the best mitigation approach against real and fiscal consequences of disasters."

World Bank, Policy Research Working Paper 5564, 2011

THE WORLD BANK
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Parametric Insurance

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PREPlanning for POSTDisaster

WHEN DO PARAMETRIC INSURANCE POLICIES PAY OUT?

Payout of pre-defined amount made when contractually agreed threshold of parameter/index is exceeded (e.g. amount of rainfall)

Parametric Insurance

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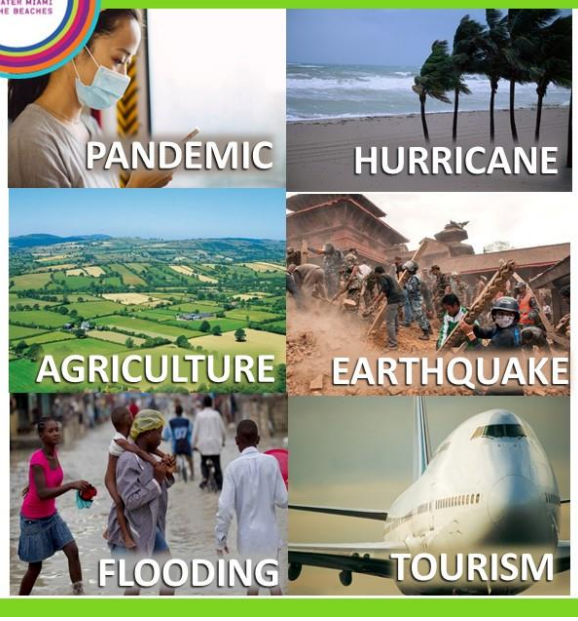
PREPlanning for POSTDisaster



ADVANTAGES

- Fast payout (2-6 weeks)
- No loss assessment required
- Otherwise uninsurable risks can be insured (e.g. loss of revenues)
- Flexibility in the use of funds

DISADVANTAGES

- Basis risk: insurance payout may deviate from actual loss

Drivers For Buying Parametric Insurance

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Parametric Insurance

COMPARING INDEMNITY AND PARAMETRIC INSURANCE PAY-OUT

Event Occurs → Intensity verified by third-party → Pay-out issued within 30-days → Confirm proof of loss within a year → Time

Indemnity Based Insurance

Event Occurs → Insured assesses damage → Insured submits claim → Insurer reviews claim → Adjuster assesses and validates claim → Claim is paid based on assessment → Time

Source: Swiss Re

Case Study for Greater Miami & the Beaches

How does this apply to your City/ County?

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PREPlanning for POSTDisaster

CITY-OWNED BUILDINGS (PROPERTY + CONTENTS): $580 MILLION

- Flood insurance deductible: $2.37M
- Flood Coverage: $38.7M
- Named storm coverage: $20M
- Deductible on each affected loss: 6.5%
  - $5M on Jackie Gleason Theater
  - Up to $10M on Convention Center

Case study for Greater Miami & the Beaches

How does this apply to your City/ County?

Robust Recovery
PREPlanning for POSTDisaster

- Miami Beach produces $611M in net revenue each year - 25% derived from:
  - **Resort Taxes:** $83M or $228k/day
  - **Parking Fees:** $58.7M or $161k/day
  - **Resort and Room Rental Taxes:**
    - After Zika: Following CDC travel warnings, it took six months to return to projected taxes - greater than USD 3.2M in potential losses
    - After Hurricane Irma: It took the City four months to return to projected taxes - greater than USD 4.5M in potential losses

MIAMI BEACH REVENUE SOURCES

What are your risks?

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HOW CAN PLANNING FOR A MAX-OF-MAX ("BLACK SWAN") EVENT HELP YOU?

- December-February: Busiest months for MB tourism
- Hurricane makes landfall in Miami in late October
- City could be shut to tourists for months + recovery will erode tourist season traffic
- Many restaurants + hotels will be out of commission in high season
- If water + sewer infrastructure inundated, it may be offline for 1+ month
- Many local workers will be consumed with personal recovery

$38.2M **projected lost resort tax revenue - 40% of annual collections

**November 75% loss
December/January 100% loss
February 75% loss
March 75% loss

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PREPlanning for POSTDisaster

CASH MANAGEMENT

- Revenue sources, reserves and cash flow post-catastrophe with Josh Sawislak + Nicole Boothman-Shepard
- FAQs
  (15 mins)

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PREPlanning for POSTDisaster

REVENUE

- **CASH IN:** Revenue sources + disruptions
- **CASH AVAILABLE:** Revenue Reserves ~ Cash burned in 1st 90 (+/-) days after event often equals *annual* budget
- **CASH OUT:** Transaction volumes + postings to General Ledger

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PREPlanning for POSTDisaster

MANAGE RISK RATING

- Protect bond rating
- Secure capital access for recovery now
- Consider parametric insurance or instruments that don't erode Federal funding
- FEMA insurance obtain + maintain on previously impacted facilities
- Other strategies

FAQs

Robust Recovery
PREPlanning for POSTDisaster

PLENARY Q + A

- Josh Sawislak, Global Director for Resilience, AECOM
- Nicole Boothman-Shepard, Resilience Strategist & Senior Policy Advisor, AECOM
- Alex Kaplan, Head, North America, Senior Vice President, Global Partnerships, Swiss Re Management (US) Corporation
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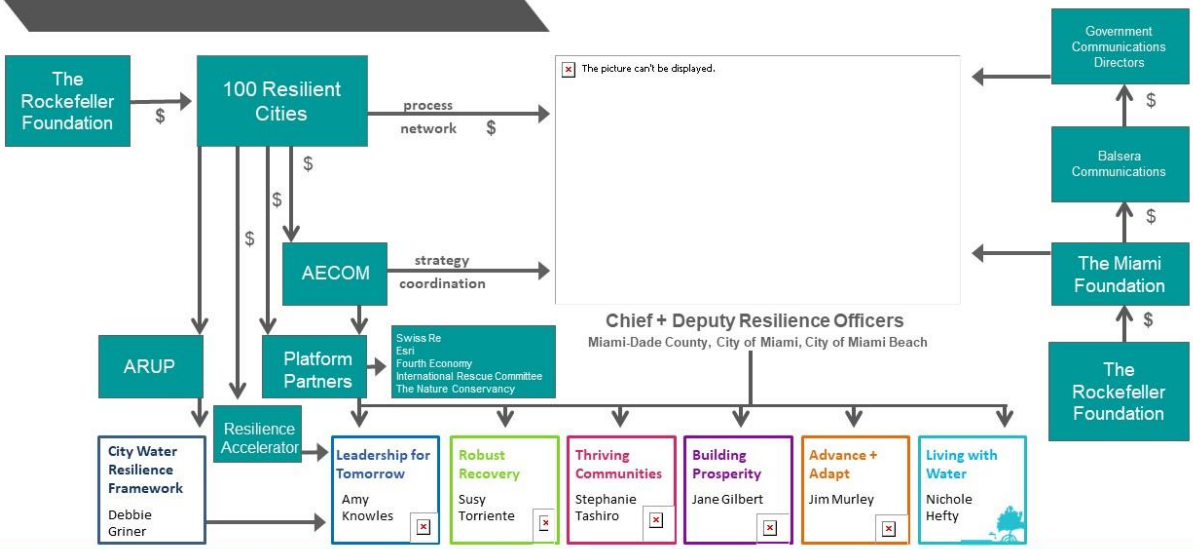
(15 mins)


Robust Recovery
PREPlanning for POSTDisaster
SITUATION: We are vulnerable to hurricanes and flooding but well-known throughout the Nation for our advanced emergency management
INTENT: This discovery area focuses on how to change our culture and policies, systems, and insurance structures now for faster, more affordable, and smarter recovery in the event of a disaster
Lifeline Infrastructure
Agenda
01:00 Welcome + Introductions
01:15 Catastrophe Functional Exercise
02:45 Case Study Analysis
04:30 Adjourn
RESILIENT

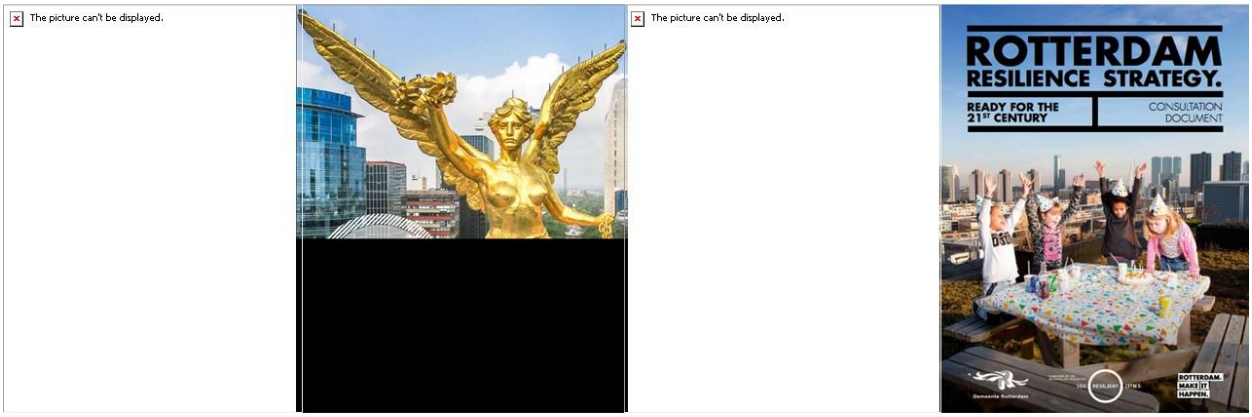
Introduction
Greater Miami & the Beaches

Our Process



What is A Resilient Strategy?

Developing our Resilience Strategy



37 urban resilience strategies have been released; 11 within the USA

How will this Case Study Aid Research?

NCHRP 08-107

IDENTIFY CHALLENGES + DELIVER SOLUTIONS

Scope
Scale
Complexity
Consequences +
Cascading Impacts

GUIDEBOOK: Contracting Strategies for Concurrent Regional Emergencies

Restore Infrastructure + Build Forward

NCHRP 08-107

CRITICAL ISSUE AREAS

- Multi-Agency Plan Harmonization
- + Implementation
- Prioritization + Capacity
- Flexible Contracting
- Manage Scope + Scale
- Innovative Delivery
- Drive Down Audit Risks

GUIDEBOOK: Contracting Strategies for Concurrent Regional Emergencies

Robust Recovery
PREPlanning for POSTDisaster

PRE-EXERCISE BRIEFING: INTEROPERABLE LIFELINE INFRASTRUCTURE

Sectors: Transportation, Water, Energy + Telecommunications, Essential Services

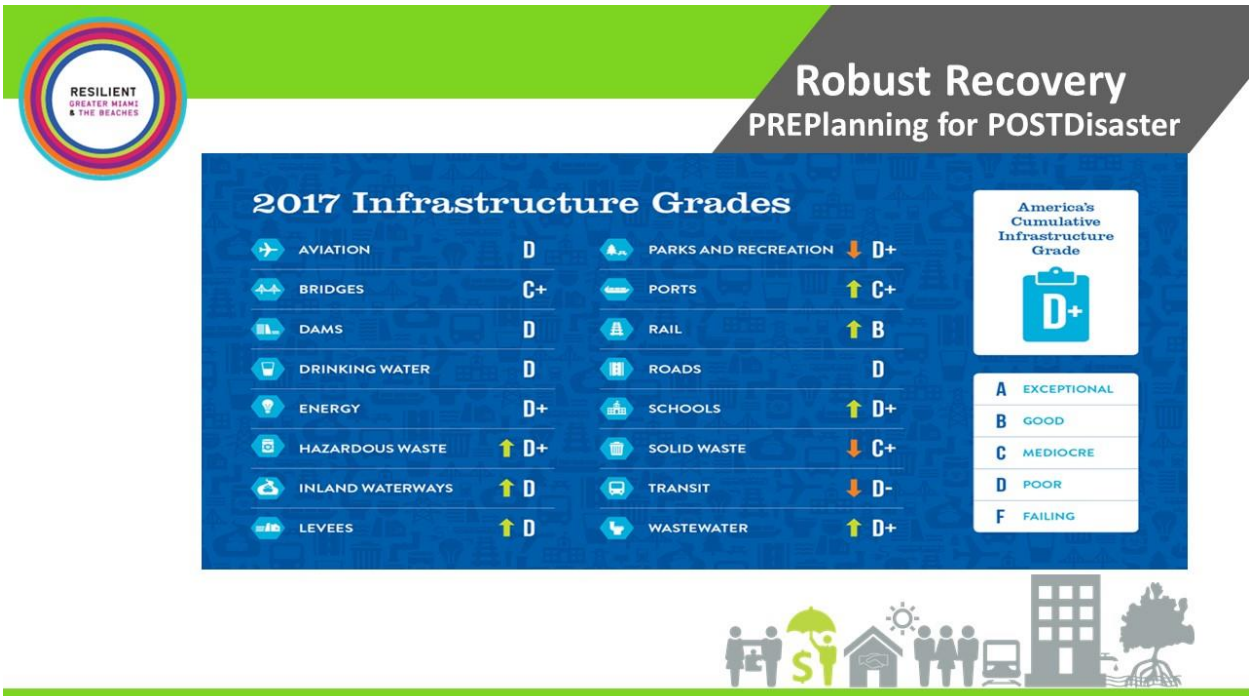
Interoperability: The capability of two or more networks, systems, devices, applications, or components to externally exchange + readily use information securely + effectively

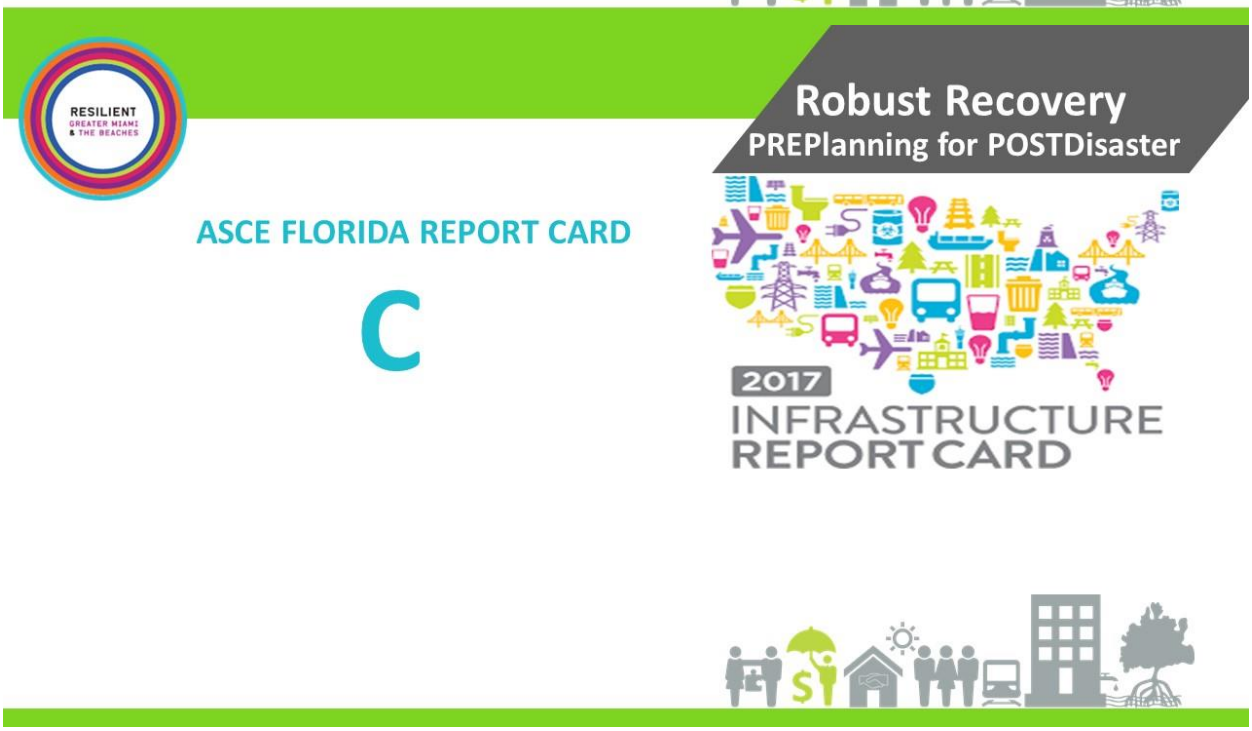
2 Modules: Response + Resilient Recovery

Robust Recovery
PREPlanning for POSTDisaster

INTENDED OUTCOMES

- Catastrophe Response Planning for Bounceback today
- Examination of Lifeline Infrastructure Interoperability
- Resilient Recovery Alternatives in 2060 Scenario


RESILIENT
GREATER MIAMI & THE BEACHES
Robust Recovery
PREPlanning for POSTDisaster
2017 Infrastructure Grades
AVIATION D
BRIDGES C+
DAMS D
DRINKING WATER D
ENERGY D+
HAZARDOUS WASTE ↑ D+
INLAND WATERWAYS ↑ D
LEVEES ↑ D
PARKS AND RECREATION ↓ D+
PORTS ↑ C+
RAIL ↑ B
ROADS D
SCHOOLS ↑ D+
SOLID WASTE ↓ C+
TRANSIT ↓ D-
WASTEWATER ↑ D+
America's Cumulative Infrastructure Grade
D+
A EXCEPTIONAL
B GOOD
C MEDIOCRE
D POOR
F FAILING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RECOVERY EXERCISE GOALS

1. Effective Project Delivery
2. Maximize Funding
3. Drive Down Audit Risks
4. Build Forward: Resilience
5. Reporting + Documentation
6. Communicate Effectively

Robust Recovery
PREPlanning for POSTDisaster

HOW WILL EXERCISE + CASE STUDY INFORMATION BE USED?

- Inspire action for bounceback
- Consider readiness for and amongst lifeline infrastructure
- Identify robust alternatives for resilience investments
- Support for Land Use Toolkit
- Consider governance, policy + funding alignment across sectors to **SUPPORT GM&B STRATEGY**

Robust Recovery
PREPlanning for POSTDisaster

WHAT IS MY ROLE: Functional Exercise + Role Playing

- Play active role in incident command
- Sector liaisons
- Ask questions + propose **SOLUTIONS**
- Collaborate
- Create safe space for everyone to explore options
- Disagreement is typical, but seek constructive options
- Make assumptions + move forward

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2 MODULES: 40 minutes each

- Emergency Response
- Resilient Recovery

4 FUNCTIONS/SECTORS

- Transportation
- Water
- Energy + Communications
- Health + Safety

Robust Recovery
PREPlanning for POSTDisaster

LIFELINE INFRASTRUCTURE

WHAT DOES YOUR SECTOR NEED + WHAT DOES YOUR SECTOR PROVIDE?

- Roadway/bridge access
- Rail/port/airport access
- Power
- Mobile phone service
- Landline phone/fax service
- Internet
- Web-based systems (data in and out)
- Clean water
- Reclaimed water
- Toilets that flush!
- Dried out facilities
- Money, food, medicine

Robust Recovery
PREPlanning for POSTDisaster

ASSUMPTION + ARTIFICIALITIES

- Incident is Managed
- FEMA Missions Assignments + Military Deployments
- Debris, Evacuation + Other Human Needs Managed

Robust Recovery
PREPlanning for POSTDisaster

START EXERCISE
Module 1

Robust Recovery
PREPlanning for POSTDisaster

HURRICANE SITUATION REPORT

- Category 5 Hurricane made landfall 5/18/18 at 9:36 PM
- Max Peak Gusts: 161 mph
- Incident period ended + recovery operations mobilized
- Population Impacted in MD County:
  - 2.2M
  - 20% in poverty
  - 786,000 evacuations
  - 1.4 M sheltered in place

Robust Recovery
PREPlanning for POSTDisaster

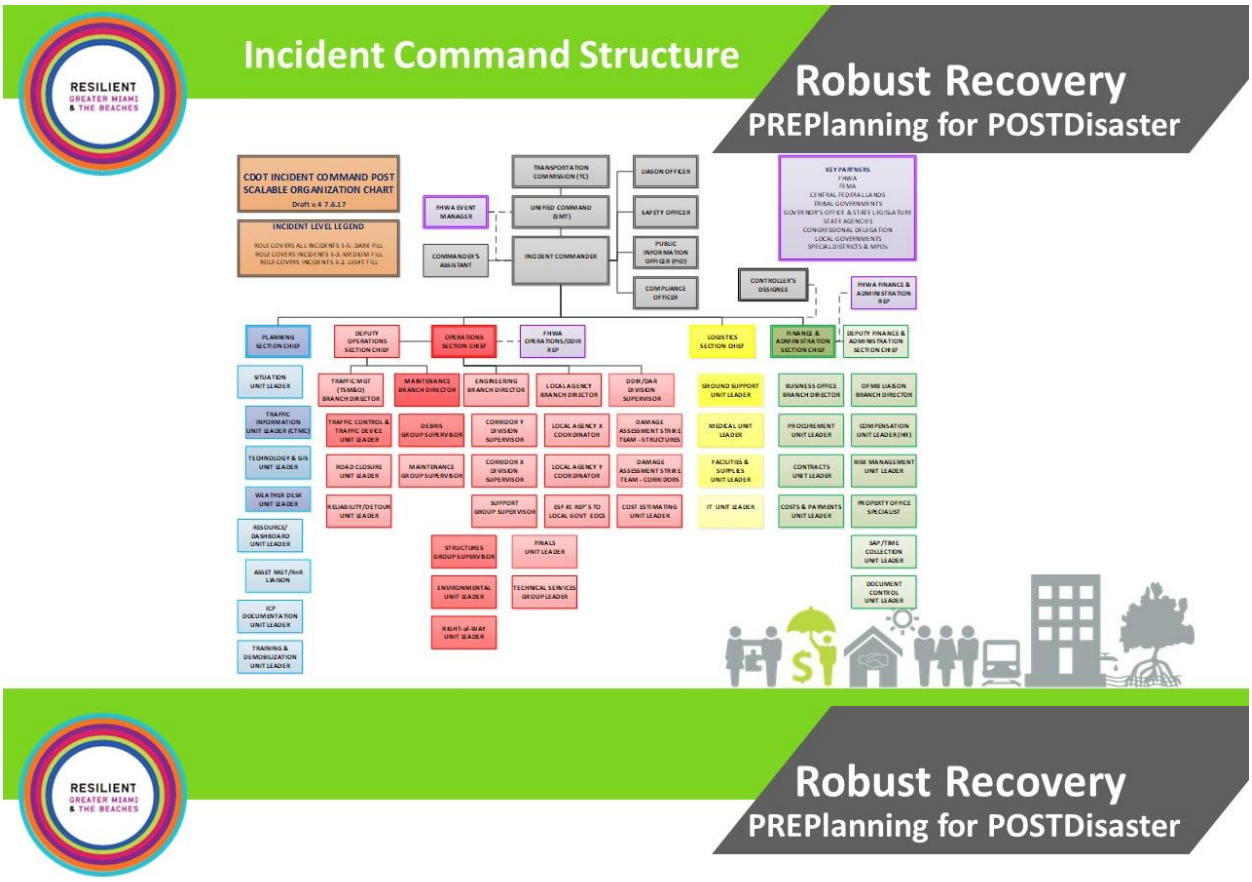
HURRICANE SITUATION REPORT

- 678.26 square miles
- 1,141 households
- 3.1M people (2010 Census) – 2.2 M in Miami-Dade County
- 834,000 thousand buildings
- 87% of buildings are residential

Robust Recovery
PREPlanning for POSTDisaster

HURRICANE SITUATION REPORT
ASSET + SYSTEM IMPACTS

- None 5%
- Minor 12%
- Moderate 24%
- Severe 50%
- Destruction 5%



MODULE 1: BOUNCEBACK to MAINTAIN HABITABILITY

- Key Tasks:
  1. Identify asset damages + Severity (Red, Yellow, Green)
  2. Group projects for procurement
  3. Develop Scope, Schedule, Budget
  4. Validate Interoperability
  5. Seek project Funding!

Robust Recovery
PREPlanning for POSTDisaster

KEY CONSIDERATIONS

- Scope
- Scale
- Complexity
- Consequences +
- Cascading Impacts

Robust Recovery
PREPlanning for POSTDisaster

MODULE 1: BOUNCEBACK to MAINTAIN HABITABILITY

CRITICAL ISSUE AREAS

- Multi-Agency Plan Harmonization
- + Implementation
- Prioritization + Capacity
- Flexible Contracting
- Manage Scope + Scale
- Innovative Delivery
- Drive Down Audit Risks

Robust Recovery
PREPlanning for POSTDisaster

START EXERCISE
Module 2

Robust Recovery
PREPlanning for POSTDisaster

MODULE 2: RESILIENT RECOVERY

- Key Tasks:
  - Resilient Design
  - Consider Adaptive Capacity
  - Consider Triple Bottom Line Benefits
    - People + Communities
    - Economic Stability + Growth
    - Environmental Stability

Robust Recovery
PREPlanning for POSTDisaster

CASE STUDY REFLECTION

- Reflections – Module 1 + Module 2
- Gallery Walk –Review resilient asset solutions + build on ideas
- Out-brief Module 2 resiliencies

Robust Recovery
PREPlanning for POSTDisaster

CASE STUDY REFLECTION

- What will it take to substantially **PREPlan for POSTDisaster**?
  - Region-wide governance
  - Policy alignment
  - Procedures
  - Funding + Benefit-Cost Analysis
  - Political capital

thank you

Leadership for Tomorrow; Robust Recovery; Thriving Community; Building Prosperity; Advance + Adapt; Living with Water
Social Equity; Innovation + Technology; Intergovernmental Collaboration

appendix

Specific adaptation strategies

Leadership for Tomorrow; Robust Recovery; Thriving Community; Building Prosperity; Advance + Adapt; Living with Water
Social Equity; Innovation + Technology; Intergovernmental Collaboration

RESILIENT GREATER MIAMI & THE BEACHES

Precedents + Best Practices

The precedents focus on how cities:

- Identify innovative financing mechanisms tailored to city governments,
- support faster disaster response and recovery, and avoid losses of life and property,
- raise awareness to aid residents in informed decision-making during storms.

Three recovery cities:

1. New Orleans, LA
2. Norfolk, VA
3. San Francisco, CA

Precedents + Best Practices

New Orleans, LA
Resilient Infrastructure Recovery + Risk Transfer for Critical Assets

- Risk assessment of critical infrastructure to determine exposures and associated costs of disasters in various scenarios.
- Ability to isolate systems critical to continued livability and have deployable private market assets prepared to repair systems immediately following an event.
- Catastrophic losses will be pre-funded through transfer of risk to private market.

Precedents + Best Practices

New Orleans, LA
Resilience Retrofit Program

- Develops a program to provide incentives to property owners who reduce their own risk.
- Explores innovative financial instruments allowing property owners to make improvements.
- Low interest capital and a potential reduction in insurance premiums serve as incentives to property owners investing in storm resilience improvements.

Precedents + Best Practices

New Orleans, LA
Microgrid Pilot Project

- Assesses the risks of energy outages to critical infrastructure systems and conducts feasibility studies for backup generation or microgrids.
- Provides energy backup during shocks and outages for a variety of co-located critical infrastructures.
- Supports faster disaster response and recovery, and avoid losses of life and property.

Precedents + Best Practices

Norfolk, VA
Resilient Zoning Code Rewrite

- Aspires to be a user-friendly document, incorporates modern best practices, supports and encourages resilient development, promotes environmentally friendly development, and recognizes different characters of districts throughout city.
- Will serve as a model for coastal zoning nationwide.

Precedents + Best Practices

Norfolk, VA
RE.bound Program

- Leverages catastrophe bonds as a mechanism for resilient infrastructure project finance.
- Models the financial benefits of specific resilient infrastructure projects upfront and integrates insurance coverage with investment in long-term risk reduction.
- Norfolk initiative focused on integrated flood management solutions in the Arts District.

Precedents + Best Practices

Norfolk, VA
Flood Risk Awareness Campaign

- Working group of city staff and insurance, banking, planning, and community representatives.
- Creates a communication campaign to alert citizens to the risks of flooding.
- Raises awareness of risks and resources to aid residents in informed decision-making.
- Uses city-owned media as well as local media to spread the word.

Precedents + Best Practices

San Francisco, CA
Energy Assurance Solar + Storage For Resiliency

- Provides an emergency source of energy during a disaster through solar energy and on-site energy storage.
- Evaluates technical and financial feasibility, identifies priority sites, sizes the system for maximum benefit and explores cost and financing models.
- Implemented through creation of disaster preparedness zones including key disaster response facilities.

Precedents + Best Practices

San Francisco, CA
Disaster Recovery Case Management Program

- Develops comprehensive user-friendly database.
- Helps case managers provide assistance through close cooperation with organizations serving vulnerable populations.
- Maintains a citizens advisory recovery committee to establish database platform, oversee the program, and serve as an advisory and oversight body during a recovery.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GREATER MIAMI
& THE BEACHES
@resilient305
PARADISE
PIONEERED BY THE ROCKEFELLER FOUNDATION
100 RESILIENT CITIES

Appendix C:
Multi-Variate Statistical Analysis

This appendix presents the applied research questions, methodologies, and results of the multi-variate statistical analysis conducted for this applied research. It was undertaken to investigate previously anecdotal observations about adverse audit findings, post-disaster. It examined correlations between procurement, contracting, and post-disaster project delivery conditions that resulted in OIG findings that recommended reductions (de-obligations) in FEMA funding as a result of US Department of Homeland Security (DHS) Office of Inspector General (OIG) audits.

C.1 Purpose and Methodology

The purpose of the analysis is to determine any statistically significant relationship between procurement methods and compliance with FEMA Public Assistance policies in force at the time work was procured. The statistical models used in the preliminary analysis are strictly descriptive and carry no causal interpretation.

The primary model takes the following form and is estimated using robust ordinary linear regression (ROLS):

$$sv_i = \beta_0 + \beta_1 pc_i + X_i' \mathrm{B} + \varepsilon_i$$

Where

- sv_i is the number of violations beside procurement and contracting violations;
- β_0 is the intercept parameter;
- β_1 is the coefficient parameter for pc_i;
- pc_i is the number of violations in the procurement and contracting process;
- X_i is the vector of other explanatory variables;
- B is the vector of coefficient parameters excluding β_0 and β_1; and
- ε_i is the error term.

The robustness of the estimates is checked with alternative models that include different sets of explanatory variables, as well as Poisson regressions given the apparent discrete distribution of the dependent variable.

C.2 Sample Data

The sample data is obtained from the DHS OIG audit reports on FEMA Public Assistance grants. Only the audit report on fund grantees (also described as sub-recipients or applicants) are included; audits on FEMA procedures and other reports not related to a state or local agency's management of grant funds are not within the scope of this study.

The sample includes all published DHS OIG audit reports on applicants published between January 2016 and February 2017 and are listed below. Beside the recentness of the audit reports relative to the time the data analysis was conducted, the time frame is arbitrarily chosen to ensure a subjectively large enough sample is represented for sufficient statistical power. The reports reviewed are shown in Table C-1.

Table C-1: Audit Findings by Homeland Security Office of Inspector General Reviewed for Analysis

Report #	Title	Date
OIG-16-107-D	The Baldwin County Commission Effectively Managed FEMA Grant Funds Awarded for Damages from Spring 2014 Storms	6/30/2016
OIG-16-110-D	Minneapolis Park and Recreation Board, Minneapolis, Minnesota Generally Accounted For and Expended FEMA Grant Funds Properly	7/7/2016
OIG-16-112-D	FEMA Should Recover $2.2 Million of $27.2 Million in Public Assistance Grant Funds Awarded to Nashville-Davidson County, Tennessee, for May 2010 Flood Emergency Work	7/15/2016
OIG-16-115-D	FEMA Should Suspend All Grant Payments on the $29.9 Million Coastal Retrofit Program until Mississippi Can Properly Account for Federal Funds	8/10/2016
OIG-16-116-D	City of Hazelwood, Missouri, Needs Additional Assistance and Monitoring to Ensure Proper Management of Its Federal Grant	8/11/2016
OIG-16-117-D	Ocean County, New Jersey, Generally Accounted for and Expended FEMA Public Assistance Funds Properly	8/12/2016
OIG-16-120-D	Phelps County, Missouri, Needs Additional Assistance and Monitoring to Ensure Proper Management of Its $1.97 Million FEMA Grant	8/17/2016
OIG-16-121-D	Washington County, Florida, Effectively Managed FEMA Public Assistance Grant Funds Awarded for a July 2013 Flood	8/19/2016
OIG-16-122-D	Portland, Oregon, Has Adequate Policies, Procedures, and Business Practices to Manage Its FEMA Grant Funding	8/9/2016
OIG-16-124-D	Nebraska Public Power District Properly Managed FEMA Grant Funds Awarded for May 2014 Storms	9/1/2016
OIG-16-125-D	Long Beach City School District in New York Generally Accounted for and Expended FEMA Public Assistance Funds Properly	9/2/2016
OIG-16-135-D	FEMA Should Recover $3.4 Million of the $3.5 Million Awarded to Hope Academy for Hurricane Katrina Damages	9/19/2016
OIG-16-136-D	Calaveras County, California, Needs Additional State and FEMA Assistance in Managing Its $10.8 Million FEMA Grant	9/22/2016
OIG-16-137-D	City of Eureka, Missouri, Needs Additional Assistance and Monitoring to Ensure Proper Management of Its $1.5 Million FEMA Grant	9/23/2016
OIG-16-140-D	FEMA Should Recover $9.9 Million of $36.6 Million Awarded to the Town of North Hempstead, New York, for Hurricane Sandy Damages	9/26/2016
OIG-16-143-D	FEMA Should Recover $25.4 Million in Grant Funds Awarded to Louisville, Mississippi, for an April 2014 Disaster	9/29/2016
OIG-16-21-D	Longmont and Colorado Officials Should Continue to Improve Management of $55.1 Million FEMA Grant	1/21/2016
OIG-16-22-D	The City of Austin, Texas, Has Adequate Policies and Procedures to Comply with FEMA Public Assistance Grant Requirements	1/21/2016
OIG-16-23-D	FEMA Should Disallow $1.2 Million of $6.0 Million in Public Assistance Program Grant Funds Awarded to the City of San Diego, California	1/25/2016
OIG-16-24-D	FEMA Should Recover $1.2 Million of $10.1 Million in Grant Funds Awarded to Tuscaloosa, Alabama, for a 2011 Disaster	1/26/2016
OIG-16-33-D	Boulder, Colorado, Has Adequate Policies, Procedures, and Business Practices to Manage Its FEMA Grant Funding	1/29/2016
OIG-16-35-D	Jamestown, Colorado, Needs Additional Assistance and Monitoring to Ensure Proper Management of Its $10.4 Million FEMA Grant	2/2/2016

Report #	Title	Date
OIG-16-36-D	The University of Wisconsin-Superior Effectively Managed FEMA Grant Funds Awarded for Severe Storms and Flooding in June 2012	2/2/2016
OIG-16-38-D	Oakwood Healthcare System, Dearborn, Michigan, Needed Additional Assistance in Managing its FEMA Public Assistance Grant Funding	2/11/2016
OIG-16-40-D	Colorado Springs Utilities, Colorado, Has Adequate Policies, Procedures, and Business Practices to Effectively Manage Its FEMA Public Assistance Grant Funding	2/18/2016
OIG-16-42-D	Colorado Springs, Colorado, Has Adequate Policies, Procedures, and Business Practices to Effectively Manage Its FEMA Public Assistance Grant Funding	2/19/2016
OIG-16-43-D	The Puerto Rico Electric Power Authority Effectively Managed FEMA Public Assistance Grant Funds Awarded for Hurricane Irene in August 2011	3/2/2016
OIG-16-52-D	FEMA Should Recover $312,117 of $1.6 Million Grant Funds Awarded to the Pueblo of Jemez, New Mexico	3/21/2016
OIG-16-60-D	FEMA Should Recover $267,960 of $4.46 Million in Public Assistance Grant Funds Awarded to The Municipality of Juyuya, Puerto Rico, for Hurricane Irene Damages	4/6/2016
OIG-16-63-D	San Bernardino County, California Generally Accounted for and Expended FEMA Public Assistance Funds Properly	4/12/2016
OIG-16-66-D	FEMA Should Disallow $1.30 Million of $2.58 Million in Public Assistance Grant Funds Awarded to the Municipality of Villalba, Puerto Rico, for Hurricane Irene Damages	4/20/2016
OIG-16-67-D	Lyons and Colorado Officials Should Continue to Improve Management of $36 Million FEMA Grant	4/20/2016
OIG-16-78-D	Colorado Should Provide the City of Evans More Assistance in Managing FEMA Grant Funds	5/3/2016
OIG-16-86-D	The West School Administration Effectively Accounted for the FEMA Emergency Grant Funds Awarded for the West, Texas Fertilizer Plant Explosion	5/9/2016
OIG-16-94-D	FEMA Held August-Richmond County, Georgia, Accountable for Not Complying with Federal Contracting Requirements when Managing a 2014 Public Assistance Disaster Grant	5/27/2016
OIG-16-97-D	FEMA Should Recover $51.2 Million in Grant Funds Awarded to Cimarron Electric Cooperative, Kingfisher, Oklahoma	6/8/2016
OIG-16-99-D	FEMA and California Needs to Assist the City of Berkeley to Improve the Management of a $12 Million FEMA Grant	6/8/2016
OIG-17-06-D	FEMA Should Recover $1.8 Million of $5.5 Million in Public Assistance Grant Funds Awarded to Columbia County, Florida, for Tropical Storm Debby Damages	11/2/2016
OIG-17-17-D	Omaha Public Power District in Nebraska Generally Accounted for and Expended FEMA Grant Funds Properly	1/4/2017
OIG-17-18-D	FEMA Should Disallow $2.0 Million of $3.59 Million Awarded to Stratford, Connecticut	1/9/2017
OIG-17-19-D	Western Farmers Electric Cooperative, Oklahoma Has Adequate Policies, Procedures, and Business Practices to Manage Its FEMA Grant	1/10/2017
OIG-17-20-D	FEMA Should Disallow $577,959 of $.29 Million Awarded to Puerto Rico Aqueduct and Sewer Authority for Hurricane Irene Damages	1/10/2017
OIG-17-21-D	Perth Amboy, New Jersey, Effectively Managed FEMA Grant Funds Awarded for Hurricane Sandy Damages	1/12/2017
OIG-17-25-D	Victor Valley Wastewater Reclamation Authority in Victorville, California, Did Not Property Managed $32 Million in FEMA Grant Funds	1/24/2017

Report #	Title	Date
OIG-17-34-D	Columbia County Roads Department, Oregon, Needs Continued State and FEMA Assistance in Managing its FEMA Grant	2/2/2017
OIG-17-35-D	Escambia County, Florida, Has Adequate Policies, Procedures, and Business Practices to Effectively Manage FEMA Grant Funds Awarded to Replace Its Central Booking and Detention Center	2/6/2017

Audit report findings related to this analysis's scope from the OIG involving Federal Highways Administration (FHWA) Emergency Relief funds were too few in number to provide adequate reliability or generalizability. Therefore, only applicable audit findings involving FEMA Public Assistance, described below, were included.

FEMA rules for compliance are grouped into the following categories:

- Procurement process
- Contract provisions
- Cost reasonableness
- Scope of work
- Allocability
- Policies and procedures
- Management and control
- Project delivery

Table C-2: Summary statistics.

Sample size	46			
Unique states and territories	20			
	Average	**Std. Dev**	**Min**	**Max**
Award amount ($mil)	18.03	21.87	0.94	105
Number of violations				
Procurement process	0.85	0.92	0	3
Contract provisions	0.33	0.70	0	3
Cost reasonableness	0.37	0.61	0	2
Scope of work	0.07	0.33	0	2
Allocability	0.74	1.00	0	4
Policies and procedures	0.37	0.85	0	3
Management control	0.63	0.61	0	2
Project delivery	0.11	0.31	0	1
Total violations	3.46	2.98	0	11

Procurement procedure and contract provisions are combined to form pc_i, whereas the sum of the rest forms sv_i. In one alternative model, sv_i also includes cost reasonableness.

The number of violations resulting in DHS OIG audit findings under each category is qualitatively determined based on the audit reports. Audit reports that find rule violations list them by section (e.g. Finding A, B). If more than one rule is broken under any given section, these violations are enumerated by subsections, and these subsections are counted toward their respective categories listed above. If no subsection exists, the finding section counts as one toward its respective category. Audit reports that find no violations present no findings.

While there is no assumption that the audits are randomly assigned, the temporal, geographic, and jurisdictional distributions of the audit subjects are considered herein as good as random (see Table C-3 and Table C-4). As the model is purely descriptive and exploratory, any additional considerations of selection bias are not discussed in the preliminary analysis.

Table C-3: Number of observations by grantee type and scope of jurisdiction.

Grant recipient type	Count
City or municipal government	21
County government	10
Utility	8
Public Education	3
Emergency Medical Services (EMS)	1
Hospital	1
Transportation	1
Indian Tribal government	1

Grant recipient jurisdiction	Count
City, town, or municipality	23
County	11
State	5
Cooperative	2
School District	2
Hospital	1
Indian Tribal government	1
University	1

Table C-4: Observations by disaster type and year.

Disaster Type	Count		Award year	Count
Storm/Flood (non-hurricane)	30		2005	2
Hurricane	12		2007	1
Wild fire	3		2010	1
Industrial	1		2011	7
			2012	7
			2013	13
			2014	6
			2015	9

C.3 Results

The results establish that procurement and contracting compliance violations that resulted in finding by the DHS OIG based on applicable provisions of 44 Code of Federal Regulations (CFR), 2 CFR Part 200, and/or FEMA's Public Assistance Policy Guide (in force when the applicable presidential disaster declaration was declared) are strongly correlated with subsequent compliance violations. The correlation and statistical significance remain stable in all models (Table C-5). This suggests that early disarray and resultant non-compliance of the procurement and contracting process is a warning sign of further Federal non-compliance involving project delivery and may warrant future study. In models 1 through 4, every additional procurement and contracting violation is associated with a 0.6 to 0.7 average increase in subsequent infractions of non-compliance. In model 5, the magnitude is naturally lower when contracting and procurement violations include cost reasonableness measures since the explanatory variable is increased on average at the expense of the dependent variable; and in model 6, the coefficients in the Poisson model are interpreted probabilistically in contrast with the magnitude in the previous models. In both of the latter cases, the statistical significance remains.

It bears repeating that the models are descriptive and do not carry causal interpretation. That said, one possible hypothesis is that agencies that have trouble complying with procurement and contracting law,

regulation, and policy in post-disaster conditions simply lack effective emergency policies and procedures or capabilities, or other resources to comply with additional Federal compliance requirements. In other words, both the failure to comply with allowable procurement and contracting requirements in post-disaster conditions and the failure to follow additional Federal compliance requirements during project delivery may be symptoms of the same organizational challenges. Indeed, if we consider the variables in each category of non-compliance infraction as simply yes or no, (i.e. yes regardless of number of violations in that category and no if there is none), failure to comply with procurement requirements is the most strongly correlated with OIG findings of non-compliance involving management control (Table C-6), a potential reflection of post-disaster administrative stress and disorganization and/or lack of information about applicable law, regulations, and policies required for FEMA Public Assistance Program disaster funding.

Table C-5: Regression results (standard deviation of coefficients and F-statistic omitted).

Dependent variable: subsequent number of violations (total – procurement and contracting)						
Model Number	**1**	**2**	**3**	**4**	**5[1]**	**6**
Model Description	**ROLS**	**ROLS**	**ROLS**	**ROLS**	**ROLS**	**Poisson**
Procurement and Contracting	0.67 ***	0.68 ***	0.70 ***	0.60 ***	0.35 ***	0.24 ***
Award amount		0.03 **	0.03 **	0.03 ***	0.04 ***	0.01 ***
City government			Omitted	Omitted	Omitted	Omitted
County government			-0.40	-0.83	-0.73	-0.41
Emergency Response			0.79	-0.37	-0.09	-0.03
Hospital			-1.83 ***	-1.28 **	-0.21	-0.39**
Public education			-1.1207	-1.69 *	-1.13	-0.81
Transportation			1.00 **	1.38 **	0.62	0.69 ***
Tribal government			-1.39 **	-0.81	-1.07 *	-0.20
Utility			-0.99	-1.01	-0.84	-0.59 *
Storm/Flood				Omitted	Omitted	Omitted
Hurricane				1.39 **	1.40 **	0.56 **
Industrial				-1.13 *	-0.78 *	-13.48 ***
Wild fire				2.34 **	2.49 **	-0.89 ***
Constant	1.49 ***	0.91 **	1.24 **	0.95	0.60	0.14
R-squares	0.2105	0.328	0.401	0.5359	0.5502	0.2303[2]
N	46	46	46	46	46	46
p-value	* < 0.1	** < 0.05	*** < 0.01			

[1] Procurement and contracting violations include cost reasonableness and subsequent violations do not.
[2] Pseudo R^2.

Table C-6: Correlation matrix for violation categories as binary variables.

	Procurement and contract	Cost reasonableness	Scope of work	Allocability	Management Control	Project delivery
Procurement and contract	1					
Cost reasonableness	0.3495	1				
Scope of work	-0.0093	0.0907	1			
Allocability	0.3533	0.0577	0.0186	1		
Management Control	0.6527	0.2942	0.187	0.3636	1	
Project delivery	0.1945	0.2244	-0.0745	0.1006	0.1654	1

Some additional observations include:

- There is a statistically significant, but quantitatively negligible, positive correlation between the number of subsequent violations and award amount that persists among the models. This could simply be due to larger projects are subject to stricter management controls or other reasons, but it could also be a spurious relationship.
- The number of subsequent violations is notably and statistically significantly higher for hurricane-related events than for local storm and flood events. Such relationship also exists for total number of violations, although the statistical significance is somewhat diminished (statistics not shown). This relationship can be further investigated to explore the difference in emergency response effectiveness based on disaster scale and magnitude between large regional events (such as tropical storm) and local events (localized storms and floods, high wind, tornados, etc.).
- The analysis does not find any statistically significant relationship between total number of violations and grantee organization type (statistics not shown).

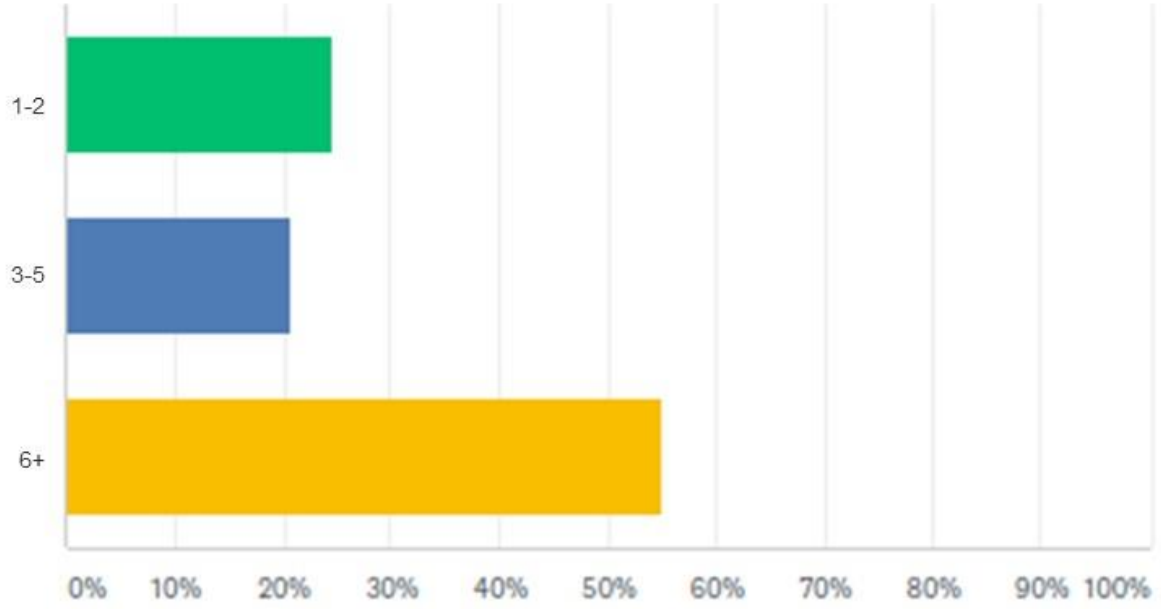
The multi-variate statistical analysis establishes important correlations that may warrant future investigations.

Appendix D:
Practitioner Survey

This appendix provides the full complement of questions and answers from the AECOM Disaster Cadre practitioner survey in graphic presentation style.

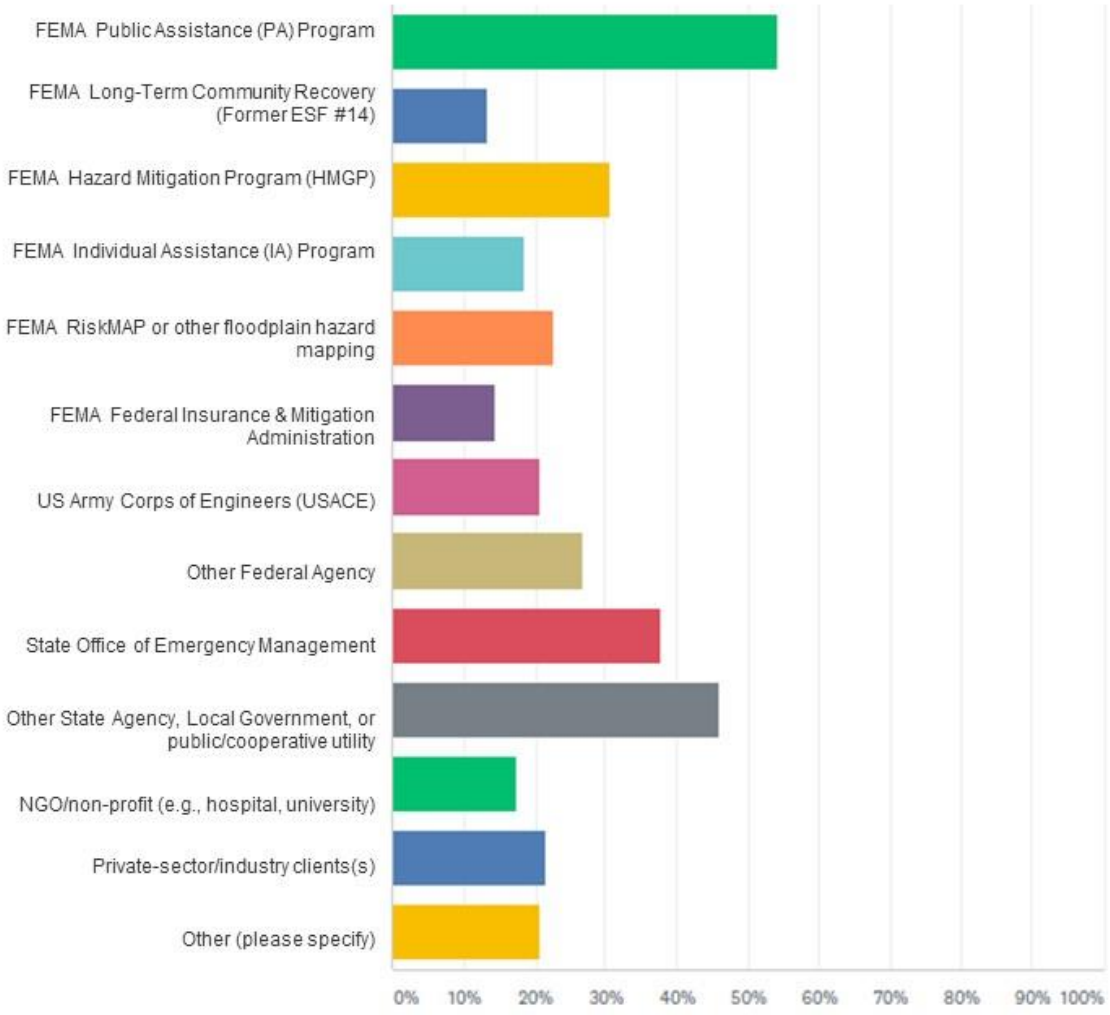
The survey was conducted through Survey Monkey. The survey received a total of 103 responses. All questions were optional. The survey provides a summary snapshot of narrative comments shared by survey respondents who each have an average of 6 or more years of disaster readiness, rapid response, and resilient recovery experience.

Q1: How many disaster-related clients/applicants have you supported in your career?



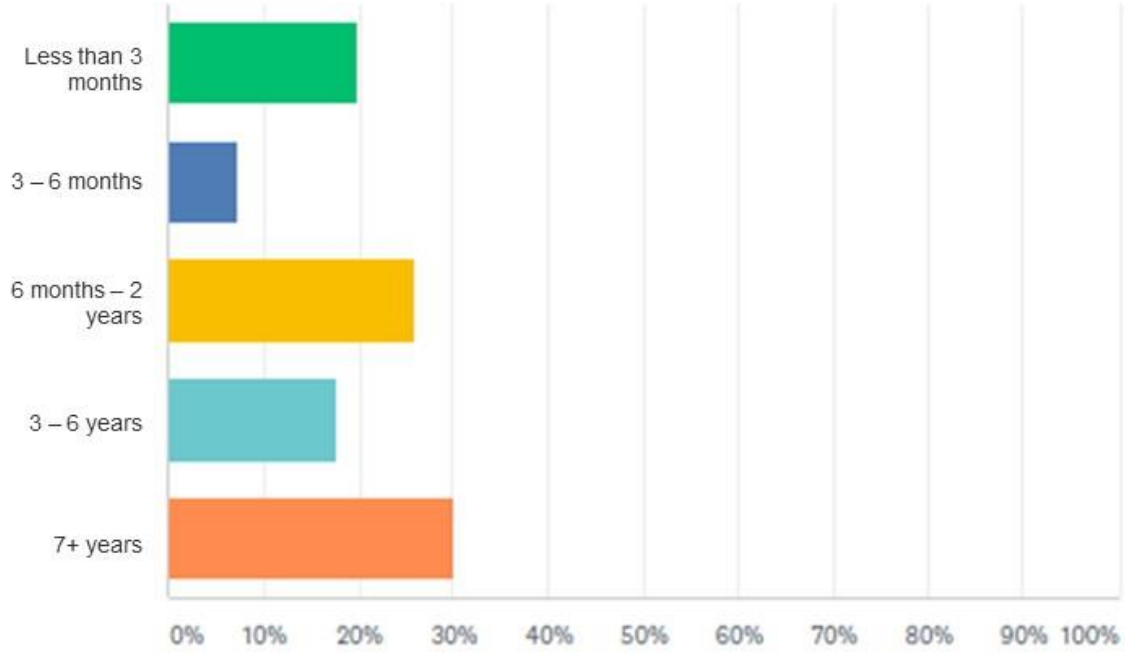
ANSWER CHOICES	RESPONSES	
1-2	24.51%	25
3-5	20.59%	21
6+	54.90%	56
TOTAL		102

Q2: Which organizations/directorates have you been mobilized to support? (check all that apply):



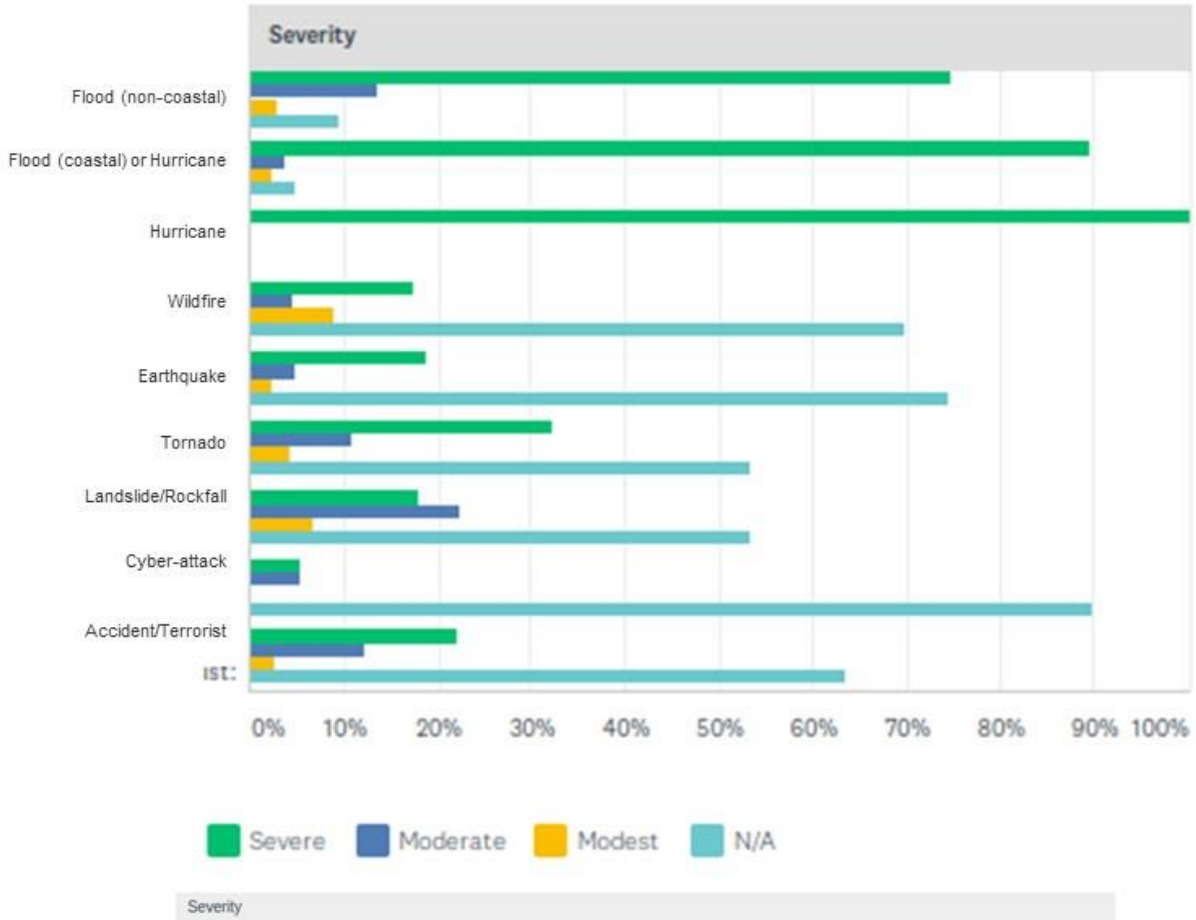
ANSWER CHOICES	RESPONSES	
FEMA Public Assistance (PA) Program	54.08%	53
FEMA Long-Term Community Recovery (former ESF #14)	13.27%	13
FEMA Hazard Mitigation Program (HMGP)	30.61%	30
FEMA Individual Assistance (IA) Program	18.37%	18
FEMA RiskMAP or other floodplain hazard mapping	22.45%	22
FEMA Federal Insurance & Mitigation Administration	14.29%	14
US Army Corps of Engineers (USACE)	20.41%	20
Other Federal Agency	26.53%	26
State Office of Emergency Management	37.76%	37
Other State Agency, Local Government, or public/cooperative utility	45.92%	45
Non-governmental agency (NGO)/non-profit (e.g. hospital, university)	17.35%	17
Private-sector/industry client(s)	21.43%	21
Other (please specify)	20.41%	20
Total Respondents: 98		

Q3: How much total time have you spent disaster deployed for response and recovery operations?



ANSWER CHOICES	RESPONSES	
Less than 3 months	19.59%	19
3 - 6 months	7.22%	7
6 months - 2 years	25.77%	25
3 - 6 years	17.53%	17
7+ years	29.90%	29
TOTAL		97

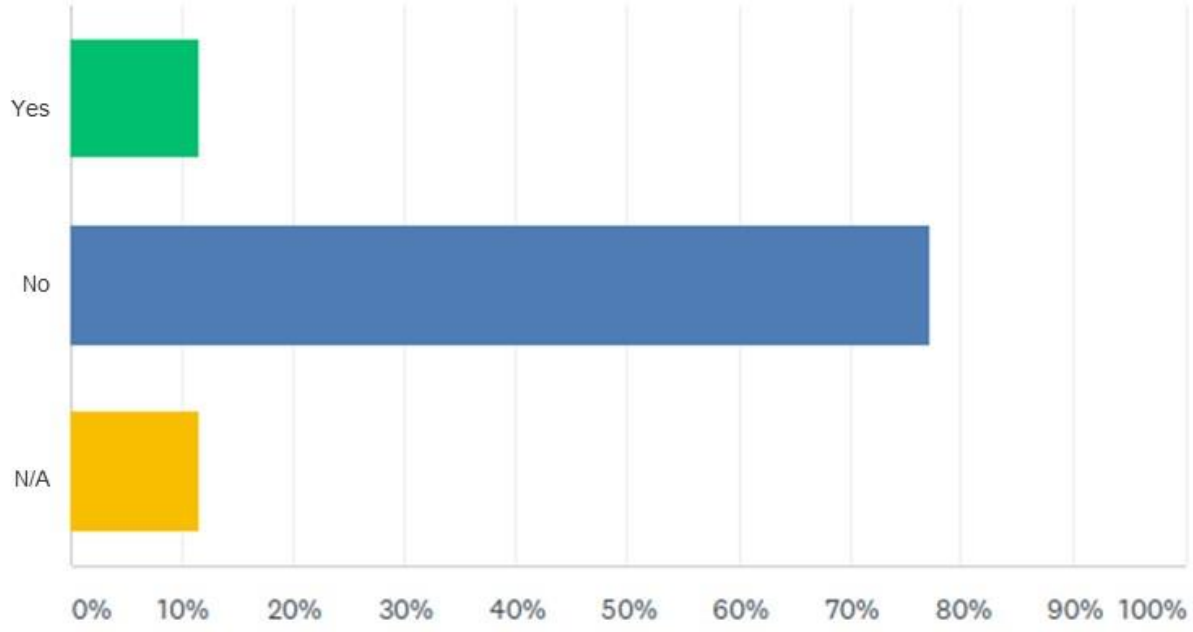
Q4: Please describe severity of event impacts for the types of disasters you have mobilized for:



Severity

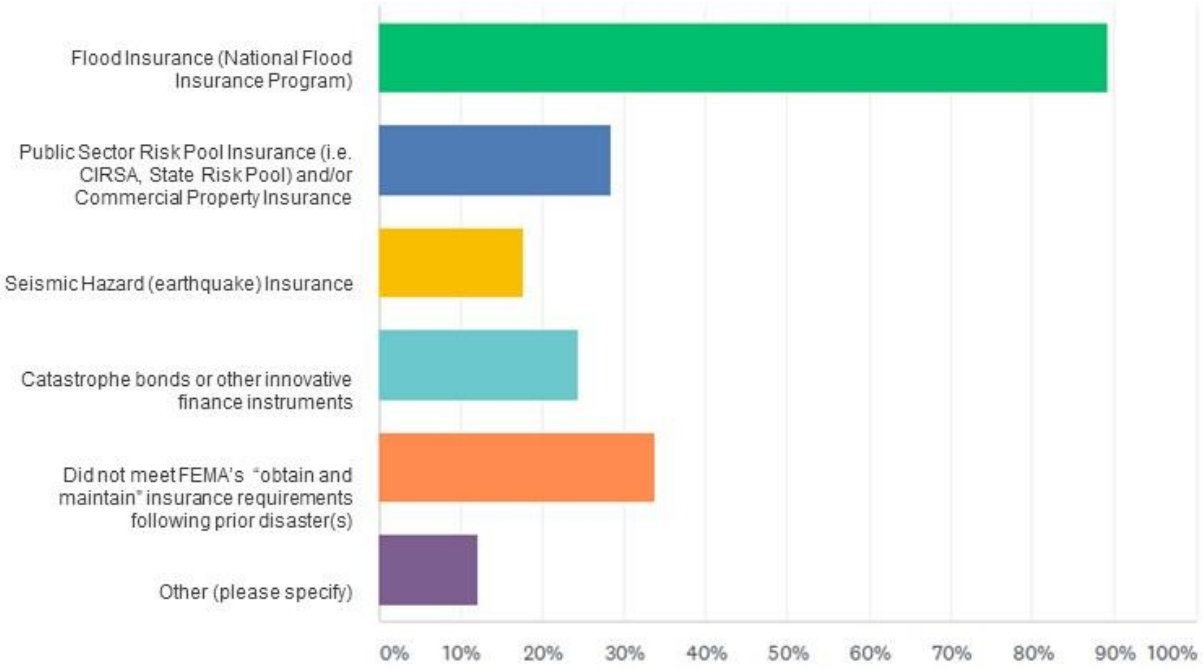
	SEVERE	MODERATE	MODEST	N/A	TOTAL
Flood (non-coastal):	74.67% 56	13.33% 10	2.67% 2	9.33% 7	75
Flood (coastal) or Hurricane:	89.29% 75	3.57% 3	2.38% 2	4.76% 4	84
Hurricane:	100.00% 1	0.00% 0	0.00% 0	0.00% 0	1
Wildfire:	17.39% 8	4.35% 2	8.70% 4	69.57% 32	46
Earthquake:	18.60% 8	4.65% 2	2.33% 1	74.42% 32	43
Tornado:	31.91% 15	10.64% 5	4.26% 2	53.19% 25	47
Landslide/Rockfall:	17.78% 8	22.22% 10	6.67% 3	53.33% 24	45
Cyber-attack:	5.13% 2	5.13% 2	0.00% 0	89.74% 35	39
Accident/Terrorist:	21.95% 9	12.20% 5	2.44% 1	63.41% 26	41

Q5: In general, applicants are adequately insured for disaster losses:



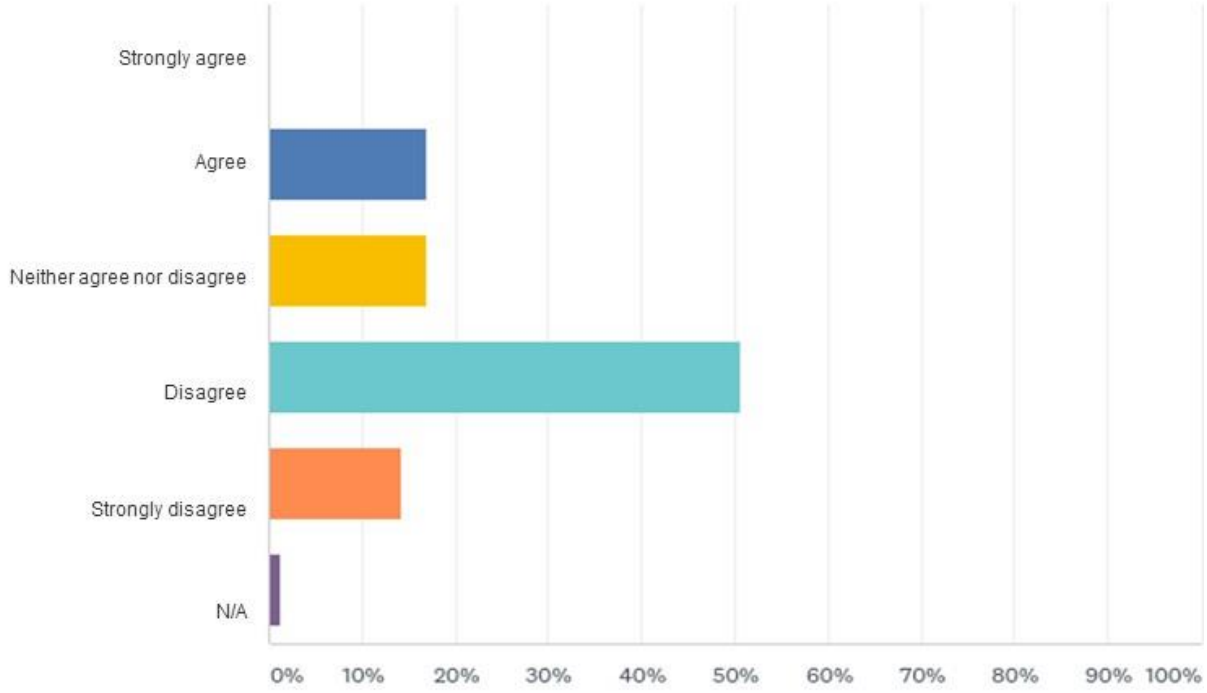
ANSWER CHOICES	RESPONSES	
Yes	11.46%	11
No	77.08%	74
N/A	11.46%	11
TOTAL		96

Q6: If No, for what type(s) of insurance do applicants sometimes lack adequate coverage (check all that apply):



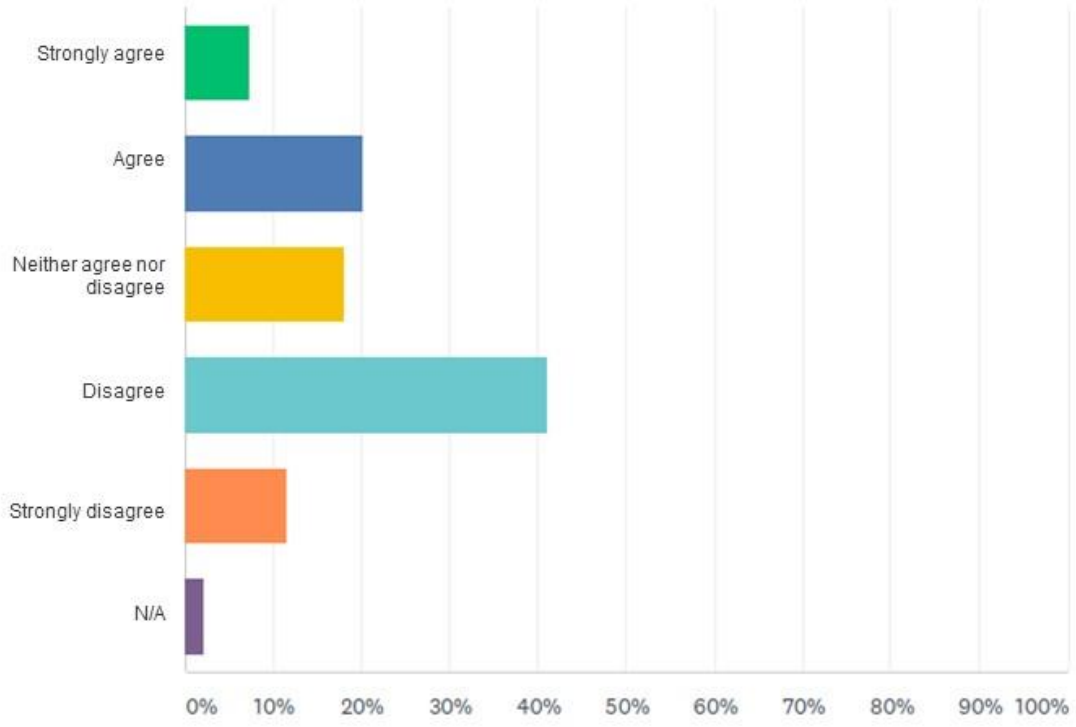
ANSWER CHOICES	RESPONSES	
Flood Insurance (National Flood Insurance Program)	89.19%	66
Public Sector Risk Pool Insurance (i.e. CIRSA, State Risk Pool) and/or Commercial Property Insurance	28.38%	21
Seismic Hazard (earthquake) Insurance	17.57%	13
Catastrophe bonds or other innovative finance instruments	24.32%	18
Did not meet FEMA's "obtain and maintain" insurance requirements following prior disaster(s)	33.78%	25
Other (please specify)	12.16%	9
Total Respondents: 74		

Q7: Applicants have a clear understanding of hazards and vulnerabilities related to the assets/facilities they own/control:



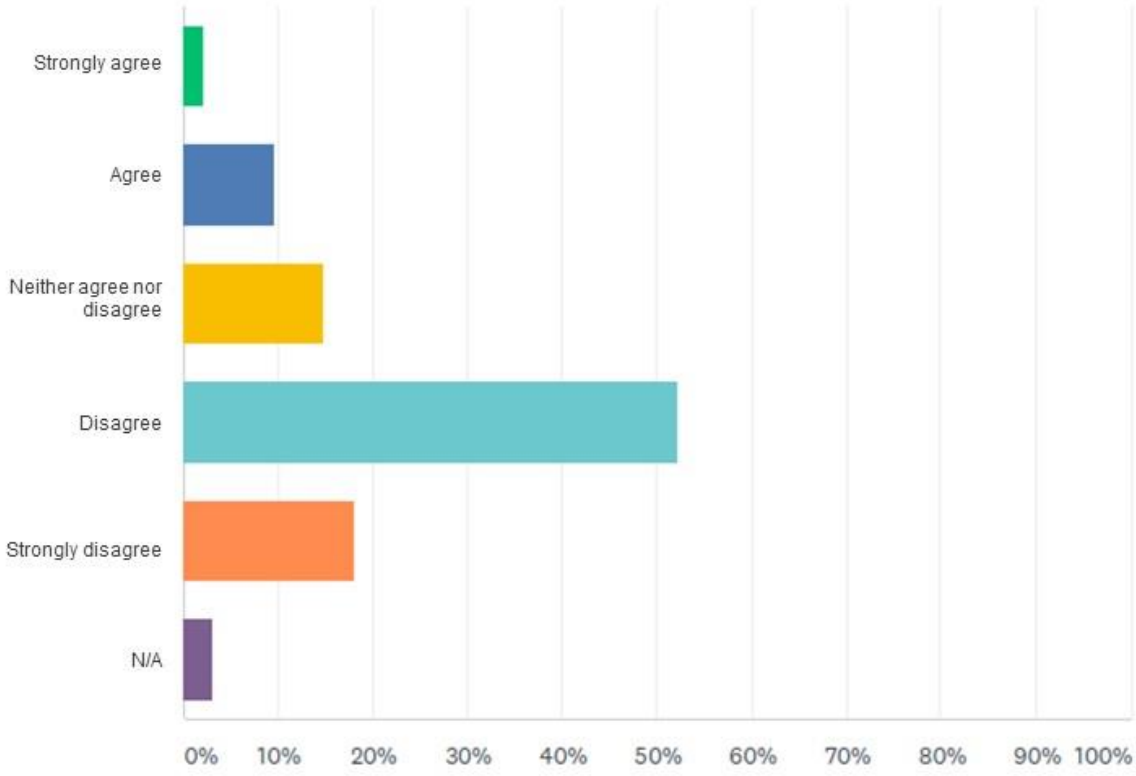
ANSWER CHOICES	RESPONSES	
Strongly agree	0.00%	0
Agree	20.00%	19
Neither agree nor disagree	18.95%	18
Disagree	47.37%	45
Strongly disagree	12.63%	12
N/A	1.05%	1
TOTAL		95

Q8: Applicants have a clear understanding of how to restore temporary assets/repairs quickly:



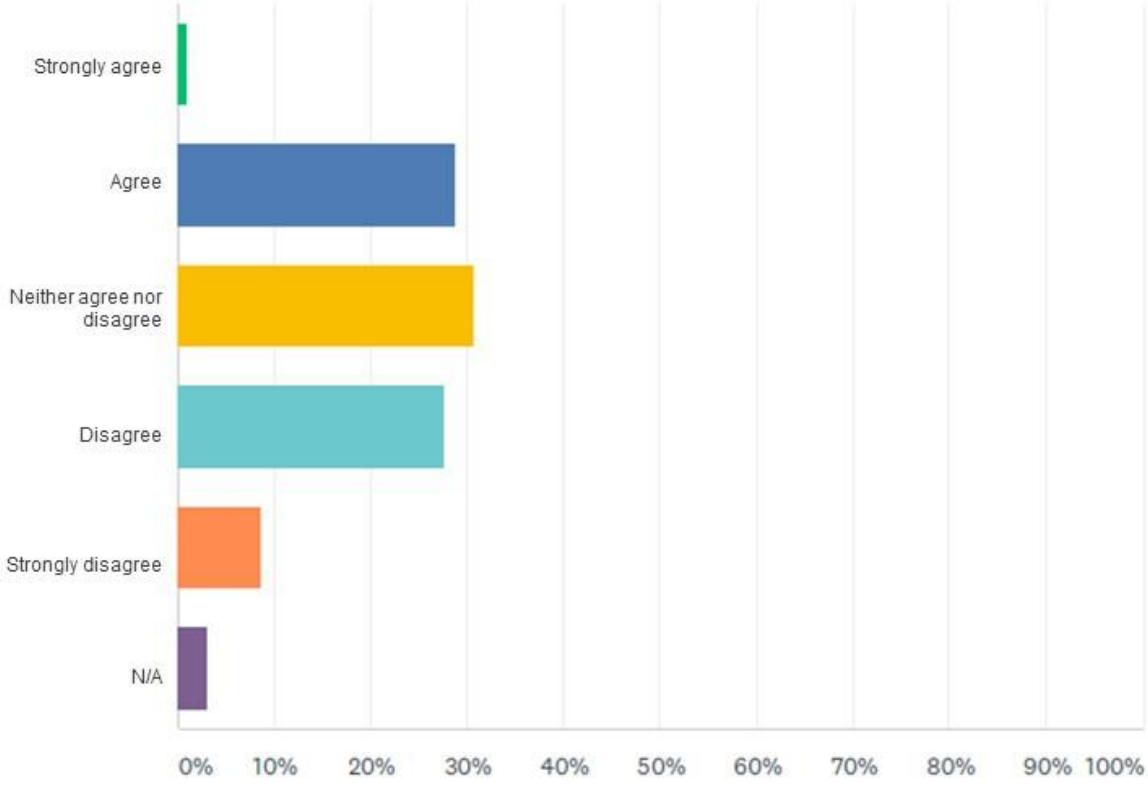
ANSWER CHOICES	RESPONSES	
Strongly agree	7.37%	7
Agree	20.00%	19
Neither agree nor disagree	17.89%	17
Disagree	41.05%	39
Strongly disagree	11.58%	11
N/A	2.11%	2
TOTAL		95

Q9: Applicants have a clear understanding of the level of effort required for resilient, long-term recovery:



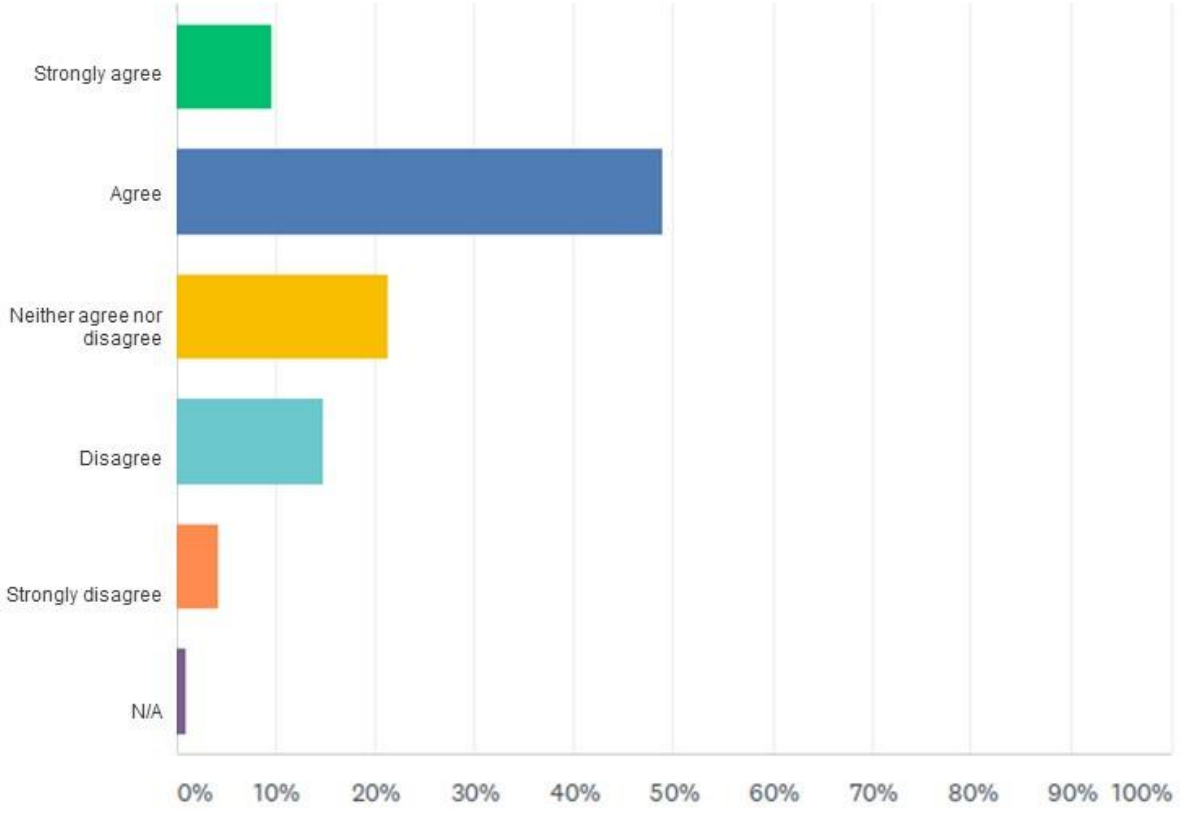
ANSWER CHOICES	RESPONSES	
Strongly agree	2.13%	2
Agree	9.57%	9
Neither agree nor disagree	14.89%	14
Disagree	52.13%	49
Strongly disagree	18.09%	17
N/A	3.19%	3
TOTAL		94

Q10: Applicants are significantly reducing risks to physical assets/facilities through increased hazard mitigations/resilience:



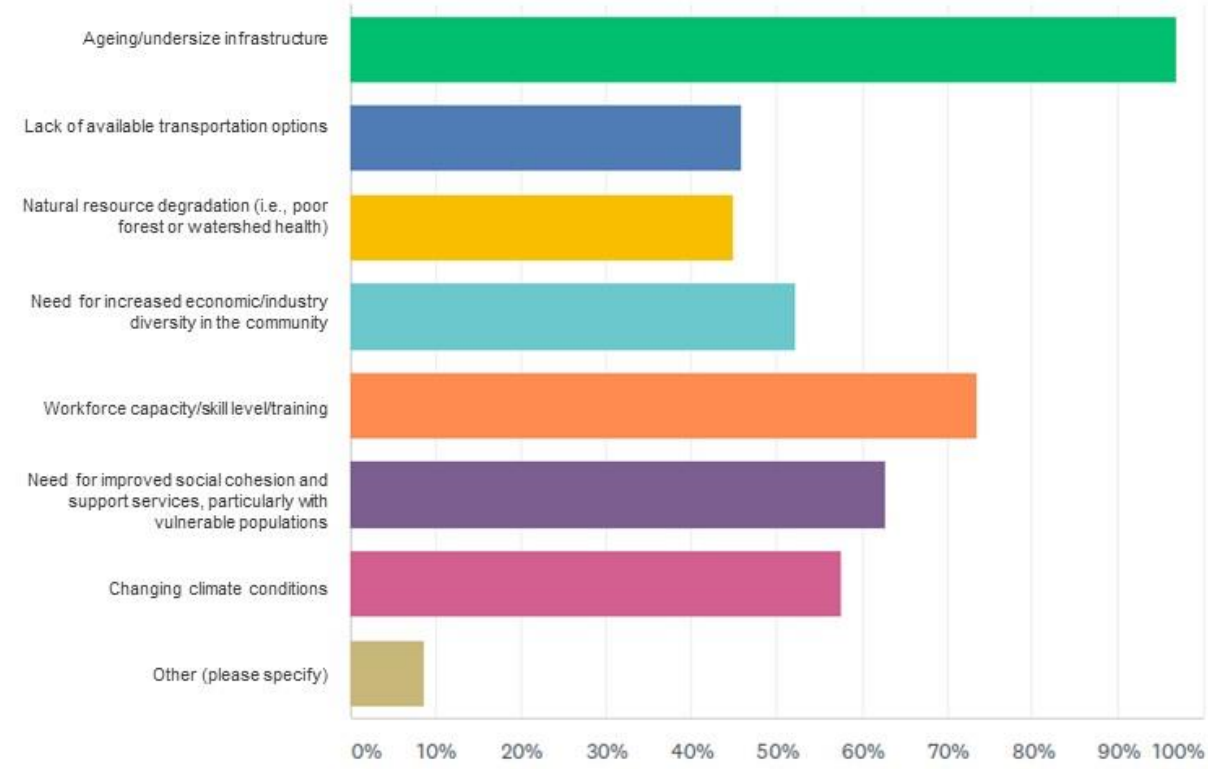
ANSWER CHOICES	RESPONSES	
Strongly agree	1.06%	1
Agree	28.72%	27
Neither agree nor disagree	30.85%	29
Disagree	27.66%	26
Strongly disagree	8.51%	8
N/A	3.19%	3
TOTAL		94

Q11: Applicants are much better prepared for subsequent events after recovering from a major or catastrophic disaster:



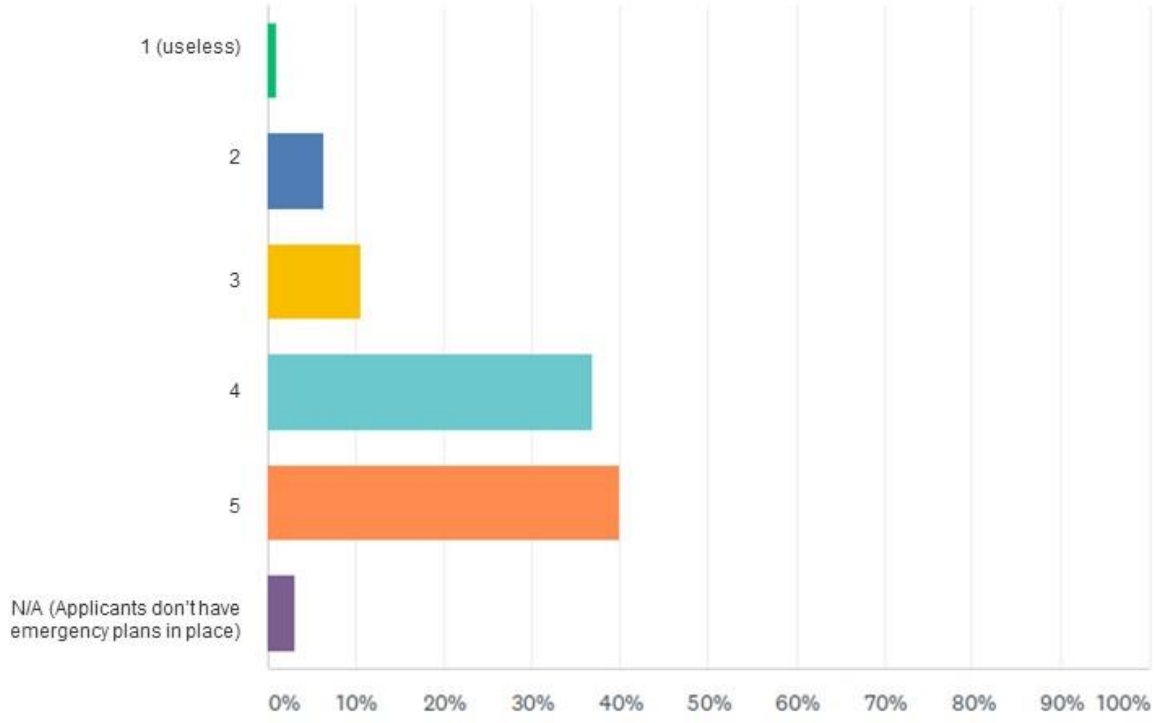
ANSWER CHOICES	RESPONSES	
Strongly agree	9.57%	9
Agree	48.94%	46
Neither agree nor disagree	21.28%	20
Disagree	14.89%	14
Strongly disagree	4.26%	4
N/A	1.06%	1
TOTAL		94

Q12: The following chronic stresses are a threat to response and recovery operations (check all that apply):



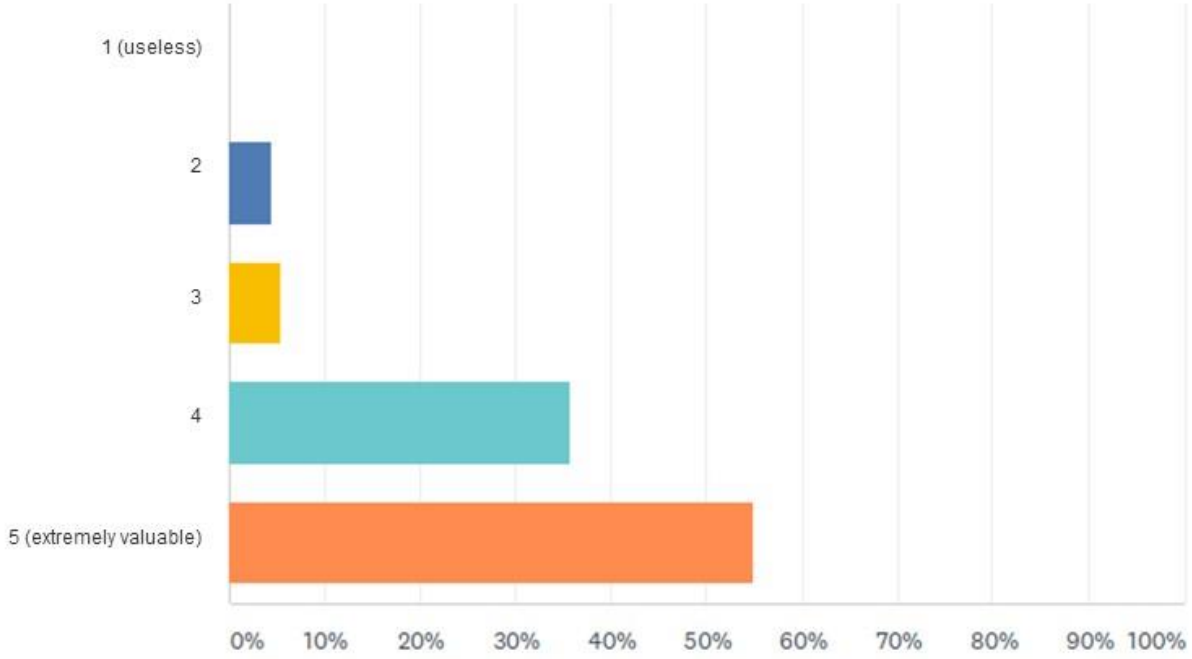
ANSWER CHOICES	RESPONSES	
Aging/undersized Infrastructure	96.81%	91
Lack of available transportation options	45.74%	43
Natural resource degradation (i.e. poor forest or watershed health)	44.68%	42
Need for increased economic/industry diversity in the community	52.13%	49
Workforce capacity/skill level/training	73.40%	69
Need for improved social cohesion and support services, particularly with vulnerable populations	62.77%	59
Changing climate conditions	57.45%	54
Other (please specify)	8.51%	8
Total Respondents: 94		

Q13: ...Prioritization/use of emergency plans by state, local and federal agencies in advance of major disasters:



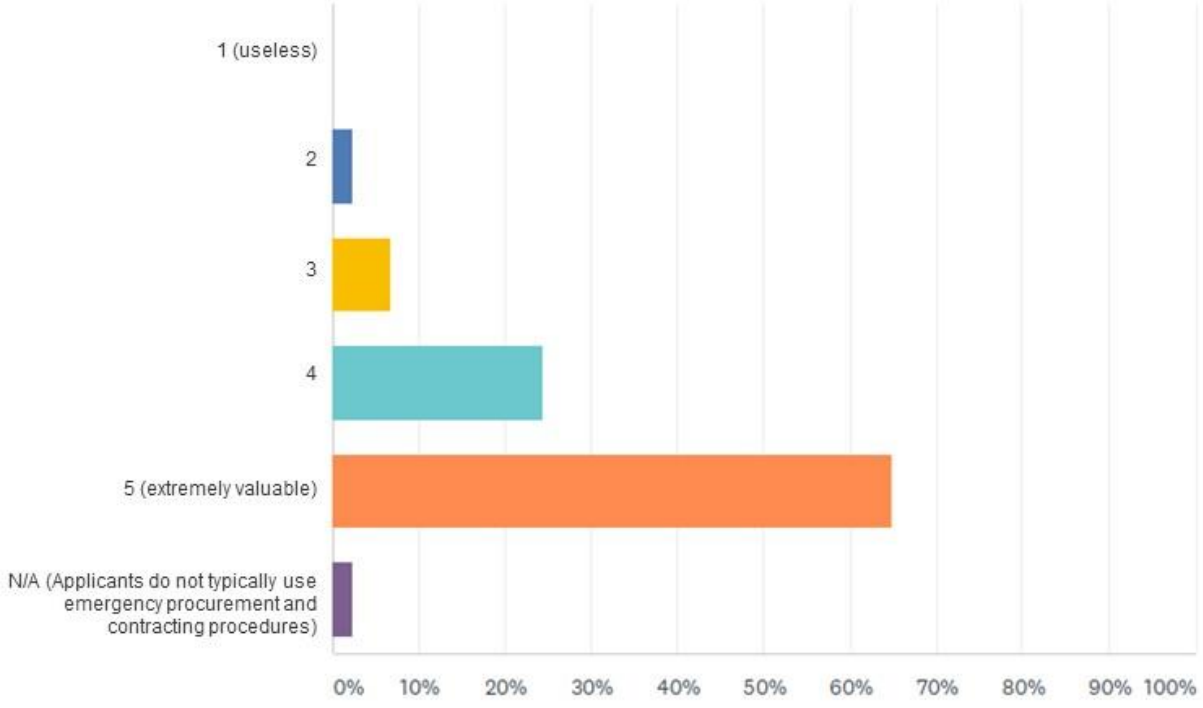
ANSWER CHOICES	RESPONSES	
1 (useless)	1.05%	1
2	6.32%	6
3	10.53%	10
4	36.84%	35
5 (extremely valuable)	40.00%	38
N/A (Applicants don't have emergency plans in place)	3.16%	3
TOTAL		95

Q14: ...Pre-disaster relationships in place between federal/state/local agency professionals:



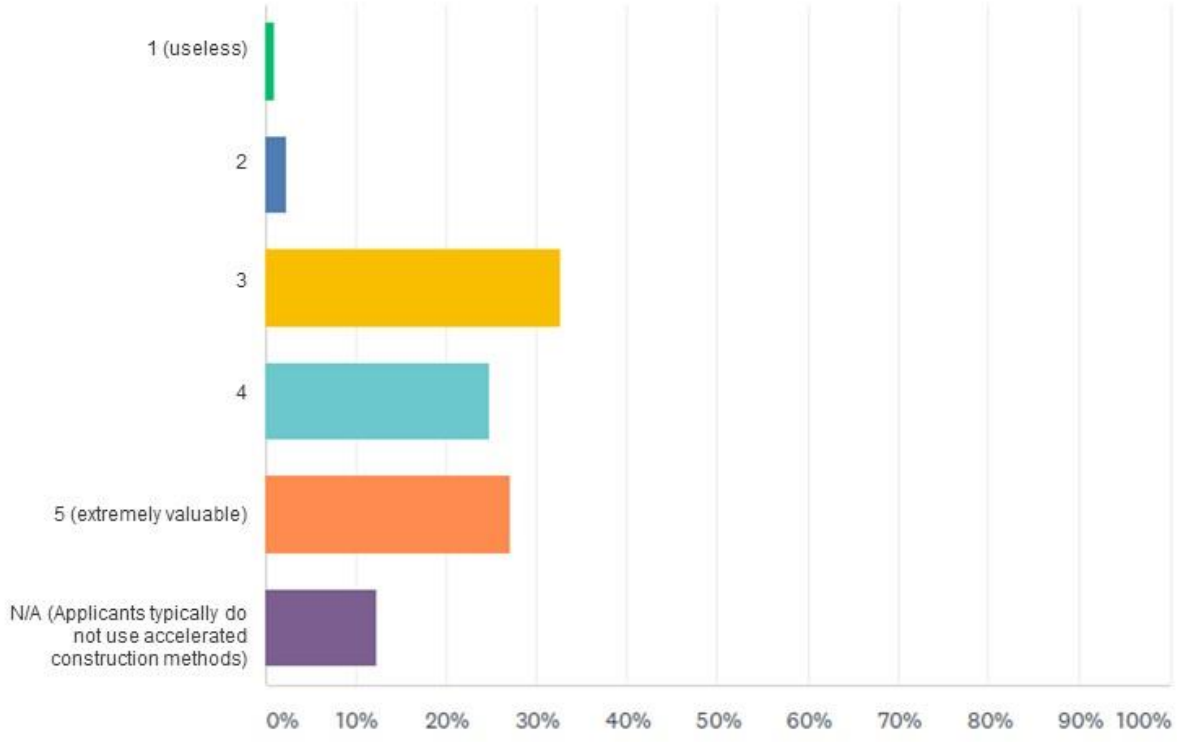
ANSWER CHOICES	RESPONSES	
1 (useless)	0.00%	0
2	4.30%	4
3	5.38%	5
4	35.48%	33
5 (extremely valuable)	54.84%	51
TOTAL		93

Q15: ...Using flexible emergency procedures including emergency procurement and/or having contracting in place pre-disaster:



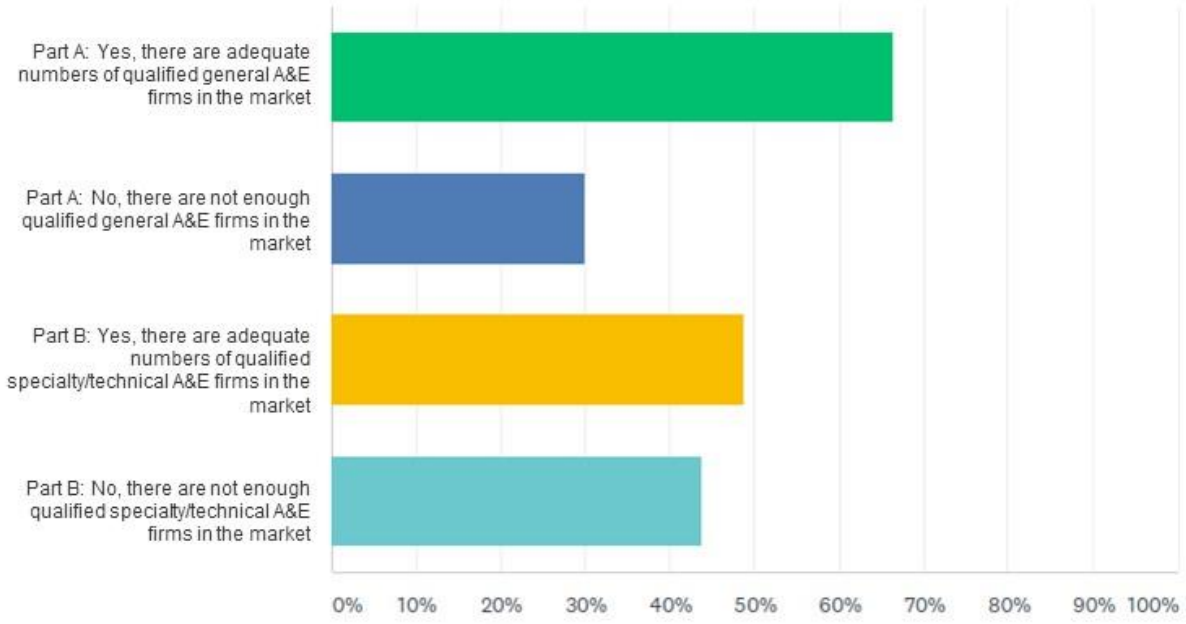
ANSWER CHOICES	RESPONSES	
1 (useless)	0.00%	0
2	2.20%	2
3	6.59%	6
4	24.18%	22
5 (extremely valuable)	64.84%	59
N/A (Applicants do not typically use emergency procurement and contracting procedures)	2.20%	2
TOTAL		91

Q16: ...Applicant use of accelerated construction methods such as design-build or construction manager/general contractor (CMGC) on major projects is:



ANSWER CHOICES	RESPONSES	
1 (useless)	1.12%	1
2	2.25%	2
3	32.58%	29
4	24.72%	22
5 (extremely valuable)	26.97%	24
N/A - (Applicants typically do not use accelerated construction methods)	12.36%	11
TOTAL		89

Q17: Do applicants attract adequate numbers of qualified architecture and engineering (A&E) firms, post-disaster (2-part question, select all that apply):

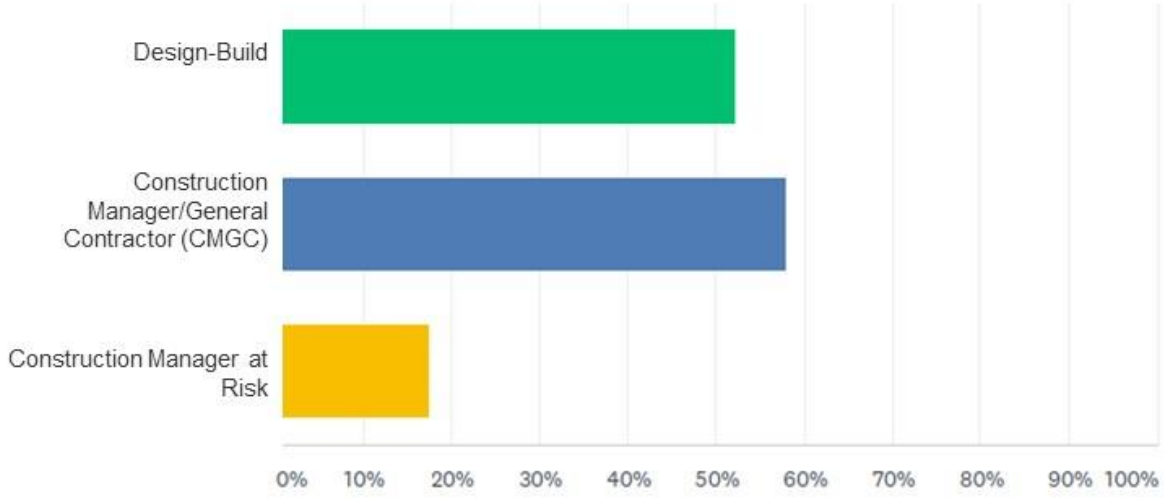


ANSWER CHOICES	RESPONSES	
Part A: Yes, there are adequate numbers of qualified general A&E firms in the market	66.25%	53
Part A: No, there are not enough qualified general A&E firms in the market	30.00%	24
Part B: Yes, there are adequate numbers of qualified specialty/technical A&E firms in the market	48.75%	39
Part B: No, there are not enough qualified specialty/technical A&E firms in the market	43.75%	35
Total Respondents: 80		

Q18: Do applicants attract adequate numbers of qualified construction contractors, post-disaster (2-part question, select all that apply):

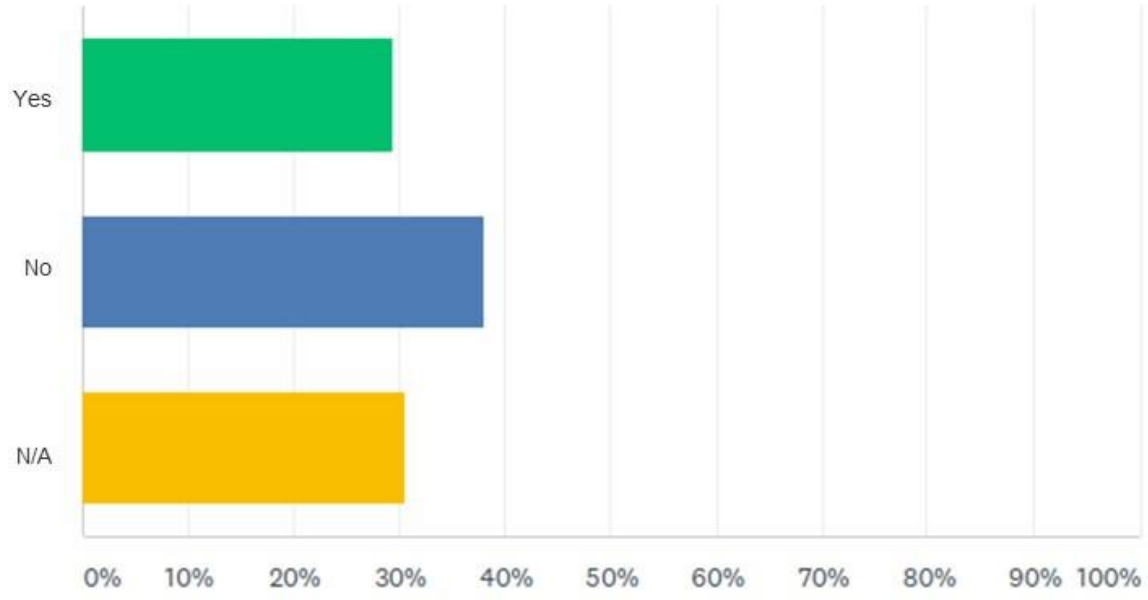
ANSWER CHOICES	RESPONSES	
Part A: Yes, there are adequate numbers of qualified general construction companies in the market	52.56%	41
Part A: No, there are not enough qualified general construction companies in the market	46.15%	36
Part B: Yes, there are adequate numbers of qualified specialty subcontractors and craft workers in the market	34.62%	27
Part B: No, there are not enough qualified specialty subcontractors and craft workers in the market	61.54%	48
Total Respondents: 78		

Q19: In your experience, which Accelerated Construction Techniques are most effective in shortening recovery time, post-disaster?



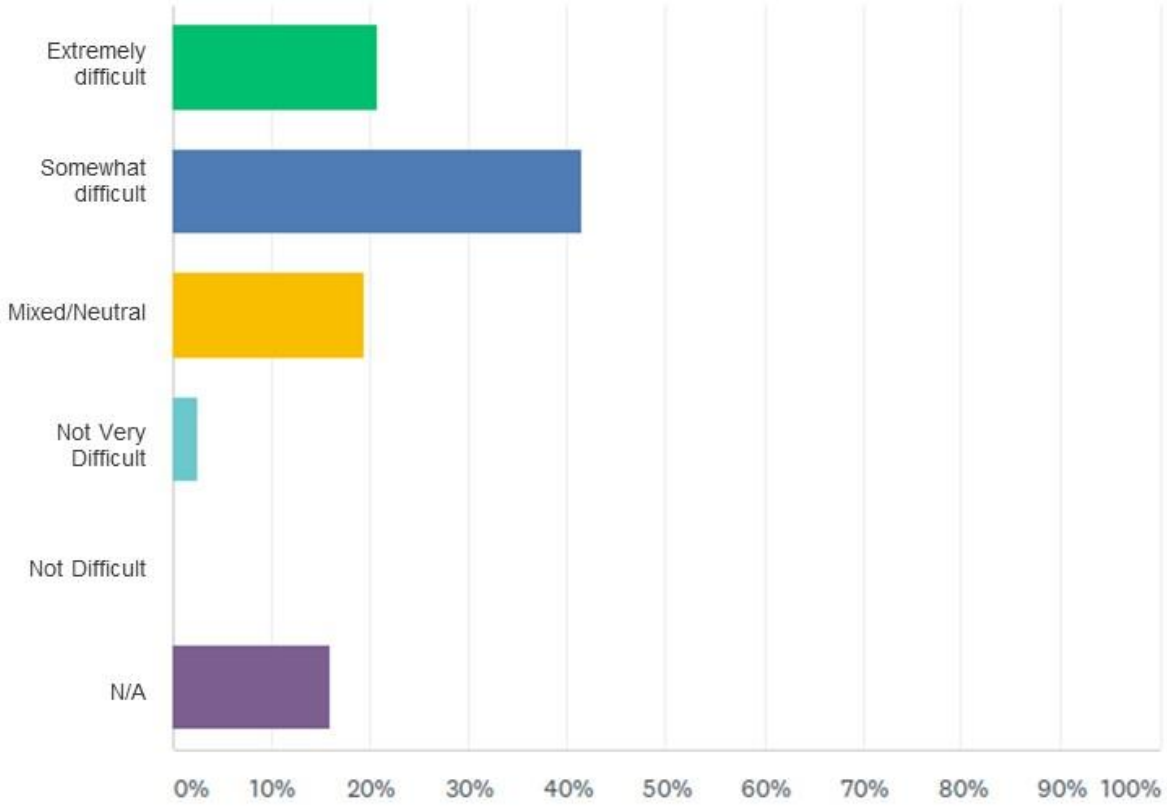
ANSWER CHOICES	RESPONSES	
Design-Build	52.17%	36
Construction Manager/General Contractor (CMGC)	57.97%	40
Construction Manager at Risk	17.39%	12
Total Respondents: 69		

Q20: In your experience, are mega-projects ($300M-$2B+) effective in shortening recovery time, post-disaster?



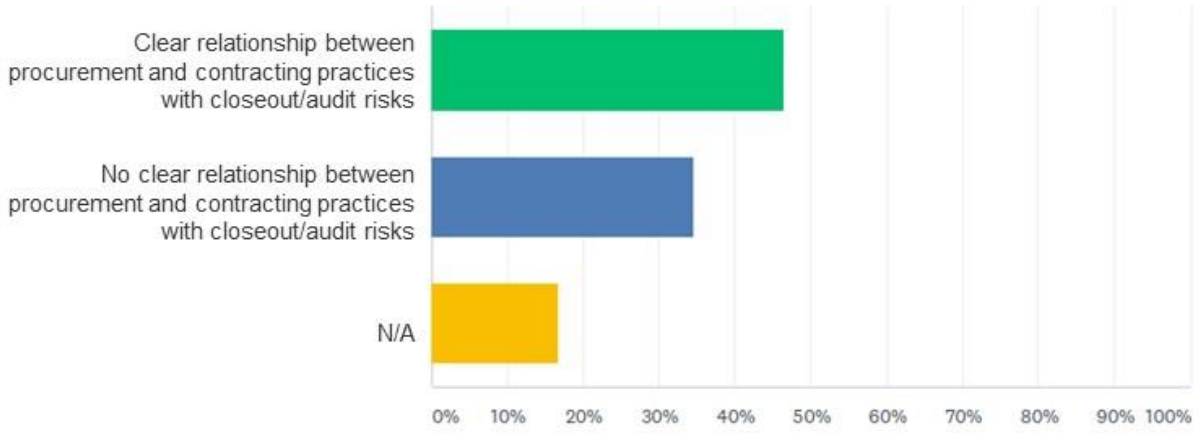
ANSWER CHOICES	RESPONSES	
Yes	29.27%	24
No	37.80%	31
N/A	30.49%	25
TOTAL		82

Q21: Please tell us if applicants have difficulty procuring and fabricating materials including long-lead items post-disaster:



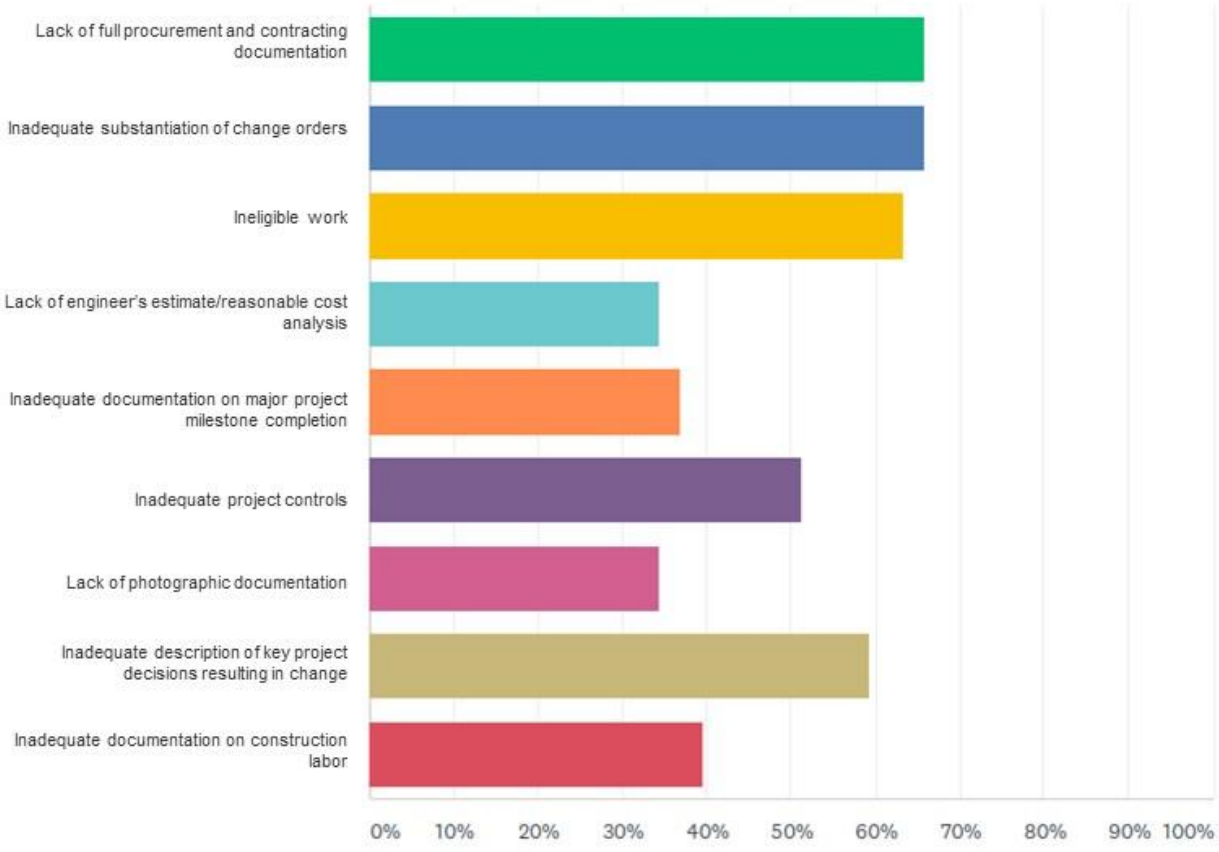
ANSWER CHOICES	RESPONSES	
Extremely difficult	20.73%	17
Somewhat difficult	41.46%	34
Mixed/Neutral	19.51%	16
Not Very Difficult	2.44%	2
Not Difficult	0.00%	0
N/A	15.85%	13
TOTAL		82

Q22: Please share observations about the relationship between procurement/contracting and closeout/audit risks:



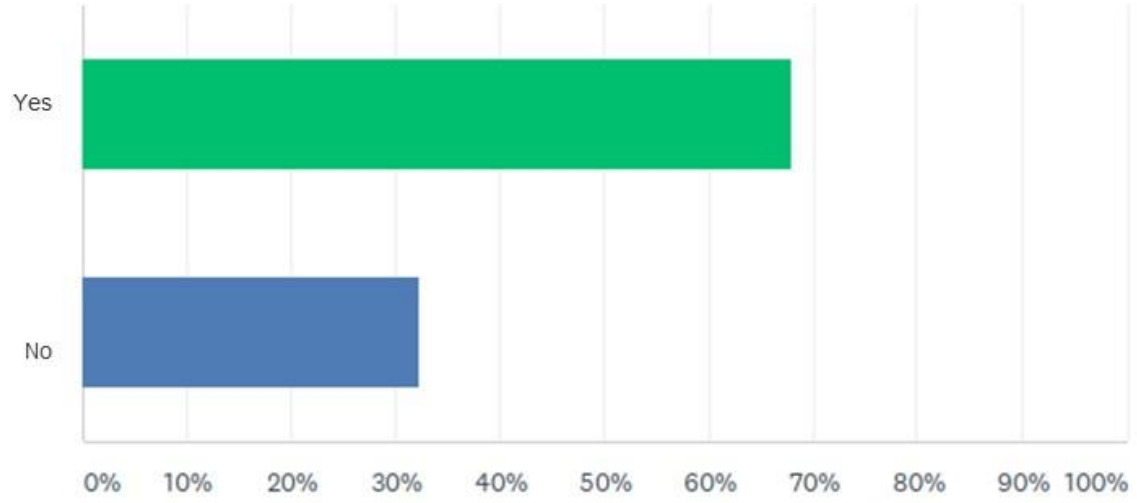
ANSWER CHOICES	RESPONSES	
Clear relationship between procurement and contracting practices with closeout/audit risks	46.43%	39
No clear relationship between procurement and contracting practices with closeout/audit risks	34.52%	29
N/A	16.67%	14
TOTAL		84

Q23: What are the most common challenges you have observed with applicant's closeout/document control on disaster projects (check all):



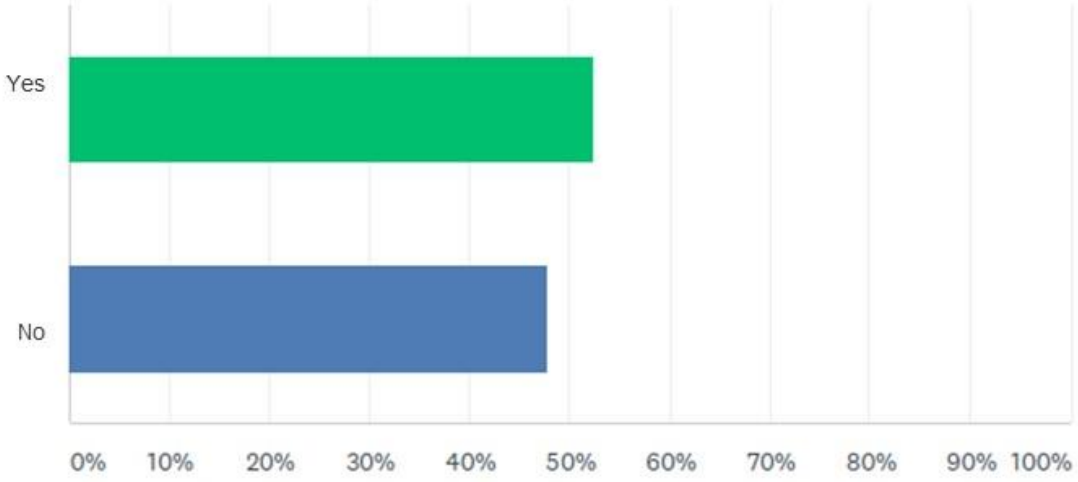
ANSWER CHOICES	RESPONSES	
Lack of full procurement and contracting documentation	65.79%	50
Inadequate substantiation of change orders	65.79%	50
Ineligible work	63.16%	48
Lack of engineer's estimate/reasonable cost analysis	34.21%	26
Inadequate documentation on major project milestone completion	36.84%	28
Inadequate project controls	51.32%	39
Lack of photographic documentation	34.21%	26
Inadequate description of key project decisions resulting in changes	59.21%	45
Inadequate documentation on construction labor	39.47%	30
Total Respondents: 76		

Q24: May the research team contact you about your comments?



ANSWER CHOICES	RESPONSES	
Yes	67.82%	59
No	32.18%	28
TOTAL		87

Q25: Would you be willing to have your name and observations appear in Contracting Strategies Guidebook for Administration of Concurrent, Regional Emergencies, a guidebook that the National Cooperative Highway Research Program selected AECOM to research and write? You would be able to review and authorize any comments prior to publication.



ANSWER CHOICES	RESPONSES	
Yes	52.33%	45
No	47.67%	41
TOTAL		86

Appendix E: Post-Disaster Funding Summary and Key Federal Guidance

The importance of federal guidance and disaster funding in concurrent regional emergencies cannot be overstated. However, to include the major rules of engagement governing awards, expenditures, and compliance would unduly weigh down the findings and recommendations, interrupting its cadence and flow, and decreasing utilization. Appendix E provides a place to include current, mission-critical federal guidance for easy reference.

E.1 Federal Regulatory Requirements on Resilient Transportation Assets

The following presents excerpts direct text from FHWA's Integrating Resilience into the Transportation Planning Process: White Paper on Literature Review Findings, Appendix B (Federal Highway Administration, 2018).

FHWA Integrating Resilience into the Transportation Planning Process: White Paper on Literature Review Findings

Appendix B: Legal Requirements to Integrate Resilience

Federal Requirements

Although State DOTs and MPOs have many reasons for considering resilience, several federal laws and regulations establish requirements that they do so. This appendix provides an overview of the regulatory requirements to incorporate resilience, followed by other, nonbinding guidance that may influence State DOTs and MPOs to integrate resilience into their planning processes.

Federal Planning Requirements for State DOTs and MPOs

In establishing resiliency in transportation planning as being in the national interest (See, e.g., 23 U.S.C. 134(a)(1).), the FAST Act (Pub. L. No. 114-94) added the following requirements to the planning processes of State DOTs and MPOs:

- Transportation planning processes must consider options to "improve the resiliency and reliability of the transportation system and reduce or mitigate stormwater impacts of surface transportation (23 U.S.C. 135(d) and 134(h); see also 49 U.S.C. 5304(d) and 5303(h))." State DOTs, in addition to considering, must also "implement."
- MPOs' long-range plans must also include an "assessment of capital investment and other strategies to . . . reduce the vulnerability of the existing transportation infrastructure to natural disasters (23 C.F.R. 450.324(g)(7))."

U.S. DOT's regulations on transportation planning recommend that MPOs consult with state and local agencies whose planning activities might relate to transportation, including those working on natural disaster risk reduction (23 C.F.R. 450.316(b)). After the passage of the FAST Act, U.S. DOT updated its MPO and statewide planning regulations to incorporate the revised language provided above.

Regulations for Facilities Repeatedly Damaged by Emergencies

For "roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events," U.S. DOT's regulations also require State DOTs to

evaluate whether "there are reasonable alternatives" (23 C.F.R. 667) leaving room to interpret what is meant by "alternatives." State DOTs must complete these evaluations by November 23, 2018, and update the evaluations every four years and as needed to add facilities to the list of facilities that have experienced repeat damage. State DOTs must consider these evaluations during project development, and the regulations encourage State DOTs and MPOs to consider "the evaluations during the development of transportation plans and programs, including TIPS and STIPs, and during the environmental review process."

Transportation Asset Management Plans

By April 30, 2018, State DOTs must develop their TAMPs and meet the following requirements:

- Establish a process for planning for the full life cycle of assets, including how to consider "information on current and future environmental conditions including extreme weather events, climate change, and seismic activity" (23 C.F.R. 515.7(b)).
- Establish a process for developing a risk-based management plan (23 C.F.R. 515.7(c)), including:
  - Identifying risks from "current and future environmental conditions, such as extreme weather events, climate change, seismic activity, and risks related to recurring damage and costs as identified" in the evaluation of facilities repeatedly damaged by emergency events (discussed above)
  - Assessing the likelihood of risks, prioritizing among risks, and developing a mitigation and monitoring approach regarding the highest priority risks
  - Summarizing their evaluation of facilities repeatedly damaged by emergency events (discussed above)
- Include a description of the condition of transportation facilities in the state, which "should be informed by" their evaluation of facilities repeatedly damaged by emergency events (23 C.F.R. 515.9(d)).
- Include a "risk management analysis" related to the evaluation of facilities repeatedly damaged by emergency events.
- Integrate the TAMP into the transportation planning processes used to develop the STIP.

Other Regulations and Guidance

Other federal regulations and guidance emphasize the importance of considering resilience but do not place requirements on State DOTs and MPOs. The FAST Act established a goal of the National Highway Freight Program to "improve the . . . resiliency of freight transportation in rural and urban areas." (23 U.S.C. 167). The Department of Homeland Security has a National Infrastructure Protection Plan, which prioritizes funding efforts where they can have the biggest impact on America's resilience to risk. FHWA Order 5520 Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events encourages State DOTs and MPOs to integrate resilience into transportation planning. Finally,

National Environmental Policy Act (NEPA) environmental review processes (which are required for most projects receiving federal funds) may consider the effects of climate change on the project under review.

E.2 FHWA Emergency Relief Program Funding Overview

The following includes summary information on FHWA's Emergency Relief Program. Much of it is derived from CDOT's 2013 Flood Event: Lessons Learned and Best Practices, Action Summary – A Resource for Preparing for and Responding to Future Events (CDOT, 2015). The FHWA Emergency Relief Manual (May 31, 2013) is the seminal policy rulebook for disaster-related repairs and reconstruction for DOTs. Transportation agencies and local agencies that benefit from these funds should ensure that staff designated to lead sections within incident command organizations and are charged with rapid response to restore essential traffic and resilient recovery to reconstruct roadways are versed in its requirements. In addition, FHWA's publication, A Guide to Federal-Aid Program and Projects, is also an important resource (Federal Highway Administration, 2019a).

FHWA ER governs eligibility and funding for disaster work. The DOT is the recipient, and local agencies are sub-recipients to the DOT. FHWA ER provides 100 percent funding for eligible emergency repairs performed within a designated time period, and roughly 80 percent funding for permanent work, with the remaining 20 percent assigned to the DOT or a local agency. However, this match requirement is calculated and varies by DOT.

FHWA documents ER project eligibility through DDIRs. A DDIR provides a windshield damage assessment with brief damage descriptions, estimated dimensions, photographs, and planning level estimate repair costs. DDIRs are compiled immediately after the event and are used to request disaster funding from FHWA and are often completed with FHWA representatives present for some or all of the field inspections. DDIRs can be revised. DDIRs are prepared by the DOT and are signed by both agencies. DDIRs are used as planning-level estimates and are revised, as needed, during design, but not typically after construction commences.

It is a best practice for the DOT and FHWA to view disaster damage together in order to agree on the general type, severity, and dimensions of damages. For its 2013 flood, CDOT and FHWA agreed to revise DDIRs if eligible project damage/scope adjustments result in a 50 percent or greater increase on projects with planning level estimates of less than $1M (e.g., due to discovered damages, eligible resiliencies, competitive market pricing). This was a replicable best practice. When a DDIR is greater than $1M, a new DDIR is typically required if the eligible project damage/scope adjustments result in a 15 percent change in a project's planning level estimate.

Program of Projects (POP)

Changes to DDIRs are monitored within the Program of Projects (POP) which FHWA uses to track eligible costs for a disaster. The POP is updated on a standing schedule and requires concurrence between FHWA and the DOT. POP data should, wherever possible, tie to dashboard reporting in order to capture essential information about project delivery status and detailed financial data.

FHWA ER provides for indirect costs, and the amount varies and is subject to negotiation between DOT and FHWA. For example, FHWA negotiated and allocated an 11% indirect cost rate for CDOT on FHWA ER emergency repair projects for the 2013 flood event. Local agencies my use audited and approved pre-disaster indirect cost rates. The URL for the FHWA Emergency Relief Manual (May 31, 2013) follows, below.

https://www.fhwa.dot.gov/reports/erm/er.pdf

E.3 FEMA Public Assistance Funding Overview

FEMA Public Assistance

FEMA funds losses that are not funded through any other source (e.g. insurance, FHWA) based on funding designated in Presidential Disaster Declarations. Funding through FEMA is initiated through a Request for Public Assistance (RPA). Most notably for DOTs, FEMA funds debris management.

For a variety of reasons, including treatment of toll road or bridge proceeds, FEMA sometimes funds emergency repairs and permanent repairs for surface transportation assets. However, for most DOTs, FEMA will fund debris management and support eligibility to repair direct damages to buildings and structures. FEMA has an innovate pilot that allows the flexible use of funds to be grouped or pooled for use. It is being elected by states and territories with increasing frequencies, and it is prudent for transportation organizations to explore this pros and cons of this program pre-disaster.

FEMA grants are typically written for a single asset, assets that share a campus, and/or groups of similar assets. The DOT can request how the grants are grouped to align with its planned project delivery, procurement, and contracting methods.

The following furnishes the link to the FEMA Public Assistance Program and Policy Guide (PAPPG), which is the seminal policy rulebook for FEMA disaster funding for STTL agencies. This guidance applies to funding received by DOTs for debris removal in addition to other eligible transportation infrastructure. PAPPG version 3.1 went into force on April 26, 2018. The Guidance in force at the time of the applicable Presidential disaster declaration governs requirements. However, in concurrent, regional emergencies FEMA may issue disaster-specific guidance and in very limited circumstances, Congress has afforded discretionary relief on certain regulatory provisions. More information on PAPPG can be found at https://www.fema.gov/media-library/assets/documents/111781.

FEMA Public Assistance: Debris Management

Debris Funds are qualified as FEMA Public Assistance Category A. DOTS must develop Debris Management Plans aligned to FEMA and FHWA eligibility rules and federal and state environmental regulations to ensure maximum reimbursement. These must be approved by FEMA which is often secured in close coordination with the state/territory emergency management agency; Debris Management Plans must be approved prior to the award of debris management funds by FEMA. It is important to regularly review FEMA Category A program policies for changes to the debris program (e.g., every 6-12 months). Consider competitively pre-selecting debris removal contractor(s) and debris monitoring professional services on standby contracts.

FEMA's Public Assistance Debris Management Guide (and other FEMA debris management publications) provide useful information and worksheets for the proper administration and delivery of FEMA-supported debris management programs and delves into the program's unique requirements. FEMA sometimes administers debris pilot programs which may include incentives such as increased match funds based on time accelerations for debris removal. This information can be requested as part of the initial applicant (sub-recipient) briefing. FEMA has a number of debris management publication available.

For more information on FEMA Public Assistance Debris Management Guide (April 3, 2014) please visit https://www.fema.gov/media-library/assets/documents/25649. The following is an excerpt of the FEMA 325, Public Assistance Debris Management Guide.

> *Chapter 2 – Costs, Piggyback Contracts*
>
> *FEMA does not favor "piggyback contracts." Applicants have used piggyback contracts on occasion to have disaster-related work performed by another jurisdiction's contractor. The variables associated with the scope of work and costs generally make this an option to be avoided. The competitive procurement requirements of 44 CFR Part 13 are also a prime concern. If FEMA encounters a request for reimbursement of costs derived from such a contract, the reimbursable costs for eligible work will be based on reasonableness (p. 19).*
>
> *In accordance with 44 CFR Part 13.36(b)(8): "Grantees and subgrantees will make awards only to responsible contractors possessing the ability to perform successfully under the terms and conditions of a proposed procurement. Consideration will be given to such matters as contractor integrity, compliance with public policy, record of past performance, and financial and technical resources" (p. 19).*
>
> *For additional contracting information, refer to Appendix G, FEMA RP9580.201,*
>
> *Fact Sheet: Debris Removal - Applicant's Contracting Checklist (p. 20).*

FEMA Public Assistance: Additional Procurement Guidance and Resources

In September 2019, FEMA updated its Field Manual Procurement Disaster Assistance Team (PDAT) Procurement Information for FEMA Public Assistance Award Recipients and Subrecipients. It is an outstanding resource to develop a deep understanding our how FEMA procurement requirements can be interpreted and offers cautions to avoid. Please visit the following for more information: https://www.fema.gov/media-library-data/1570129404293-8d938ec9c10063348edca477a7b24bbd/PDATManualUpdate_10-03-19.pdf

FEMA also runs the Emergency Management Institute (EMI), a training and development institution in Emmitsburg, MD. EMI offers both online and on-campus instruction (as well as satellite instruction organized in cooperation with state/territory emergency management agencies). Online instruction is free of charge, and on-campus instruction is typically free for public sector employees. The URL for EMI is below: https://training.fema.gov/emi.aspx

E.4 Other Funding

In major and catastrophic disaster events, federal and state agencies sometime appropriate additional funding for disaster recovery and allow discretionary funds to be used for recovery work, particularly in low-income areas. Congress often authorizes HUD to appropriate Community Development Block Grant - Disaster Recovery (CDBG DR) for concurrent, regional disasters. When this occurs, it is important for the DOT to work closely with the Governor Office (and/or recovery office) to collaborate on leveraging

all sources of funds to achieve regional recovery and resilience objectives. A wealth of information on the program and its requirements can be accessed via the following URL:
https://www.hudexchange.info/programs/cdbg-dr/

Appendix F: Wayfinding: Tools and Useful Resources

This section organizes tools into one section. It also promotes strong resources that (1) contributed to the applied research but included more high-quality content than could fully promoted herein, or (2) provided outstanding content that fell outside of the scope of this applied research but offers real value to transportation professionals involved in concurrent, regional emergencies.

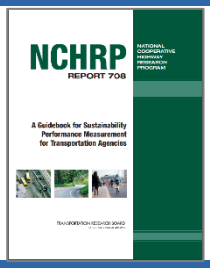
Text used in Appendix to describe each tool is copied directly from agency, program, or entity that produced that tool or publication.

F.1 Transportation Research Board (TRB)'s National Cooperative Highway Research Program (NCHRP)

Table F-1: NCHRP Publications

1 Guidebook for Sustainability Performance Measurement for Transportation Agencies (2013)

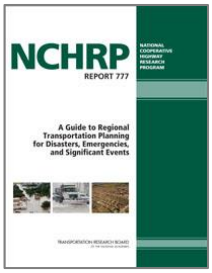
https://ssti.us/wp/wp-content/uploads/2011/11/nchrp_rpt_708.pdf



The guidebook provides resources for state departments of transportation (DOTs) and other agencies to tailor a performance measurement program for sustainability that is relevant to their specific needs and contexts. Agencies can adapt and use the generally applicable framework in ongoing performance measurement programs or as a part of a new sustainability initiative. The recently enacted transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21), emphasizes performance measurement.

2 A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events (2014)

http://www.trb.org/Publications/Blurbs/171087.aspx



The research (literature review, survey, and interviews) discovered multijurisdictional transportation planning for disasters, emergencies, and significant events taking place in many locations across the country, in many different institutional frameworks. Such planning shares precepts of communication and collaboration, supported by eight basic principles that enable communities to better recover after a major disruption. Effective planning is comprehensive, cooperative, informative, coordinated, inclusive, exercised, flexible, and continuous. These principles connect the many disciplines, levels of government, and private, nonprofit, and public-sector agencies that contribute to a good community plan. They provide a shared vocabulary for a collaborative effort that promises sound preparation, effective response, and rapid recovery

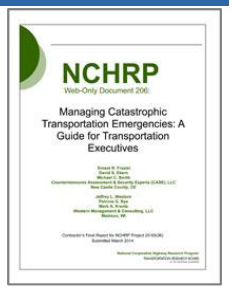
3 Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects

http://www.trb.org/Publications/Blurbs/171479.aspx

TRB's National Cooperative Highway Research Program (NCHRP) Report 787: Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects presents guidance for transportation agencies on design management under construction manager/general contractor and design-build project delivery. The guidance includes case studies of projects successfully developed using these alternative procurement strategies.

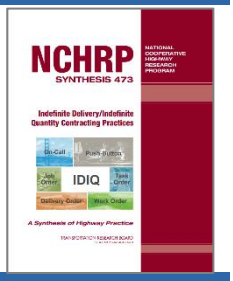
4 Managing Catastrophic Transportation Emergencies: A Guide for Transportation Executives (2014)

https://www.nap.edu/download/22304#



TRB's National Cooperative Highway Research Program (NCHRP) Web-Only Document 206: Managing Catastrophic Transportation Emergencies: A Guide for Transportation Executives provides guidance to new chief executive officers (CEOs) about the roles and actions that CEOs take during emergency events.

5 Indefinite Delivery/Indefinite Quantity Contracting Practices (2015)



https://www.researchgate.net/profile/Douglas_Gransberg/publication/280610335_Indefinite_DeliveryIndefinite_Quantity_Contracting_Practices/links/55be2ba308aed621de120e0c/Indefinite-Delivery-Indefinite-Quantity-Contracting-Practices.pdf

The synthesis covers multiple aspects of IDIQ practice, including contracting techniques, terminology used by transportation agencies, contract advertising and award practices, successful contracting procedures, pricing methods, risk management issues, and effective contract administration practices.

6 Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) (2009)

http://www.trb.org/Publications/Blurbs/160337.aspx

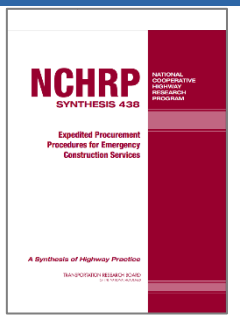
TRB's National Cooperative Highway Research Program (NCHRP) Report 525: Surface Transportation Security, Volume 15: Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) is designed as a planning tool for top-down estimation of both capital and operating budget implications of measures intended to reduce risks to locally acceptable levels. CAPTA supports mainstreaming an integrated, high-level, all-hazards, national incident management system-responsive, multimodal, consequence-driven risk management process into transportation agency programs and activities.

7 Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion (2008)

https://www.nap.edu/catalog/23075/selection-and-evaluation-of-alternative-contracting-methods-to-accelerate-project-completion

TRB's National Cooperative Highway Research Program (NCHRP) Synthesis 379: Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion explores the process for selection of alternative contracting methods that can potentially accelerate project completion. The report also examines factors associated with selecting one type of alternative contracting technique over another.

8 Expedited Procurement Procedures for Emergency Construction Services (2012)



https://www.nap.edu/catalog/22691/expedited-procurement-procedures-for-emergency-construction-services

Touran et al 2009 surveyed DOTs on most effective method for addressing risks and the clear preference was for CMGC due to early contractor involvement. The contractor could help prepare more realistic plans and schedule. However, DB was judged to be better for accelerated schedule. Respondent DOTs showed a distinct preference for lump sum, sticking with routine procedures

Design and constructions contracts tend to be different. Designers are familiar with qualification based selection since the passage of the Brooks Act in 1972 permitted it along with sole source. Contractors, in contrast, are accustomed to lowest bid, open competitions. The most often used method for emergency contract awards was low bid for prequalified contractors. They require the lowest administrative oversight, and literature without exception found the requirement to have a notable impact on success of project.

Six state DOTs who replied to the survey faced protests to their emergency contract awards. All but one (MN) had their cases dropped before going to court while Minnesota successfully defended the process. Perry and Hines (2007) discussed 4 best practices for insulating DOTs to protests: careful adherence to laws/regulations, emergency contracts only to supply the immediate need before returning to mandated procedures, prohibit emergency contract renewal without competitive bidding, use a list of prequalified bidders. The study and literature recommend that DOTs should maintain a list of prequalified emergency consultants and contractors also to manage risk.

9 A Guide to Planning Resources on Transportation and Hazards (2009)

http://www.trb.org/Main/Blurbs/162332.aspx

TRB's National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP) have jointly released A Guide to Planning Resources on Transportation and Hazards. The report was published as NCHRP Research Results Digest (RRD) 333 and as TCRP RRD 90. The report highlights a framework for thinking about the stages of a disaster, and identifies some of the most current and innovative hazard-related research.

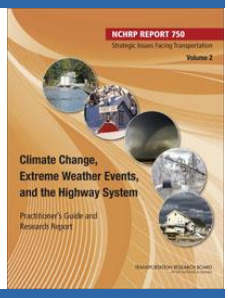
10 A Pre-Event Recovery Planning Guide for Transportation (2013)

https://www.nap.edu/download/22527

This report identified steps to prepare for recovery of transportation infrastructure. It contains numerous appendices addressing case studies, damage assessment, pre-event recovery planning, funding and other topics.

11 Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report (2016)

http://www.trb.org/Main/Blurbs/169781.aspx



TRB's National Cooperative Highway Research Program (NCHRP) Report 750: Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report provides guidance on adaptation strategies to the likely impacts of climate change through 2050 in the planning, design, construction, operation, and maintenance of infrastructure assets in the United States (and through 2100 for sea-level rise).

12 Case Studies in Cross-Asset, Multi-Objective Resource Allocation (2019)

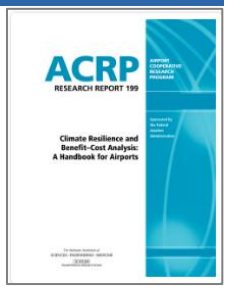
https://www.nap.edu/catalog/25684/case-studies-in-cross-asset-multi-objective-resource-allocation

Transportation agencies face a complex set of challenges as they make cross-asset resource allocation decisions. Such decisions entail deciding how much to invest in an agency's roads, bridges, intelligent transportation systems (ITS), and other traffic and safety assets to achieve a variety of competing objectives, such as improving pavement and bridge conditions, increasing mobility, and enhancing safety.

Table F-2: Other TRB Publications

1 Climate Resilience and Benefit–Cost Analysis: A Handbook for Airports (2019)

https://www.nap.edu/catalog/25497/climate-resilience-and-benefit-cost-analysis-a-handbook-for-airports



ACRP Research Report 199 is a handbook on how to apply benefit–cost analysis tools and techniques to improve decision making affecting resilience of airport infrastructure projects in response to potential long-term impacts of climate change and extreme weather events. This handbook will help practitioners recognize, enhance, and adapt insights and procedures identified from related research currently available or under development affecting both airports and other infrastructure projects. In particular, the handbook is designed to improve the process by which infrastructure investment strategies are evaluated, with an emphasis on ensuring climate-related resiliency. Procedures for presenting assumptions and

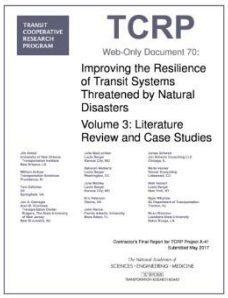
results transparently and for implementing the process are also included so that industry users and decision makers can understand and communicate the outcome of the analytical process.

2 TRB Circular: Transportation Systems Resilience (2017)

http://www.trb.org/Main/Blurbs/176885.aspx

TRB's E-Circular 226: Transportation System Resilience: Preparation, Recovery, and Adaptation explores research issues related to implementing transportation systems resilience, and explores themes of a whole system approach to resilience, weather and advances in forecasting, an integrated approach to cyber-physical security for transportation, a European perspective on research for resilient road infrastructure, training and recruiting qualified employees who can assist during adverse events, and improving the resilience of transit systems threatened by natural disasters. This report accompanies the September/October 2017 print edition of the TR News.

3 Improving the Resilience of Transit Systems Threatened by Natural Disasters, Volume 3: Literature Review and Case Studies (2017)



https://www.nap.edu/catalog/24972/improving-the-resilience-of-transit-systems-threatened-by-natural-disasters-volume-3-literature-review-and-case-studies

TRB's Transit Cooperative Research Program (TCRP) Web Only Document 70: Improving the Resilience of Transit Systems Threatened by Natural Disasters, Volume 3: Literature Review and Case Studies includes appendicies that outline the literature reviewed and 17 case studies that explore how transit agencies absorb the impacts of disaster, recover quickly, and return rapidly to providing the services that customers rely on to meet their travel needs. The report is accompanied by Volume 1: A Guide, Volume 2: Research Overview, and a database called resilienttransit.org to help practitioners search for and identify tools to help plan for natural disasters.

F.2 Federal Highways Administration (FHWA)

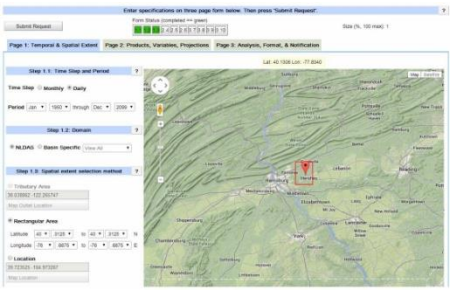
Table F-3: FHWA Tools

1 FHWA INVEST Tool

Tool and Guides: https://www.sustainablehighways.org/

The Tool allows transportation agencies to evaluate the sustainability of their agency practices and projects across the entire transportation lifecycle, by self-assigning points based on how well they have met requirements set out for each particular criterion. Criteria specific for infrastructure resiliency are incorporated into the Tool's categories (called "modules") for planning at the state and regional level, and for project development. These resiliency criteria help agencies plan and design for current and future hazards, including climate change. The Tool notes that planning and designing for infrastructure resiliency supports all of the triple bottom line principles of sustainability (environmental, social, and economic) as it provides energy savings, improves safety and security of the transportation system and users, and reduces future spending on infrastructure replacement.

2 CMIP Climate Data Processing Tool (2016/2018)



User Guide:
https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/user_guide/cmip_user_guide.pdf

CMIP5 Tool:
https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/user_guide/cmip5_climate_data_processing_tool_10-29-18.xlsm
Spreadsheet tool that processes downscaled climate projections from the World Climate Research Programme's Coupled Model Intercomparison Project (CMIP) CMIP3 and CMIP5 databases into relevant statistics for transportation planners, including changes in the frequency of very hot days and extreme precipitation events that may affect transportation infrastructure and

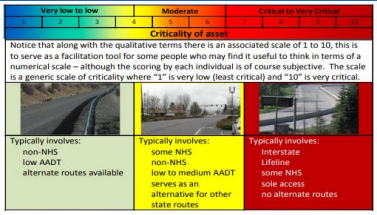
services by the middle and end of the century.

3 Sensitivity Matrix (2015)

Tool: https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/sensitivity_matrix.xlsm Spreadsheet tool that documents the sensitivity of roads, bridges, airports, ports, pipelines, and rail to 11 climate impacts.

4 Guide to Assessing Criticality in Transportation Adaptation Planning (2015)

Guide: https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/criticality_guidance/criticality_guidance.pdfDiscusses common challenges associated with assessing criticality, options for defining criticality and identifying scope, and the process of applying criteria and ranking assets.



5 Vulnerability Assessment Scoring Tool

User Guide: https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/vast_users_guide.pdf

Tool: https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/scoring_tools_guide/ vast.xlsmSpreadsheet tool that guides the user through conducting a quantitative, indicator-based vulnerability screen. Intended for agencies assessing how components of their transportation system may be vulnerable to climate stressors.

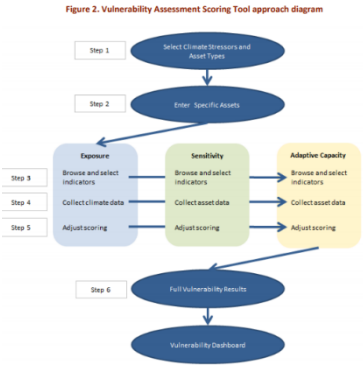
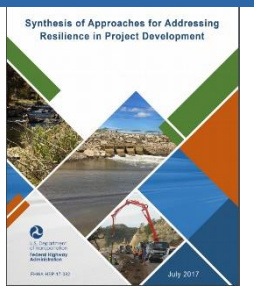


Table F-4: FHWA Publications

Engineering	
1	**Synthesis of Approaches for Addressing Resilience in Project Development (2017)**

https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/synthesis/fhwahep17082.pdf This report synthesizes lessons learned and innovations from a variety of recent FHWA studies and pilots to help transportation agencies address resilience concerns at the asset level in engineering-informed adaptation studies



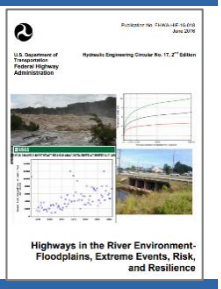
2 Transportation Engineering Approaches to Climate Resiliency (2015)

https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/index.cfm

The objective of this project is to develop recommended engineering practices for identifying and evaluating project-level vulnerabilities from future extreme weather events and climate change and designing solutions to respond and adapt to those vulnerabilities. Engineering analyses of a diverse set of transportation assets around the country were performed in order to identify best practices for improving the resiliency of the transportation system to extreme weather and climate change. The result will be a cross-cutting set of recommendations for engineering practice to cover a wide range of facility types and locations.

3 Hydraulic Engineering Circular 17: Highways in the River Environment - Floodplains, Extreme Events, Risk, and Resilience, 2nd Edition (2016)

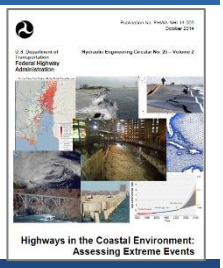
https://www.fhwa.dot.gov/engineering/hydraulics/pubs/hif16018.pdf



Provides technical guidance and methods for assessing the vulnerability of transportation facilities to extreme events and climate change in riverine environments.

4 Hydraulic Engineering Circular No. 25 – Volume 2 (FHWA-NHI-14-006), 2014

https://www.fhwa.dot.gov/engineering/hydraulics/pubs/nhi14006/nhi14006.pdf

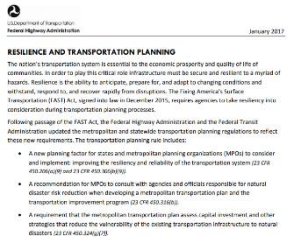


Manual provides guidance and methods for assessing the vulnerability of coastal transportation facilities to extreme events and climate change.

Planning

5 Resilience and Transportation Planning (2017)

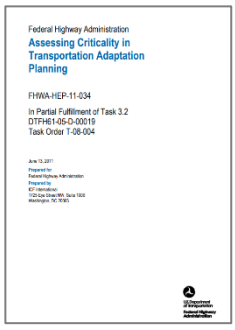
https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/ratp/index.cfm



This fact sheet outlines updates to the metropolitan and statewide transportation planning regulations to reflect new FAST Act requirements to address resilience and natural disaster risks.

6 Assessing Criticality in Transportation Adaptation Planning (2011)

https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/assessing_criticality/cta092111.pdf



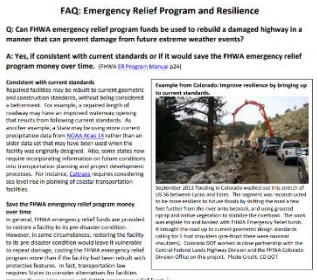
This memo discusses approaches for narrowing the universe of transportation assets to study in a climate change vulnerability and risk assessment by assessing their "criticality" and otherwise narrowing study scope. It identifies common challenges and draws on examples from the FHWA Adaptation Conceptual Model Pilots and the ongoing USDOT Gulf Coast Phase 2 study.

Emergency Relief

7 FAQ: Emergency Relief Program and Resilience (2017)

https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/er_faq/fhwahep17029.pdf

Explains that FHWA emergency relief funds may be used to rebuild damaged highways to be more resilient to future extreme weather events if cost effective or consistent with current design standards.


FAQ: Emergency Relief Program and Resilience

Q: Can FHWA emergency relief program funds be used to rebuild a damaged highway in a manner that can prevent damage from future extreme weather events?

A: Yes, if consistent with current standards or if it would save the FHWA emergency relief program money over time. (FHWA ER Program Manual, p24)

Consistent with current standards

Repaired facilities may be rebuilt to current geometric and construction standards, without being considered a betterment. For example, a repaired length of roadway may have an improved waterway opening that results from following current standards. As another example, a State may be using more current precipitation data from NOAA Atlas 14 rather than an older data set that may have been used when the facility was originally designed. Also, some states now require incorporating information on future conditions into transportation planning and project development processes. For instance, Colorado requires considering sea level rise in planning of coastal transportation facilities.

Example from Colorado: Improve resilience by bringing up to current standards.

September 2013 flooding in Colorado washed out this stretch of US 36 between Lyons and Estes. The segment was reconstructed to be more resilient to future floods by shifting the road a few feet further from the river onto bedrock, and using ground rip-rap and native vegetation to stabilize the riverbank. The work was eligible for and funded with FHWA Emergency Relief funds. It brought the road up to current geometric design standards calling for 1-foot shoulders (pre-flood there were minimal shoulders). Colorado DOT workers in close partnership with the Central Federal Lands Highway Division and the FHWA Colorado Division Office on this project. Photo Credit: CO DOT

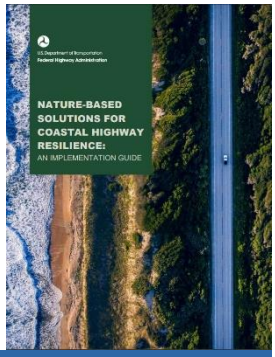
Save the FHWA emergency relief program money over time

In general, FHWA emergency relief funds are provided to restore a facility to its pre-disaster condition. However, in some circumstances, restoring the facility to its pre-disaster condition would leave it vulnerable to repeat damage, costing the FHWA emergency relief program more than if the facility had been rebuilt with protective features. In fact, transportation law requires States to consider alternatives for facilities repeatedly requiring repair with FHWA emergency relief funds.

Multi-Disciplinary

8 Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide (2019)

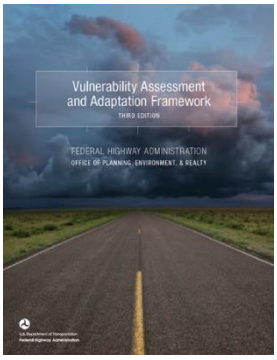
https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/



The Implementation Guide is designed to help transportation practitioners understand how and where nature-based solutions can be used to improve the resilience of coastal roads and bridges. Upfront, it summarizes the potential flood-reduction benefits and co-benefits of these strategies. From there, the guide follows the steps in the project delivery process, providing guidance on how to consider nature-based solutions in the planning process, how to conduct a site assessment to determine whether nature-based solutions are appropriate, key engineering and ecological design considerations, permitting approaches, construction considerations, and monitoring and maintenance strategies.

9 Vulnerability Assessment and Adaptation Framework, Third Edition (2017)

https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/

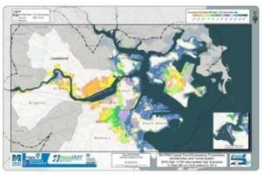


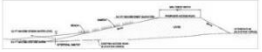
The Federal Highway Administration's (FHWA's) Vulnerability Assessment and Adaptation Framework (the Framework), third edition, is a manual to help transportation agencies and their partners assess the vulnerability of transportation infrastructure and systems to extreme weather and climate effects. It also can help agencies integrate climate adaptation considerations into transportation decision-making. The Framework provides an in-depth and structured process for conducting a vulnerability assessment. The Framework describes the primary steps involved in conducting a vulnerability assessment. For each step the Framework features examples from assessments conducted nationwide between 2010 and 2017 and includes links to related resources that practitioners can access for additional information.

The information presented in the Framework is geared toward State departments of transportation (DOTs), metropolitan planning organizations (MPOs), and other agencies involved in planning, building, maintaining, or operating transportation infrastructure.

10 2013-2015 Climate Resilience Pilot Program: Outcomes, Lessons Learned, and Recommendations (2016)

https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/final_report/index.cfm





The Federal Highway Administration's (FHWA)'s Climate Resilience Pilot Program sought to assist state Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Federal Land Management Agencies (FLMAs) in enhancing resilience of transportation systems to extreme weather and climate change. From 2013 to 2015, nineteen pilot teams

partnered with FHWA to assess transportation vulnerability and evaluate options for improving resilience. This report synthesizes lessons learned, needs identified, and recommended next steps from the pilot program. Illustrative project findings, outcomes, and examples are distributed throughout the report.

Asset Management	
11	**Managing External Threats through Risk-Based Asset Management**

https://www.fhwa.dot.gov/asset/pubs/hif13018.pdf

Explains how risk-based asset management serves as a climate adaptation strategy.

F.3 Federal Emergency Management Agency (FEMA)

Table F-5: FEMA Tools

1	**HAZUS**

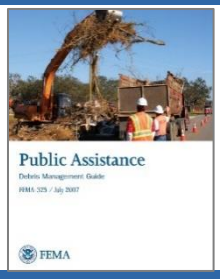
https://www.fema.gov/HAZUS-software; https://www.fema.gov/HAZUS

HAZUS is a nationally applicable standardized methodology developed by the Federal Emergency Management Agency (FEMA). A downloadable software package called HAZUS-MH (for Multi-Hazard) gives users access to FEMA's models for estimating potential losses from earthquakes, floods, and hurricanes. The software package uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods. Users can then visualize the spatial relationships between populations and other, more permanently fixed geographic assets or resources for the specific hazard being modeled, a crucial function in the pre-disaster planning process.

Table F-6: FEMA Publications

1	**Public Assistance Debris Management Guide (2007)**

https://www.fema.gov/media-library-data/20130726-1826-25045-7418/fema_325__debris_management_guide_2007.07.25.pdf



The core components of a comprehensive debris management plan incorporate best practices in debris removal, reflect FEMA eligibility criteria, and are tailored to the specific needs and unique circumstances of each applicant. FEMA developed this guide to provide applicants with a programmatic and operational framework for structuring their own debris management plan or ensuring that their existing plan is consistent with FEMA's eligibility criteria.

2	**Design Guide for Improving Critical Facility Safety from Flooding and High Winds: Providing Protection to People and Buildings (2007)**

https://www.fema.gov/media-library/assets/documents/8811

This manual concentrates on critical facilities (hospitals, schools, fire and police stations, and emergency operation centers). It is based on the behavior of critical facilities during Hurricane Katrina and makes recommendations on the performance of these types of buildings. It provides building professionals and decisionmakers with information and guidelines for implementing a variety of mitigation measures to reduce the vulnerability to damage and disruption of operations during severe flooding and high-wind events. It includes extensive information on the impact of storm surges to the Gulf Area.

3 Pre-Disaster Recovery Planning Guide for Local Governments (2017)

https://www.fema.gov/media-library-data/1487096102974-e33c774e3170bebd5846ab8dc9b61504/PreDisasterRecoveryPlanningGuideforLocalGovernmentsFinal50820170203.pdf

This Guide is designed for local governments to help them to prepare for recovery from future disasters by engaging with the whole community and planning for recovery activities that are comprehensive and long term.

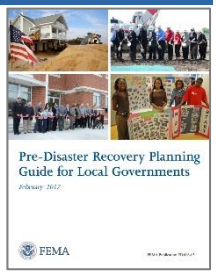


Table F-7: FEMA Webinars

1 Building Resilient Infrastructure and Communities Webinar Series (BRIC) (2019)

https://www.fema.gov/drra-bric

FEMA and its partners are working on the development and implementation of DRRA Section 1234: National Public Infrastructure Pre-Disaster Hazard Mitigation Grant Program. This program, which FEMA has named Building Resilient Infrastructure and Communities (BRIC), will be funded through the Disaster Relief Fund as a six percent set aside from estimated disaster grant expenditures. A series of webinars held in June 2019 provided a brief overview of the BRIC program development and facilitated an open conversation with stakeholders through the chat platform. Participants were encouraged to share their thoughts and ideas in real-time during these webinars or had the option to provide comments on a dedicated idea sharing platform known as Ideascale.

(Guidebook on BRIC is in development and should be released in 2020)

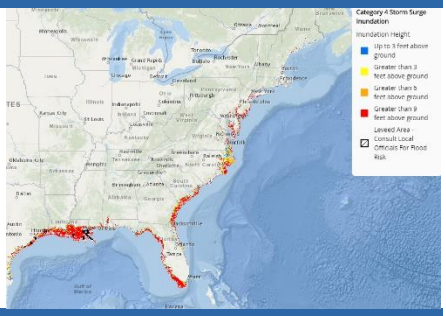
F.4 Environmental Protection Agency (EPA)

Table F-8: EPA Tools

1 Storm Surge Inundation and Hurricane Strike Frequency Map

https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=852ca645500d419e8c6761b923380663

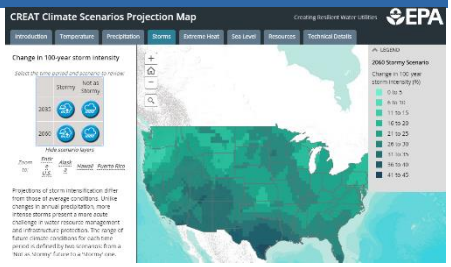
This mapping tool illustrates current worst-case coastal storm surge or inundation scenarios and hurricane strike frequency derived from Sea, Lake, and Overland Surge from Hurricanes (SLOSH) models by the National Oceanic and Atmospheric Administration (NOAA), 100 and 500 year flood plains from the Federal Emergency Management Agency (FEMA), and hurricane strike dataset from the National Hurricane Center (NHC).



2 Scenario-Based Projected Changes Map

https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=3805293158d54846a29f750d63c6890e

This mapping tool provides easy to access scenarios of projected changes from EPA's Climate Resilience Evaluation and Awareness Tool for annual total precipitation, annual average temperature, precipitation intensity for the 100-year storm, number of days per year with temperatures above 100 F, and sea-level rise for coastal locations.

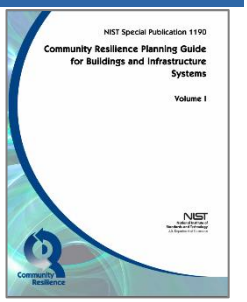


F.5 National Institute of Standards and Technology (NIST)

Table F-9: NIST Publications

1 Community Resilience Planning Guide (2016)

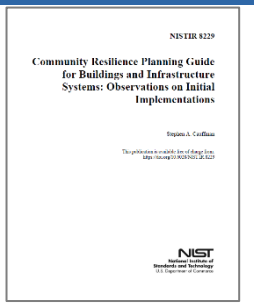
https://www.nist.gov/topics/community-resilience/planning-guide



The NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems (Guide) provides a practical and flexible approach to help all communities improve their resilience by setting priorities and allocating resources to manage risks for their prevailing hazards. Volume I of the Guide describes the six step planning process and provides a worked example to illustrate the process. Volume II is a resource that describes how to characterize the social and economic dimensions of the community, dependencies and cascading consequences, and building and infrastructure performance. Using the Guide can help communities to integrate consistent resilience goals into their comprehensive, economic development, zoning, mitigation, and other local planning activities that impact buildings, public utilities, and other infrastructure systems.

2 Community Resilience Planning Guide for Buildings and Infrastructure Systems: Observations on Initial Implementations (2018)

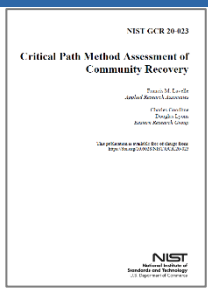
https://www.nist.gov/publications/community-resilience-planning-guide-buildings-and-infrastructure-systems-observations



The National Institute of Standards and Technology (NIST) published the Community Resilience Planning Guide for Buildings and Infrastructure Systems (NIST SP 1190) in October 2015. The Guide describes a six-step process to develop a community resilience plan. The Guide was intended to be flexible, so that it could be used to create a standalone plan or to complement other planning processes by integrating resilience measures into long-term plans. Since the Guides release, several communities have begun to use the Guide to develop resilience plans. This report documents three of those early applications. The three applications, Fort Collins, Colorado, Delaware Department of Transportation, and Howard County, MD, offer three different approaches to the use of the Guide and demonstrate its flexibility.

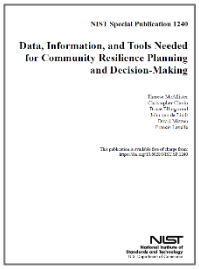
3 Critical Path Method Assessment of Community Recovery (2020)

https://www.nist.gov/publications/critical-path-method-assessment-community-recovery



The critical path method (CPM) is investigated as a tool for identifying recovery activities that control the timeline for restoration of key community functions in the wake of a major disruptive event, such as a hurricane or tornado. Three recovery endpoints are studied: (1) restoring drinking water systems to normal operations, (2) returning children to school, and (3) returning businesses to normal operations. Interviews were conducted with individuals in seven communities who led recovery efforts between 2011 and 2019. The primary goal was to identify and document the sequence and duration of activities that would have delayed key recovery milestones if they had started later or taken longer to complete. Within each function, intermediate milestones are also identified, for example, students returning to school in temporary modules or the partial reopening of a business. Master tables for water, schools, and business are developed that summarize the activities on the critical paths identified in each community. Several opportunities to speed up the recovery process are identified, and issues relevant to the modeling of community recovery are discussed.

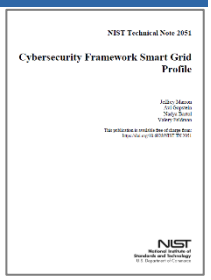
4 Data, Information, and Tools Needed for Community Resilience Planning and Decision-Making (2019)



https://nvlpubs.nist.gov/nistpubs/specialpublications/NIST.SP.1240.pdf

Research at the National Institute of Standards and Technology (NIST) and the Center for Risk-Based Community Resilience Planning (Center) supports community resilience planning and risk-informed decision-support for mitigating the impacts of natural hazards. To this end, NIST and the Center organized a workshop on community resilience data, information, and tools for community resilience planning and decision-making. The October 2018 workshop aimed to: (1) gain an improved understanding of communities' resilience decision-making processes, (2) identify issues associated with obtaining data and information, (3) identify common data needs for the development and use of community-focused tools, (4) identify analysis tools currently used to support planning and decision-making by communities, and (5) develop potential actions to address the issues and needs. Based upon input from the community,
practitioner, academic, and government stakeholders received in the workshop and research by NIST and the Center, this report summarizes the current approaches, issues, and gaps in resilience data, information and tools that help communities to plan and implement resilience strategies.

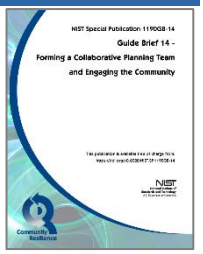
5 Cybersecurity Framework Smart Grid Profile (2019)



https://www.nist.gov/publications/cybersecurity-framework-smart-grid-profile

The Smart Grid Profile is an initial attempt to apply risk management strategies from the Framework for Improving Critical Infrastructure Cybersecurity (Cybersecurity Framework) to the smart grid. The Profile provides cybersecurity risk management guidance to power system owners/operators by prioritizing cybersecurity activities based on their effectiveness in helping power system owners/operators achieve common high-level business objectives for the smart grid. The Profile also provides a list of considerations relevant to the challenges power system owners/operators may experience as they implement these cybersecurity activities in infrastructures with high concentrations of distributed energy resources (DERs).

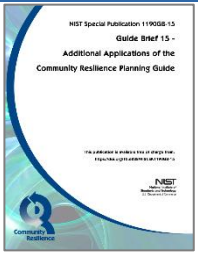
6 Guide Brief 14 - Forming a Collaborative Planning Team and Engaging the Community (2019)



https://www.nist.gov/publications/guide-brief-14-forming-collaborative-planning-team-and-engaging-community

The purpose of this Guide Brief is to provide information that communities may use to accomplish the first step of the Guide: forming a collaborative planning team and engaging the community. Identifying and engaging appropriate planning team partners and beginning community outreach and engagement early in the process will inform needs and priorities for community resilience. The planning process is more effective when communities identify leaders with vested authority and include key stakeholders who will help develop the community resilience plan and shepherd it though local approval/adoption. This Guide Brief includes best practices, elements of FEMA's Local Mitigation Planning Handbook [FEMA 2013], as well as lessons learned from FEMA's Building Resilience with Diverse Communities Program [FEMA 2014]. It also offers resources to assist community leaders in forming their collaborative planning teams and engaging the community at large.

7 Guide Brief 15 - Additional Applications of the Community Resilience Planning Guide (2019)



https://www.nist.gov/publications/guide-brief-15-additional-applications-community-resilience-planning-guide

This Guide Brief provides examples of how the NIST Community Resilience Planning Guide can also be used for resilience planning at the state, regional, county, and organizational scales. The Guide is written for use by communities that have distinct boundaries and function under the jurisdiction of a governance structure, but the concepts can be applied at other scales as well. When a common approach is used to develop resilience plans between interacting or cooperative government agencies (e.g., state, county, community), regional planning agencies (e.g., councils of governments), institutions (e.g., universities, military bases) and organizations, their resilience plans may better align. The level of collaboration and consistency can improve significantly if participants use a common vocabulary, planning process, and set of performance goals for built

and social environments. The NIST Guide can help provide this consistency. A summary of the guide alignment with the FEMA National Planning System and its mission areas is also described, to illustrate how efforts in these areas can be integrated into resilience planning.

F.6 National Academy of Engineering (NAE)

Table F-10: NAE Publications

1 Increasing Community Resilience Through Improved Lifeline Infrastructure Performance (2019)

https://www.nae.edu/212179/Increasing-Community-Resilience-through-Improved-Lifeline-Infrastructure-Performance

The concept of community resilience is complex and multi-dimensional, relying upon social science, engineering, earth sciences, economics, and other disciplines to improve the way communities prepare for, resist, respond to, and recover from disruptive events. Community resilience can break the cycle of destruction and recovery and reduce the impacts of earthquakes and other hazards. This article presents important observations and findings from a recent study commissioned and funded by the National Institute of Standards and Technology to (1) assess current societal expectations of acceptable lifeline infrastructure system performance levels and (2) propose actions pertaining to policy, modeling, systems operations, and research needs that will facilitate improved lifeline infrastructure performance during disasters.

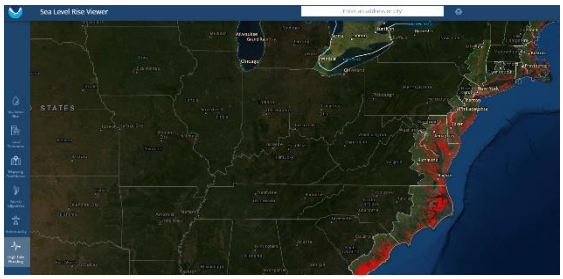
F.7 National Oceanic and Atmospheric Administration (NOAA)

Table F-11: NOAA Tools

1 Sea Level Rise (and High Tide Flooding) Viewer

https://coast.noaa.gov/slr/

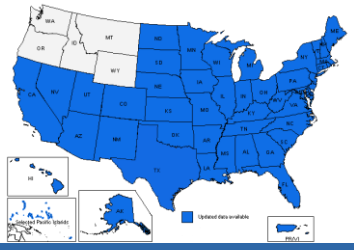
Use this web mapping tool to visualize community-level impacts from coastal flooding or sea level rise (up to 10 feet above average high tides). Photo simulations of how future flooding might impact local landmarks are also provided, as well as data related to water depth, connectivity, flood frequency, socio-economic vulnerability, wetland loss and migration, and mapping confidence.



2 Precipitation Frequency Data Server (PFDS)

https://hdsc.nws.noaa.gov/hdsc/pfds/

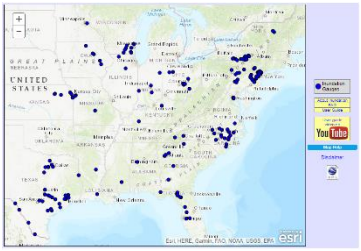
The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Upon clicking a state on the map above or selecting a state name from the drop-down menu, an interactive map of that state will be displayed. From there, a user can identify a location for which precipitation frequency estimates are needed.



3 Inundation Mapping Interface

https://water.weather.gov/ahps/inundation.php

These online interactive maps help emergency managers and decision makers visualize where inundation will affect their communities. When flood forecasts are released by the National Weather Service, officials have the option to refer to these maps and scroll through the different river flood stages to see how inundation could impact local roads, building infrastructure, and resources. Users are then able to make better informed decisions on bridge and road closures, as well as evacuations.



F.8 U.S. Climate Resilience Toolkit

Table F-12: U.S. Climate Resilience Toolkit Tools

1 The Climate Explorer

https://crt-climate-explorer.nemac.org/

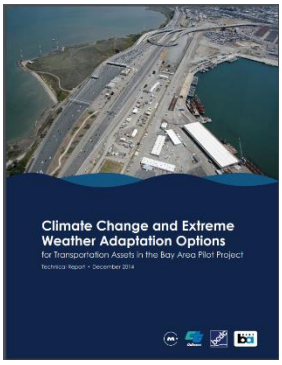
The Climate Explorer offers graphs, maps, and downloadable data of observed and projected climate variables for every county in the contiguous United States. The tool shows graphs and maps of climate projections for temperature, precipitation, and related climate variables for two possible futures: one in which humans make a moderate attempt to reduce global emissions of heat-trapping gases, and one in which the rate of global emissions continues rising through 2100.

F.9 California Agencies (MTC, Caltrans, BCDC, BART)

Table F-13: California Publications

1 Climate Change and Extreme Weather Adaptation Options for Transportation Assets in the Bay Area Pilot Project (2014)

http://files.mtc.ca.gov/pdf/MTC_ClmteChng_ExtrmWthr_Adtpn_Report_Final.pdf



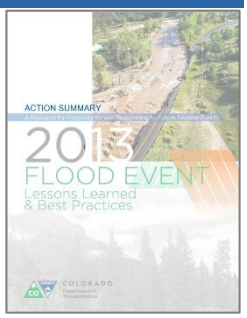
The Metropolitan Transportation Commission (MTC), the San Francisco Bay Conservation and Development Commission (BCDC), the California Department of Transportation, District 4 (Caltrans) and San Francisco Bay Area Rapid Transit District (BART) have partnered on a collaborative sub- regional pilot project to assess adaptation options for a subset of key transportation assets vulnerable to sea level rise (SLR) in Alameda County. This study builds on the Adapting to Rising Tides: Transportation Vulnerability and Risk Assessment Pilot Project which was completed in 2011 and identified representative critical transportation assets vulnerable to sea level rise (SLR). Both projects were funded by the Federal Highway Administration (FHWA). The first study developed detailed risk profiles for approximately 30 transportation assets including road, rail and transit. Having identified the risks, and in order to move from assessment to action, three focus areas within Alameda County containing 'core' transportation assets and 'adjacent' community assets were selected for further study to ensure a thorough understanding of their vulnerabilities. Once that enhanced vulnerability had been assessed, a set of detailed, representative adaptation strategies have been developed as potential solutions to protect key bridge, highway, transit and community assets from future inundation.

F.10 Colorado Department of Transportation (CDOT)

Table F-14: CDOT Publications

1 2013 Flood Event Lessons Learned and Best Practices, A Resource for Preparing for and Responding to Future Disaster Events (2015)

Available by request



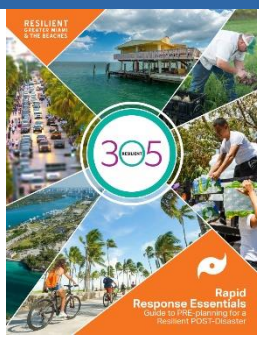
This Action Summary translates 2013 Flood Best Practices and Lessons Learned into a set of concrete and actionable recommendations for CDOT to meet aggressive performance goals in a future flood event. As a learning organization, CDOT is committed to continuous improvement. Taking the recommended action steps will advance efficiencies in emergency response and recovery operations, support robust financial stewardship, and make significant gains in building a resilient statewide transportation infrastructure.

F.11 Resilient 305: Miami and the Beaches, FL

Table F-15: Miami and the Beaches Publications

1 Resilient 305: Rapid Response Essentials – Guide to PRE-planning for a Resilient POST-Disaster

Available by request



This Rapid Recovery Essentials Guide helps GM&B communities start response and recovery operations after the emergency management professionals stabilize immediate post-disaster conditions such as life-saving rescues and sheltering operations.

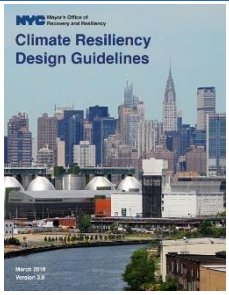
The Guide identifies critical path tasks to bounce forward after a major or catastrophic shock – your readiness will be materially improved if you begin these recommended activities today. Together, these tasks will shorten downtime of critical services, buildings and infrastructure. The Guide also provides tips to help you organize for robust recovery and make new and reconstructed assets more resilient while leveraging co-benefits to restore quality of life for people and communities, kickstart the local economy, and advance environmental sustainability and adapt to climate change.

F.12 New York City, NY

Table F-16: New York City Publications

1 Climate Resiliency Design Guidelines (2019)

https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v3-0.pdf



The Climate Resiliency Design Guidelines ("the Guidelines") provide step by-step instructions on how to supplement historic climate data with specific, regional, forward-looking climate change data in the design of City facilities. Resilient design is intended to become an integral part of the project planning process for City agencies and designers. All new projects and substantial improvements should assess risks to climate change hazards in the context of the project's purpose, asset type, site location, and funding, and then determine the appropriate resilient design strategies using the Guidelines. The Guidelines apply to all City capital projects except coastal protection projects (e.g. sea walls, bulkheads, and levees), for which the City is developing separate guidance. Implementing the Guidelines will result in designs that will make City facilities more resilient to climate change and promote the health, safety, and prosperity of New Yorkers.

F.13 United Nations Office for Disaster Risk Reduction (UNDRR)

Table F-17: UNDRR Tools

1 Disaster Resilience Scorecard for Cities

https://www.unisdr.org/campaign/resilientcities/toolkit/article/disaster-resilience-scorecard-for-cities

United Nations Office for Disaster Risk Reduction with the support of European Commission, IBM, AECOM and other partners and cities participating in the Making Cities Resilient Campaign have updated the Disaster Resilience Scorecard for Cities .The Scorecard provides a set of assessments that will allow local governments to assess their disaster resilience, structuring around UNDRR's Ten Essentials for Making Cities Resilient. It also helps to monitor and review progress and challenges in the implementation of the Sendai Framework for Disaster Risk Reduction: 2015-2030.

1a Disaster Resilience Scorecard for Cities – Preliminary Level

https://www.unisdr.org/campaign/resilientcities/assets/toolkit/Scorecard/UNDRR_Disaster%20resilience%20%20scorecard%20for%20cities_Preliminary_English.pdf

Level 1: Preliminary level , responding to key Sendai Framework targets and indicators, and with some critical sub-questions. This approach is suggested for use in a 1 to 2 day city multi-stakeholder workshop. In total there are 47 questions indicators, each with a 0 – 3 score.

1b Disaster Resilience Scorecard for Cities – Detailed Level

https://www.unisdr.org/campaign/resilientcities/assets/toolkit/Scorecard/UNDRR_Disaster%20resilience%20%20scorecard%20for%20cities_Detailed_English.pdf

Level 2: Detailed assessment. This approach is a multi-stakeholder exercise that may take 1 –4 months and can be a basis for a detailed city resilience action plan. The detailed assessment includes 117 indicator criteria, each with a score of 0 – 5.

Appendix G:
Grab and Go: Sample Tools and Templates

This Appendix provides ready access to tools and templates that have primarily been developed in support of rapid response and resilient recovery for those who are in the midst of crisis. The tools will support to transportation professionals working in incident command functions after disaster such as recovery section chiefs within as well as personnel assigned to the finance and administration section. These resources were developed by CDOT in support of its response and recovery efforts immediately following the 2013 flood and/or developed in response to gaps identified by CDOT's post-recovery *Emergency Procedures Working Group.* Other tools were provided by FHWA.

G.1 CDOT Incident Command Post Scalable Organization Chart

Figure G-1 presents CDOT's disaster (rapid response and recovery) organization chart that is aligned to the US Department of Homeland Security's Incident Command System (ICS), but adjusted to meet the needs of a transportation agency. The shading is tied to incident levels (event type and severity). Using the ICS model has proven valuable in recovery for a number of concurrent, regional emergencies. Training is also key.

> *" It's important for people to be trained. We got grants from Homeland Security to have our people trained on the implementation of ICS and the benefits of it. Over the course of a couple years, ICS becomes second nature and how we do business. With ICS, you know the chain of command.* - Jim Weinstein

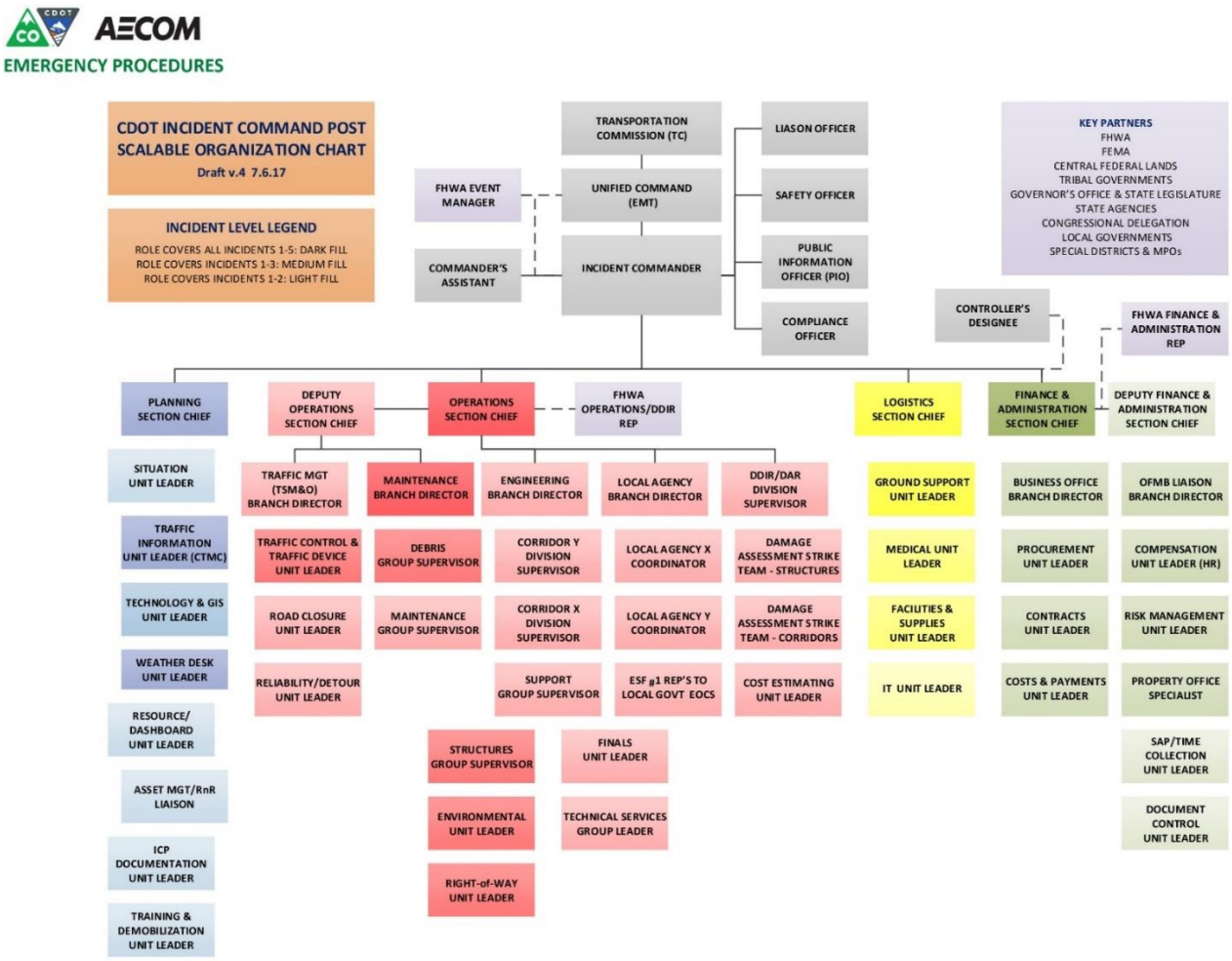


Figure G-1: CDOT Incident Command Post Scalable Organization Chart

G.2 FHWA Emergency Relief Process

Figure G-2 presents FHWA's process flow for its Emergency Relief Program.

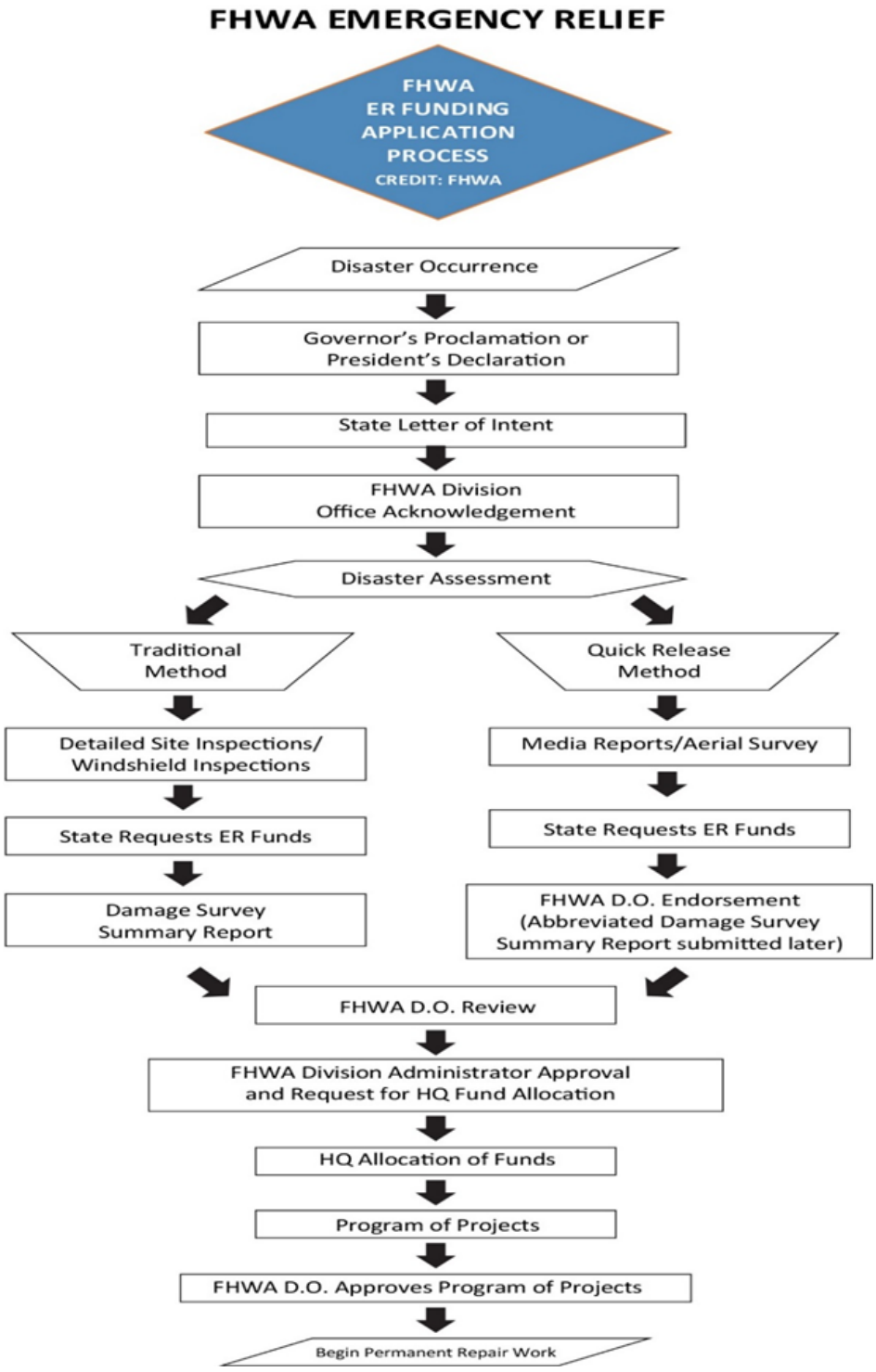


Figure G-2: FHWA Emergency Relief Process

G.3 FWHA ER Decision Tree

Figure G-3 presents a decision tree to guide decisions in alignment with FHWA Emergency Relief work authorization.

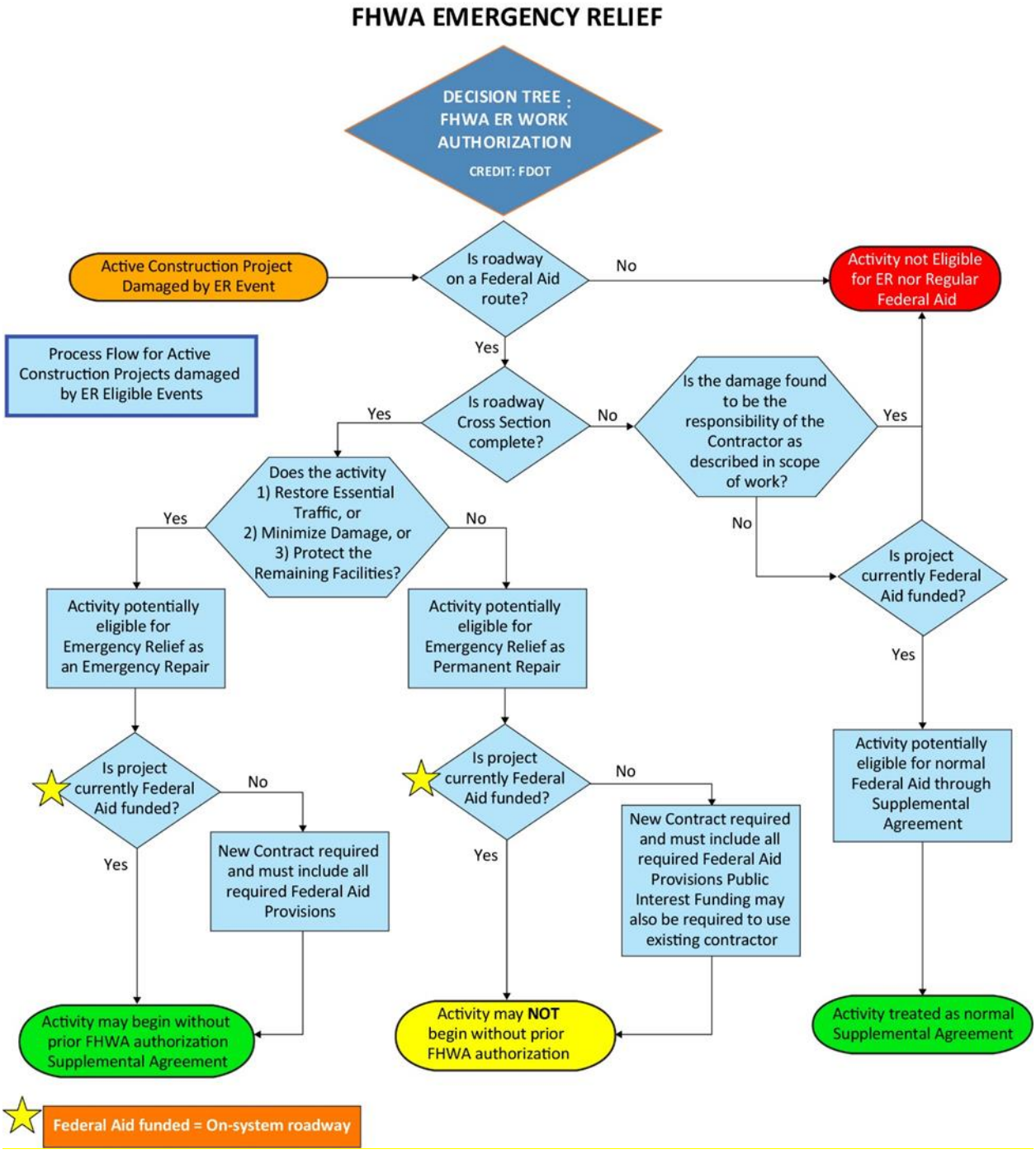


Figure G-3: FWHA ER Decision Tree

G.4 CDOT Disaster Operations Goals

The Flood Recovery Office leadership team reviewed the Infrastructure Recovery Force Work Plan For 2013 Disaster. This document included the Infrastructure Recovery Force (IRF) Values, Commander's Intent, Strategic Missions, and the IRF Mission Statement that drove the initial Emergency effort for the Flood Recovery. The original Mission Statement was as follows:

Infrastructure Recovery Force (Rapid Response Phase) Mission

"Conduct an aggressive response and recovery campaign to repair destroyed and damaged roads and bridges which will allow other CDOT resources to continue normal day-to-day operations and the delivery of newly established RAMP program."

The team decided a new Mission Statement would better encompass the Flood Recovery Office purpose moving forward. As a team, the group crafted a new message that would better describe the activities of the FRO.

Flood Recovery Office Mission Statement

"In our continuing effort to recover from the 2013 Flood, we will work together through partnership to effectively and responsibly re-build a better, stronger, more resilient transportation infrastructure system, while maximizing federal and state reimbursements."

Flood Recovery Office Values

- Safety– We work and live safely! We protect human life, preserve property, and put employee safety before production!
- People – We value our employees! We acknowledge and recognize the skills and abilities of our coworkers, place a high priority on employee safety, and draw strength from our diversity and commitment to equal opportunity.
- Integrity – We earn Colorado's trust! We are honest and responsible in all that we do and hold ourselves to the highest moral and ethical standards.
- Customer Service- We satisfy our customers! With a can-do attitude we work together and with others to respond effectively to our customer's needs.
- Excellence- We are committed to quality! We are leaders and problem solvers, continuously improving our products and services in support of our commitment to provide the best transportation systems for Colorado.
- Respect- We respect each other! We are kind and civil with everyone, and we act with courage and humility.

Strategic Goals

The original IRF documents included a list of Strategic Missions. Initial discussions and edits yielded Strategic Missions for the FRO. After continued discussion, it was decided that Strategic Missions, as they apply to the Flood Recovery Office, were actually Strategic Goals. They are as follows:

- Response Goals - Complete all emergency response projects and finalize all documentation and payments by June 30, 2014
- Recovery Goals - Coordinate business office support functions to help ensure the financial integrity of flood related business transactions, help maximize the reimbursement of federal dollars, while limiting CDOT's out-of-pocket liability.
- Recovery Goals - Have all state highways damaged by the 2013 Flood, permanently restored by December 31, 2017
- Recovery Goals - Have all local federal-aid roadways damaged by the 2013 Flood, permanently restored by December 31, 2019
- Recovery Goals - Communicate, collaborate and coordinate with all stakeholders during the flood recovery process to incorporate the needs of our partners
- Recovery Goals - Evaluate design options, using a risk and resiliency process, to protect our infrastructure assets from natural threats while limiting social, economic & environmental impacts

Each unit (department) further developed their own goals as part of their unit's individual workplans.

Table G-1 presents disaster response and recovery missions goals that guided CDOT's work on the 2013 flood. The flood recovery mission and goals cascaded from CDOT's mission.

Table G-1: CDOT Disaster Operations Goals

Goal	Components	
Goal 1: Efficient Project Delivery	• Emergency Repairs • Debris & Debris Monitoring • Permanent Repairs	• Environmental • Hydrology
Goal 2: Build Back Better – Risk and Resiliency	• Risk and Resiliency (RnR) • Colorado Resiliency Framework	
Goal 3: Maximize Eligible Funding	• Build Good Relationships with Federal Funders • Understanding Eligible Funding/Scope • Documenting Damages • Aligning Project Delivery with Eligible Funding • Memorializing Policy Decisions	• Ensuring Compliance • FHWA ER Funding • Programs of Projects (PoP) • FEMA Funding • Other Funding • State Match to Local Agencies • Combining Multiple Funding Sources
Goal 4: Mitigate Audit Risks	• Procurement • Contracting/Pricing • Final Reviews & Payments for Emergency Repair Projects	• Super Circular • Business Processes and Procedures

Goal	Components	
Goal 5: Data/Document Management	• Inbound Data from the Field • Website • GIS & Mapping	• Program Management Dashboard • Photo Management • Document Control
Goal 6: Effective Communications		

G.5 CDOT Completing Emergency Repairs

Figure G-4 presents CDOT's decision tree on making decisions about emergency repair work to stabilize roadways and restore essential traffic. It not only helps CDOT make actionable decisions quickly, if defined responsible parties (e.g. maintenance or region engineering).

AECOM

EMERGENCY PROCEDURES

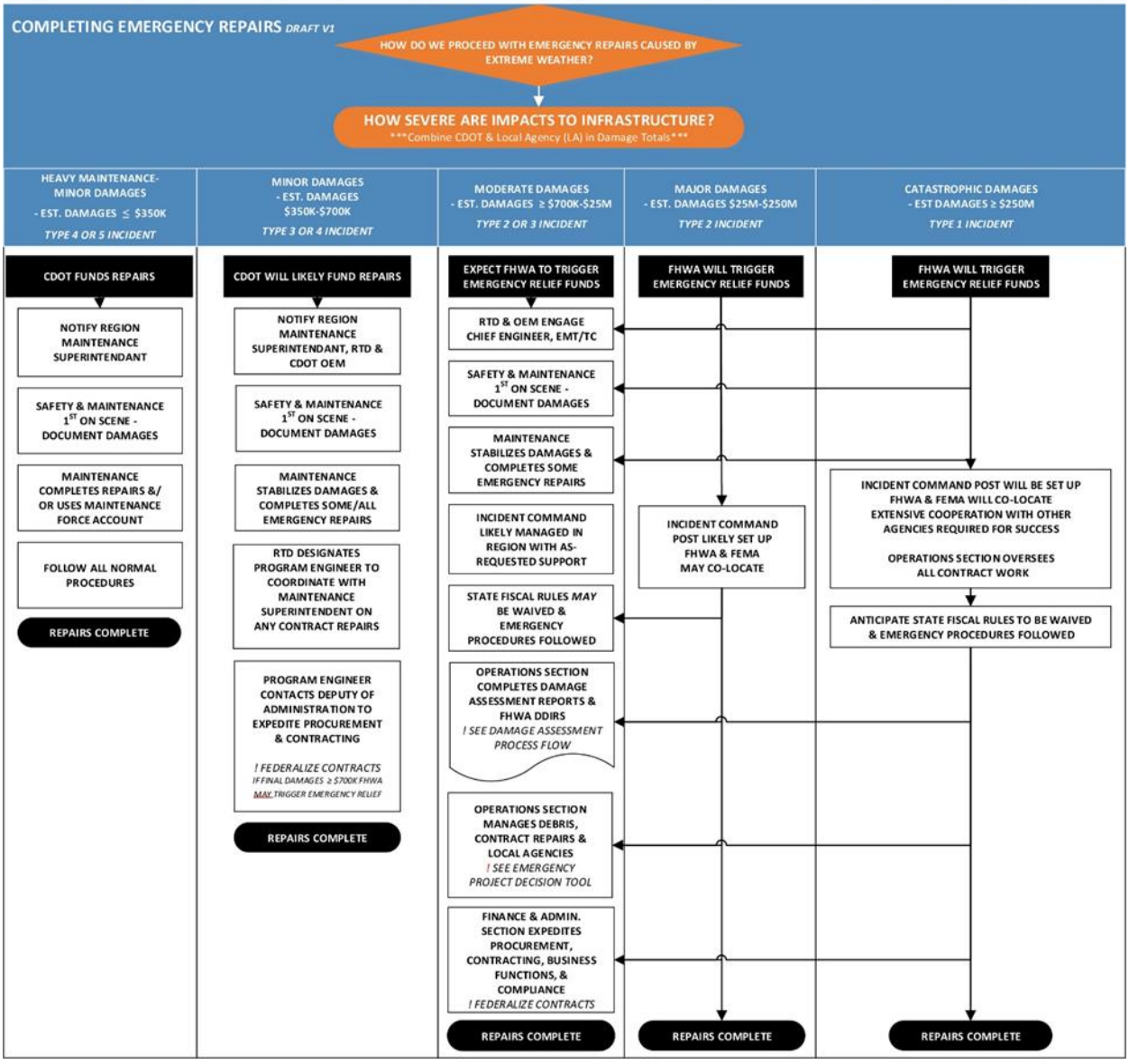


Figure G-4: Completing Emergency Repairs

G.6 Funding CDOT Emergency Repairs

Figure G-5 presents CDOT's decision tree to provide transparency on funding sources and clarifies when Federal disaster funding may be in play. Note that critical path tasks differ based on the scale and estimated costs of disaster damages.

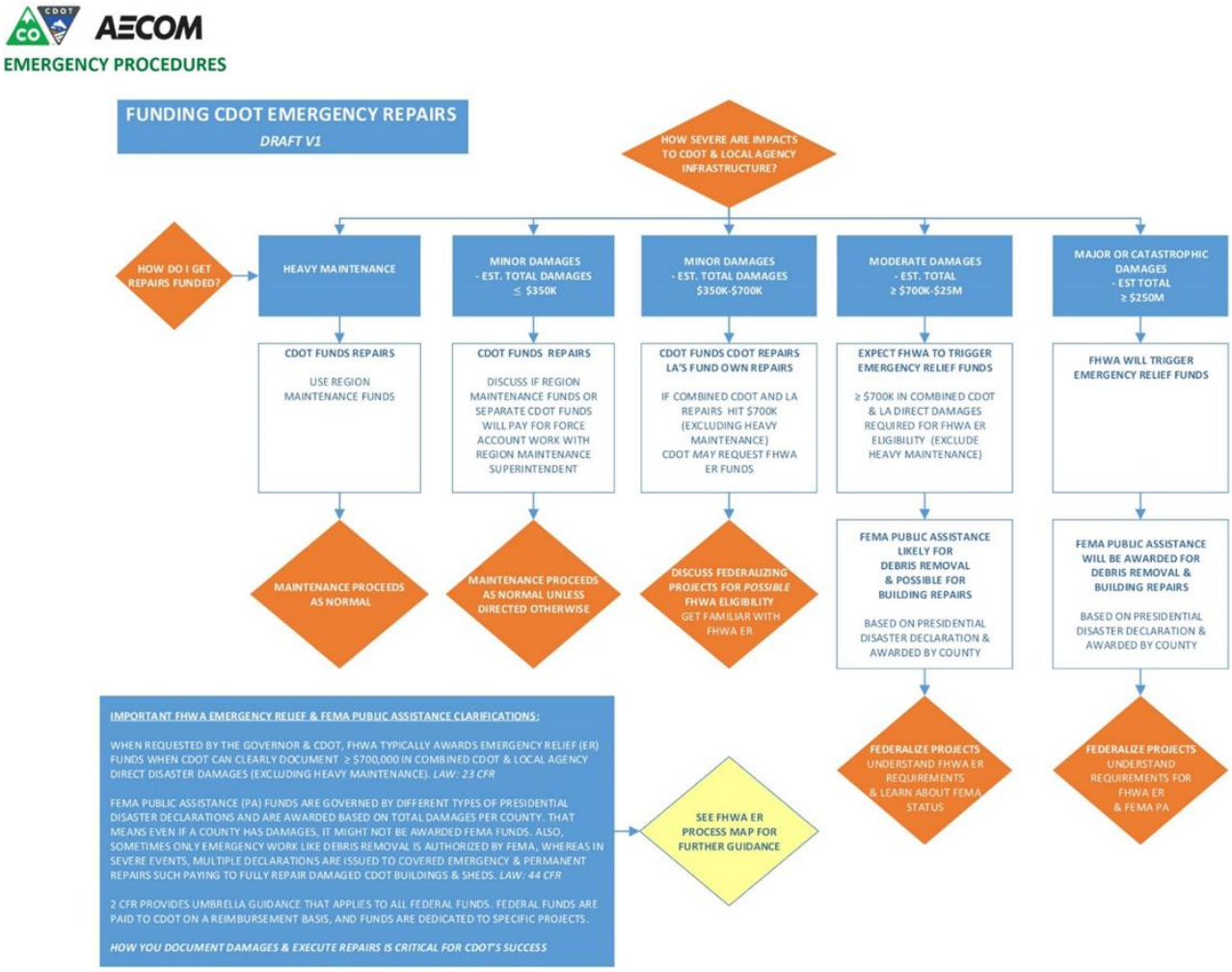


Figure G-5: Funding CDOT Emergency Repairs

G.7 Requesting Help: CDOT Incident Management, Response and Recovery

Figure G-6 presents CDOT's resource to its staff as they get ready for and respond to emergencies and disasters of all types and scales. For staff such as region engineers who lack disaster experience, accessing reliable information can feel like navigating a labyrinth. This simple chart (names removed) helps staff directly contact the leaders responsible for overseeing key areas of responsibility to get the right answer the first time, fast.

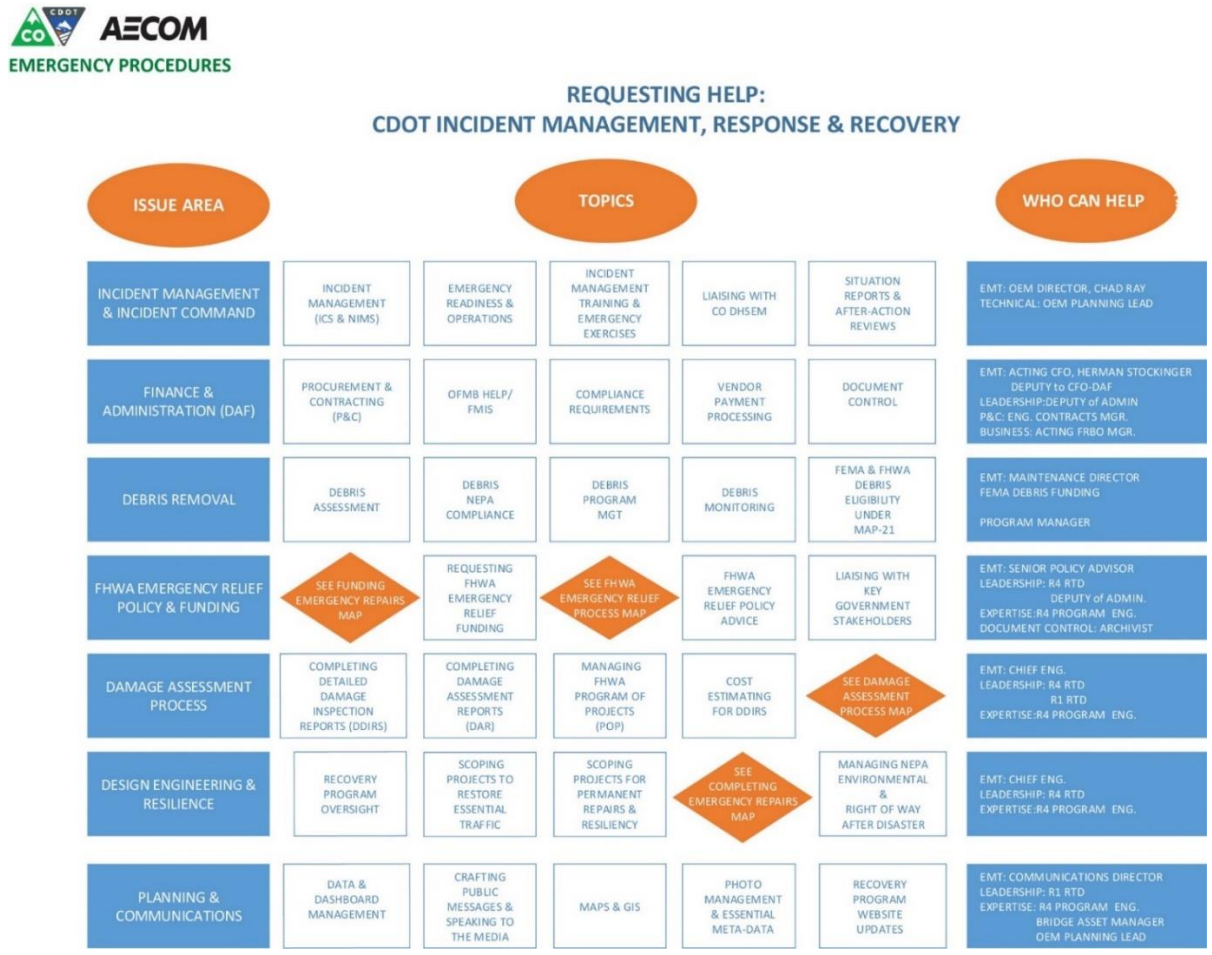


Figure G-6: Requesting Help: CDOT Incident Management, Response and Recovery

G.8 CDOT Damage Assessment Tool

The following presents CDOT's damage assessment report (DAR) template that was sent to local agencies in 2015 in anticipation of flooding. FHWA DDIRs are important, but they are intended to be rapid windshield assessments. DARs are mission-critical to tell the story of the emergency or disaster, both as a record of the project and for the audit trail. DARs provide important details when documenting single projects that can cost from $250,000-$250,000,000. DARs have been instrumental for Hurricane Katrina, Superstorm Sandy, the Colorado 2013 Flood, the Calgary 2013 flood, and recent events. A full CDOT DAR is included at the end of this Appendix.

DAMAGE ASSESSMENT REPORT FOR FEDERAL-AID ROADS

Local Agency:

County:

Route (MP-MP):

Site Name:

Existing Conditions

Roadway Facility

- Classification, Typical Section (Width, number of lanes, C&G or shoulders) showing end conditions
- Description of grade and topography (i.e. canyon, flat, mountainous)
- ADT
- Access Points
- Other amenities (i.e. Sidewalk, bike lanes, trail)
- Why is this facility essential?

Hydraulic/Structural Facility

- Description of existing hydraulic structures (Culverts, bridge, length, width, etc.)
- Year of facility
- Structure number if applicable and rating
- Design year

Description of Existing Conditions

- Make sure to state if it was an existing FHWA ER site from the 2013 event. If so, identify CDOT subaccount number for site, if known

Causation

- Flooding event including date, describe specific impact of event on the infrastructure

Description of Recommended Emergency Protective Measures

- Describe any recommended feasible and cost reasonable recommended actions to avoid or reduce damages
- What is CDOT's risk if this site floods: How severe do you think the damage will be to the CDOT asset(s)?
- What is the community risk if this site floods: Do you anticipate that possible flood impacts (e.g. bridge failure) at this site will cause other problems (e.g. downstream) or nearby (e.g. local hospital)?

Description of the Damage

- If this site has May 2015 damages, describe:
    - Severity of the damage
    - Dimensions of the damage/justify amounts
    - Describe the roadway section lost
    - If applicable, try to segregate 2013 flood damages from new 2015 damages

Provide Photos (proof of damage)

- Ensure GPS and date features are turned on

Description of Recommended Emergency Repairs

- If this site has May 2015 damages, describe any recommended emergency repairs to protect life/safety, prevent further damages and to restore essential traffic.

Description of Recommended Permanent Repairs

- Describe work required to replace the facility in kind with required safety improvements and CDOT standard practices
- Capture NEPA, ROW, Utilities other items required to repair facility

Appendix

Maps

Additional Photos

G.9 CDOT Workflow by Issue Area

Figure G-7 presents CDOT's workflows by issue area for CDOT's Emergency Procedures Working Group. While the content may or may not be applicable, the concept of monitoring by workstream with objectives, requirements, key deliverables, and progress monitoring provided a simple, real-time dashboard on progress that was also supported with drill-down information for each workstream. CDOT assigned a sub-committee for each workflow to move from ideas to action. CDOT used a data-driven dashboard that provided real-time data on both the financials and project delivery status. Major milestone status was also linked to State websites so the public could be informed about key project milestones.

AECOM

EMERGENCY PROCEDURES

WORKFLOW

***Please expand font, print on 11"x17" paper, or hard copy submission of report to enhance readability**

CDOT WORKING GROUP ON EMERGENCY PROCEDURES
EXECUTIVE SUMMARY: TASK ORDER 13 FINAL SUMMARY BY WORKSTREAM 7.25.18

FRAMEWORK	1. INCIDENT COMMAND CADRE *Emergency*	2. PROCUREMENT & CONTRACTING *Emergency*	3. MAINTENANCE & DEBRIS MANAGEMENT *Emergency*	4. LOCAL AGENCY COMPLIANCE *Emergency*	5. TECHNOLOGY INNOVATION *Department-wide & Emergency*	6. 2013 FLOOD ACTION STRATEGIES & FHWA FIRE REVIEW *Emergency*
OBJECTIVES	DEVELOP FLEXIBLE AND READY CDOT INCIDENT COMMAND CADRE	PROCURE EMERGENCY SERVICES AND CONTRACTORS ON STAND-BY BASIS	PROMOTE READINESS TO LEAD DEBRIS MANAGEMENT, PROVIDE 1ST ON SCENE INTEL, AND DOCUMENT ROADWAY STABILIZATIONS	REFINE BUSINESS PROCESSES AND TRAINING TO IMPROVE LOCAL AGENCY SUPPORT AND COMPLIANCE	USE TECHNOLOGY TO STREAMLINE BUSINESS PROCESSES AND INCREASE EFFICIENCY AND DATA RELIABILITY	UTILIZE 2013 FLOOD ACTION STRATEGIES AND MONITOR RESPONSE TO FHWA FIRE OBSERVATIONS
REQUIREMENTS	1. Develop flexible CDOT emergency cadre for ICP that scales to meet specific event severity/magnitude (region and multi-region) 2. Evaluate Emergency Operations Plan and provide feedback 3. Develop semi-annual training/exercise for ICP staff and Just-in-Time training 4. Build content for CDOT web-based interface for ICP staff to rapidly tap key information (e.g. tools/templates, process flows, training, org chart)	1. Issue emergency procurements including: - Prof. Services NPS (capacity) - Increase bridge inspection NPS - Construction IDIQ - Design-build IDIQ - Debris Removal IDIQ - Consider robust pre-qualifications process - Secure FHWA approval for contracting pilots 2. Develop emergency contract template 3. Develop best contracting strategy evaluation tool 4. Pursue other key event procurements 5. Identify key ICP roles/ authority for rapid contracting	1. Educate maintenance leaders on debris management planning and FEMA policy 2. Facilitate planning sessions for development of Debris Management Plan 3. Provide mark-ups on Debris Management Plan 4. Identify training for debris management and monitoring 5. Identify process improvements needed for Emergency-Maintenance Work Orders	1. Refine ICP staffing structure to support Local Agencies and process flows 2. Develop training for Local Agency compliance in emergencies (leverage FHWA resources) 3. Include FRO/FRBO representatives on Local Agency Working Group	1. Streamline field data collection with technology tools (e.g. Form 10's), and leverage other CDOT technology innovations 2. Ensure effective data collection and synthesis through enterprise integration 3. Include field-based disaster modules (e.g. FHWA DDIRs, insurance)	1. Direct 2013 flood Action Strategies to appropriate divisions not addressed in objectives 1-4 2. Support follow-through on performance objectives 1-4 to respond to FHWA 2016 FIRE observations 3. Work with Human Resources to integrate ICP functions into PDQs & address compensation
KEY DELIVERABLES	Dept. of Finance & Administration and Engineering Validation Groups - Scalable ICP structure for single-region and multi-region events at different magnitudes - Selected, trained and ready CDOT emergency cadre - Programmed training and exercises (pre- and post-event) - Web interface for easy access to information ICP staff need - Provide mark-ups on CDOT Emergency Operations Plan	Dept. of Finance & Administration and Engineering Validation Groups - Complete emergency NPS and IDIQs for professional services and construction in compliance with State/Federal rules - Negotiate additional procurements that facilitate successful response/recovery - Emergency contract template ready to go	Dept. of Finance & Administration and Maintenance - Provide mark-ups on Debris Management Plan - Conduct training on FEMA - Identify additional training for debris management and monitoring - Identify process improvements needed for Emergency-Maintenance Work Orders - Draft debris removal scope	Dept. of Finance & Administration and Engineering Validation Groups - Draft and Final Emergency Procedures for Local Agency Manual - ICP Structure for Local Agency Monitoring/Support - Training Modules (pre- and post-event) and exercise developed	Dept. of Finance & Administration and Engineering Validation Groups - Field-based data collection tools (engineering) - Enterprise integration for any new tools with CDOT Platform & Applications	Dept. of Finance & Administration and Engineering Validation Groups - Provide feedback and technical assistance to stakeholders (e.g. CDOT OEM, LA Working Group, DAF) - Update process flows on emergency business processes - Provide emergency tools for ICP use - Compensation policy in place
PROGRESS	**COMPLETE** - Scalable ICP structure for single-region and multi-region events at different magnitudes COMPLETE - Provided mark-ups on CDOT Emergency Operations Plan COMPLETE -Compensation policy was advanced through cooperation with Policy, HR, Payroll, and OEM IN PLANNING - Programmed training and exercises (pre- and post-event) IN PLANNING - Web interface "e-command" for easy access to information ICP staff need to perform effectively - Outreach to IT is required to advance this task	**COMPLETE** - NPS contracts have adequate capacity, and emergency capacity can be added - Additional bridge inspection vendors added to NPS COMPLETE - Emergency NPS contracts will use new contract templates COMPLETE - Draft Debris Management Scope. Requires review. NEXT STEPS - Emergency IDIQs will be modelled after current IDIQ pilots when IDIQs are adopted in late 2018	**COMPLETE** -Facilitated multiple debris-management education and planning sessions with staff - Facilitated planning for Debris Management Plan Development - Marked-up Debris Management Plan - Facilitated training on FEMA Debris Management Policy - Drafted Debris Management contract scope of work including 2013 lessons learned - Developed debris management org chart - Facilitated planning and outline requirements for emergency Maintenance Work Order compliant with FHWA ER	**COMPLETE** - ICP Structure for Local Agency Monitoring/Support within Operations Section IN PLANNING - Draft and Final Emergency Procedures for Local Agency Manual are being developed when CDOT sponsor is ready NEXT STEP: - Training Modules (pre- and post-event) and disaster exercises are being designed when CDOT sponsor is ready	**COMPLETE** - Field-based data collection tools (engineering) have been evaluated as part of LEAN process for technology - NEXT STEP: Tools for emergency use still need be layered into new technology COMPLETE - Field-based debris and emergency roadway repairs requirements have been scoped to include all additional emergency/FHWA ER requirements - NEXT STEP: Requirements will be integrated in next generation maintenance technology rollout as resources permit	**COMPLETE** - Updated and validated business process flows for F&A COMPLETE - Developed and validated process flows on emergency repair projects, disaster funding, and requesting help COMPLETE - Developed and validated Emergency Repair Project Tool to help engineers identify best procurement and contract methods for project scope/ scale/complexity COMPLETE - Policy concurrence on compensation - NEXT STEP: Include emergency roles in PDQs

Figure G-7: CDOT Workflow by Issue Area

G.10 Emergency Repair Project Decision Tool Worksheets 1 and 2

Figure G-8 and Figure G-9 present customizable templates to guide decision making on emergency projects and to create linkages to that same project/asset's resilient recovery. Worksheet 1 is for simple projects that can quickly be restored to pre-disaster condition. Worksheet 2 guides the user through key considerations to better understand and make decisions related to project complexity. The CDOT original follows.

EMERGENCY REPAIR PROJECT DECISION TOOL: WORKSHEET No. 1 **Emergency Repairs Subaccount #: _____**

EMERGENCY REPAIR PROJECT INFORMATION	
Project Name	Inc. watershed/community
Project Location	Inc. MP/E&N/GPS
Date	
Resident Engineer	Print Name: Title: Region:
Budget Estimate	DDIR Construction Only: $ DDIR Total Costs: $
Project Est. Duration	Planning: Design: Construction:
Scope of Work ***Attach DDIR & DAR*** *Attach additional detail*	
Unique Project Factors *Note all known now*	Potential Severe Damages Highly Complex Project ROW Issues Critical Corridor NEPA Impacts No Alternate Routes Available Bridges/Structures Impacted Urgent Community Impacts
Funding	**ASSUME FEDERAL FUNDING:** ***Set Up Project To Meet All FHWA 1273 Requirements***
Design	Yes – *External Consultant* Yes –*Staff Only* No – *Not needed*
Construction Management	Yes – *External Consultant* Yes – *Staff Only*

KEY EMERGENCY REPAIR PROJECT DECISIONS				
Procurement Engineering	N/A	NPS *(Specify)*	New: *Secure 3 qualification-based proposals*	
Procurement Construction Mgt	N/A	NPS *(Specify)*	New: *Secure 3 qualification-based proposals*	
Procurement Construction	N/A Maintenance	Emergency IDIQ	Collect 3 bids by Email	New Advertisement
Construction Pricing ***Additional Conditions***				
Contract Delivery				
Right of Way (ROW)	Project Within Existing ROW		ROW Purchase or Easement Required	
NEPA Complexity	High – *complex*	Moderate – *needs environmental support*	Low – *no issues anticipated*	
Level of Work Note all that apply	One & Done – *Complete all work now* Restore Essential Traffic Now – *Asphalt*		Restore Essential Traffic Now – *Gravel only* Other	
Additional Permanent Repairs Required?	No: *One & Done* Yes: *Consider Resilience Analysis*	Yes: *Repair to Pre-Disaster Condition* Yes: *Consider Other Betterments*	Yes: *Repair to Standards & Specifications*	

Figure G-8: Emergency Repair Project Decision Tool Worksheet 1

EMERGENCY REPAIR PROJECT DECISION TOOL: WORKSHEET No. 2 **Emergency Repairs Subaccount #:_____**

KEY PROJECT DECISION SUPPORT	
Summary	**This tool is designed to aid in rapid decision-making on emergency repair projects**
Community Impacts *See Situation Reports*	Community is functioning Community is negatively impacted Community access is cut off!
Criticality High ADT/Freight	High Moderate Low
Alternate route redundancy?	Yes – good through construction Yes – very short term only No - detour not feasible No - consider detour
Road closure(s)	Yes – road open through construction Yes – very short term only No - road closed through construction
Heavy Equipment Route	Yes – must be able to handle heavy equipment No – alternate routes available
Permanent repair project complexity	High Moderate Low
Severe damages	Yes – entire corridor destroyed (crown to ROW) Yes – some segments (crown to ROW) destroyed No
Permanent repairs can be completed quickly & efficiently	Yes – expedite whole project No – complete emergency repairs now then permanent repairs
Right of Way (ROW)	No – project in existing ROW Yes - Easement(s) Required Yes - ROW Purchase(s) Required
NEPA Status	Categorical Exclusion & 128 *Complete* 128 *in Process* 128 Required *Supported Needed*
Utilities/Railroad (RR)	Yes – Major Utilities Impacted No - No Major Utilities Impacted Yes – RR crossing damaged Yes – RR crossing affected No – No RRs crossing impacts
Bridges/Structures	Yes – bridges/structures impacted Yes – Abutments & Scour only No
STIP Status	*Yes – this location in the long-range transportation for STIP construction? No * *May not be eligible for FHWA ER funding*
Governor's Disaster Declaration Status	Yes – Governor declared disaster No – Declaration is pending No - Declaration Anticipated
Funding - Has FHWA acknowledged disaster	Yes – FHWA signed *DDIR No – *DDIR is in Draft No – *DDIR is NOT Anticipated *Detailed Disaster Damage Report (DDIR) describes project scope of damages with planning level cost estimate signed by FHWA*
Special Safety	Yes – Unique Safety Issues No – Follow Standard Standards & Specifications for Safety
Permanent Repair Resiliency Potential	Yes – Build back stronger No – Resiliency not feasible/cost effective Help Requested
Other Betterments *Specify*	Yes No – Not feasible or cost effective

Figure G-9: Emergency Repair Project Decision Tool Worksheet 2

G.11 CDOT Decision Support Toolkit: Emergency Repairs to Disaster-Impacted Infrastructure Narrative

The following tool presents CDOT's entire Emergency Project Decision Tool. In this full version, Worksheet 2 is followed by narrative explanations/guidance to consider when developing the scope of work for a project that is clearly complex with lots of moving parts and where there is potential to leverage co-benefits. *[Worksheets 1 and 2 are already presented above in template form, this only shows the narrative component]*

DECISION SUPPORT TOOLKIT: *EMERGENCY REPAIRS TO DISASTER-IMPACTED INFRASTRUCTURE*

Overview

This document was developed to rapidly walk the engineer/project team through critical project considerations to aid in the selection of the best procurement, contracting and project delivery methods to repair damages to a disaster-impacted roadway or structure.

- Worksheet 1 captures key project information and documents the engineer's decisions about how the project will be set up and delivered.
- Worksheet 2 provides prompts to promote decision support to the engineer/team and highlights key project factors to consider when setting up and delivering the project including which specialty groups to consult early in the process.
- This Decision Support Toolkit discusses procurement, contracting and project delivery options in greater detail with attention to disaster-impacted transportation infrastructure and important disaster-related project tips.

Background

This toolkit draws heavily on CDOT's *Project Delivery Selection Matrix* but is truncated to recognize the constraints engineers face following disasters. It also reflects lessons learned from the 2013 flood and encourages you to consider risks and innovation. CDOT Engineers from HQ and the Regions were involved in developing and validating this toolkit. *Suggestions for improvement are welcome.*

Restoring Essential Traffic

What is restoring essential traffic?

Per CDOT's December 13, 2013 memorandum on guiding the restoration essential traffic signed by FHWA:
The road is open to essential traffic when it is open to allow access for emergency vehicles and local traffic. There is not a requirement to provide highway speed of use, permanent surfacing for smoothness of the roadway, construction to line and grade similar to the facility prior to the event, or roadway use periods uninterrupted be traffic flagging control to facilitate on-going repairs. Therefore, the emergency repair is considered the repair that provides the ability to move traffic on a gravel surface, a detour, a temporary bridge, or through a roadway section cleared of debris. All efforts should be made to complete all repairs, both emergency and permanent in the emergency phases (see below). See essential traffic memorandum, attached.

Scale & Complexity of Disaster Impacts

Most disaster events are relatively limited in area, scope and complexity. Others take one's breath away. The following walks through considerations to guide the engineer's approach to organizing the project's planning based on the scale of the impact.

Projects with Low-Moderate Disaster Damages and Straight-Forward Repairs

If the disaster project damages and repair scope seem clear, complete and relatively straightforward (e.g. repair to pre-disaster design), it is worth considering completing the permanent repairs immediately with no temporary repairs. For example, if a redundant route it available, an impacted road or bridge could be closed for a week while construction for the entire project is competitively bid and rapidly contracted. This ***One and Done*** type project uses resources efficiently and gets the transportation asset up and running to its full capacity quickly. In doing so, it makes more time available to dedicate to larger, more complex multi-year projects.

Projects with Severe Damages and/or Corridor-Scale Impacts

The extent of a disaster damages - the impacts on communities, the economy and the environment – often drive the pace of disaster response with life/safety always of the first concern. When immediate safety is addressed, sometimes the first response is to (GO!) rapidly and fully repair the most severely damaged transportation infrastructure. However, repairing severely damaged infrastructure is often difficult, complex, and represents a major taxpayer investment. Sometimes it is better to slow down in order to speed ahead.

Some factors to consider:

- ***What is the minimum scope to safely restore essential traffic?*** By using a simple fix to restore essential traffic, the engineer has more time to find the best long-term solution to plan, design, procure, contract, and deliver the project on-time and on-budget and preserved the potential for resiliencies, betterments and/or innovative contracting.

- ***Does this project need specialized support due to complex ROW, environmental, public engagement requirements?*** If dedicated support of specialty groups is needed to successfully plan, design and deliver the project, restoring essential traffic to "buy" planning time might be a good option.

- ***Would this project require special collaboration?*** Is this a Federal Lands Access Program (FLAP) project? Are Tribal lands involved? Is there a known historic or culture site within 500 feet of the impacted asset? Should we consider asking the Governor's Office to consider CO Army National Guard support for this project? Allow planning time to coordinate with partners and stakeholders effectively.

- ***Are repair costs FHWA eligible to rebuild to CDOT Specifications?*** That depends. Typically, FHWA will support repairs to CDOT specifications only in those corridor segments or structures that are severely (catastrophically) damaged and where CDOT already has (or is about to) bring the adjacent segments up to CDOT Specifications. For example, if CDOT specifications call for a 10'-12' roadway shoulder, but CDOT has made recent nearby improvements on the corridor with an 8' shoulder allowed through a waiver, FHWA will likely only pay for up to an 8' shoulder.

- ***Does this transportation infrastructure have high potential to be rebuilt resiliently?*** Can it be designed to reduce impacts to the transportation assets in a future disaster? Would rebuilding stronger (higher, elsewhere) reduce negative impacts to critical assets surrounding CDOT's transportation infrastructure like hospitals, hydro-electric dams, fire stations or police barracks, sensitive waterways or habitat? CDOT worked with a consultant to develop a Risk and Resiliency (RnR) method of analysis to help guide the consideration of resilient reconstruction alternatives. FHWA has a number of conditions that must be met for resiliency improvements to be paid for with FHWA Emergency Relief funds so ensure it is clear if - and what exactly - FHWA will support and whether or not CDOT will fund any balance.

- ***Do conditions like remaining useful life, future growth and congestion, multi-modal access, and/or potential autonomous vehicle use affect how the project might be planned, designed or delivered?*** If so, vet these betterments in planning. Betterments funded by FHWA in disasters are limited, but if long-term planning is the best plan for Colorado either FHWA or CDOT may be willing to support additional investments to accommodate real needs.

- **Does the project have good potential to use an innovative contracting method?** Design-build and Construction-Manager General Contractor (CMGC) are the two methods of innovating contracting CDOT uses as this time. Consider if either of these methods might provide savings in costs, time and/or risk on the project (see CDOT's *Project Delivery Selection Matrix* for a comprehensive analysis of innovative contracting options as well as *CDOT's Design-Build Manual*).

Procurement & Contracting Options

- New competitive procurement.

- Emergency procurement: contact not fewer than 3 firms and receive qualified response from not fewer than 2 firms for either qualifications-based selection for consultants or bid-based selection (or other basis) for construction.

- Indefinite-Quantity-Indefinite Delivery (IDIQ) or standby contract for emergency work.

- Selection from list of pre-qualified or (competitively selected) preferred vendors. Note: access to submit as a pre-qualified vendor must remain open until vendor selection per 2 CFR.

Project Delivery Options

The most common options for project delivery are Design-Bid-Build (DBB), Design-Build (DB), and Construction Manager/General Contractor (CMGC). However, after disaster, maintenance forces may be used to construct minor repairs, and some projects are completed without design.

Maintenance Forces might have a capacity to complete repairs on a modest project.

Construction Services Only In some cases, only construction contractors - without the support of professional design/engineering services - are engaged for emergency repair projects to restore to pre-disaster conditions. In this case, modest engineering direction will be given in the field.

Design-Bid-Build is the traditional project delivery method in which professional design/engineering services are engaged using a planning level cost estimate, and then a separate construction contract is awarded based on the lowest (or best value) bid or unit prices based on the designer's completed "bid set" construction documents and quantities. In the case of errors and omissions, the construction costs to correct design errors and omissions are the responsibility of the owner except for any redesign fees for which the design consultant is typically responsible.

Design-Build is a project delivery method in which both design and construction services are procured in the same contract from a single, legal entity referred to as the design-builder. The method typically uses Request for Qualifications (RFQ)/Request for Proposals (RFP) procedures rather than the DBB Invitation for Bids procedures. The design-builder controls the details of design and is responsible for the cost of any errors or omissions encountered in construction.

Construction Manager/General Contractor (CMGC) is a project delivery method in which the agency contracts separately with a designer and a construction manager. An engineering firm is engaged through a professional services contract to provide design services and produce drawings. A construction manager is procured separately to perform construction management services and act as the construction contractor. The significant characteristic of this delivery method is a contract between an agency and a construction manager who will be at risk for the final cost and time of construction. Construction industry/Contractor input into the design development and constructability of complex and innovative projects are the major reasons an agency would select the CMGC method. Unlike DBB, CMGC brings the builder into the design process at a stage where definitive input can have a positive impact on the project. CMGC is particularly valuable for new non-standard types of designs where it is difficult for the owner to develop the technical requirements that would be necessary for DB procurement without industry input. It represents additional risks to the owner, however, as the CM is also the construction contractor, rather than acting as the owner's representative as would be the case in DBB.

Construction Pricing - *Additional Conditions*

- Unit Bid Pricing
- Time and Materials (T&M) with Not-to-Exceed (NTE) Cap (Force Account)
- Fixed Firm Price/Lump Sum
- Cost + Fixed Fee
- Incentive (e.g. time)
- Economic Price Adjustment (EPA)
- Force Account for Mobilization Only
- Note: Cost plus Percentage of Cost Prohibited per 2 CFR

Special Disaster-Related Conditions to Consider

Safety

Safety is always top of mind in a disaster. Special attention should be given to dynamic and changing field conditions (e.g. additional rockfall or slope failures) that present risks to staff and workers. Similarly, after disaster, competing and incomplete information sometimes results conflicting direction which can cause confusion in the field, work is sometimes performed without design/engineer drawings, and there is persistent pressure to get the work done quickly. Unless managed effectively, it can lead to chaos and unsafe conditions in the field. Take the time to follow CDOT specifications on project safety planning, and include the necessary staff and budget required to deliver the job safety.

Defining Scope of Work

Developing the scope of work for a project post-disaster can be difficult because sites may be fully or partially inaccessible and complete data on impacts might not be available. In addition, weather conditions can decrease visibility on a site, and planning time may be negligible. This can make defining the scope clearly for effective job mobilization and oversight difficult. An unclear scope also

makes managing costs and risks challenging and can leave CDOT open to change order requests by contractors. Define the scope as well as possible (including type or work, dimensions/quantities), and consider working with procurement to build in a "reset" with contractors after a specified number of days on the job to build new information into the scope (such as updated material types and unit prices), and adjust accordingly. CDOT is developing procurement and contracting support for emergencies with the unique conditions in view (see below).

It is not atypical in emergency projects to make discoveries (e.g. a roadway did not initially look undermined, the size of a void was underestimated, a culvert collapsed) or to have the scope be impacted by changing conditions (e.g. a new embankment failure). Develop a protocol to anticipate changing conditions or discoveries that may be encountered on the job include them in the project risk register to manage risks and costs.

Project Schedule

Due to disruptions to the travelling public, it is critical to restore essential traffic as quickly possible with safety in view. When critical corridors are impacted or the event is large-scale, the Governor or CDOT may make commitments on the timeline for restoration of essential traffic. As the engineer, it is important that you are aware of these public commitments so that projects can be structured to accomplish this goal. At times, this can involve construction around-the-clock so special consideration should be given to project safety, structure, sequence, and oversight.

Project Funding

Project funding is discussed briefly throughout this resource. FHWA requires a State Disaster Declaration request to FHWA which is distinct from a Presidential Disaster Declaration. FHWA will consider acknowledging a state request for a FHWA ER funding when the State has declared a disaster and CDOT has documented not less than $700,000 in disaster-caused damages to Fed-aid Roads. This process is managed through CDOT headquarters.

If FHWA awards the declaration, it will take time for funds to flow – even years – which means that all of the federal compliance requirements must be followed in order to be eligible for later reimbursement so stay connected to the status of funding and if and how the project will be accomplished if funds are not immediately available. CDOT and FHWA work together to identify projects. FHWA maintains the whole disaster portfolio within a Program of Projects (POP) listing all eligible projects. Each eligible project is defined with a Detailed Damage Inspection Report (DDIR) which includes a windshield damage and scope description and a planning-level cost estimate. The DDIR is signed by CDOT and FHWA and is required for project funding. Because FHWA Emergency Relief funds are governed by a special pot of funds, some requirements differ from other FHWA funds.

What is Generally Covered?

If FHWA acknowledges a disaster, the severity of damages governs what is and what is not eligible. Only damages directly caused by the disaster are eligible. FHWA does not support repairs to disaster impacts that are considered heavy maintenance. The functional classification needs to be above a minor rural collector.

If damages are fairly straight-forward, there is no need to separate projects into distinct emergency and permanent projects. These "one and done" projects are best accomplished quickly to create space for more demanding disaster projects and, at the same time, provide relief to the traveling public. FHWA supports the normal pro-rata share (approximately 82.79%) of these costs.

FHWA emergency repairs will support restoring essential traffic (discussed above). That means no permanent scope should be included except where absolutely necessary to support life/safety. FHWA supports 100% of these costs.

FHWA generally pays for permanent repairs to restore to pre-disaster design/condition where damages that exceed heavy maintenance to moderate severity within the limits of the damage. Even if CDOT specifications call for code upgrades, FHWA will generally not support these upgrade costs (e.g. widening, upsizing culverts). FHWA supports the normal pro-rata share (approximately 82.79%) of these costs.

Where a structure or segments of a roadway are severely damaged (catastrophically damaged), FHWA will typically support the restoration to CDOT specifications within the limits of the damage as long as CDOT has demonstrated a history of doing so on that asset/corridor. In addition, on severely damaged assets may be eligible for funds for resiliencies and/or betterments, but these requests are closely vetted by FHWA to ensure the additional investments are justified and cost reasonable. FHWA may also agree to cover the partial cost of a resiliency or betterment.

In a federally-declared disaster, FEMA is the agency responsible for funding debris removal. It has a distinct set of rules governing the funds. CDOT maintenance will be the primary liaison with FEMA and will oversee debris removal. FHWA and FEMA have delineated responsibilities on debris removal. The "haul and tip" debris removal tasks including any staging, sorting, chipping (etc.) must be tracked and managed under the FEMA rules and will be supported by the debris removal contractor. If, however, vegetative other debris is within the right of way and is obstructing the completion of emergency repairs, the construction contractor repairing the roadway may push the debris aside to allow for construction to continue. This pushing aside of debris is part of the emergency repair project scope and is not considered debris removal. When this clear distinction between pushing aside debris and hauling away debris becomes murky, such as in the canyons, FHWA and FEMA will meet together with CDOT to figure our project-specific solutions.

What is Generally Not Covered?

Making repairs outside the limits of the disaster damages is generally prohibited except where absolutely needed to accomplish the repairs. Performing work that reconstructs an asset where less invasive repairs are needed is generally not allowed.

Is there a project STIP'd for construction now disaster damaged?

Because FHWA already supports projects that are STIP'd in construction, FHWA is not allowed to fund the permanent repairs for any damaged scope in a STIP'd project. For example:

- SH 119C is STIP'ed for construction next year from MM 57-MM 63 for the following scope: replace the roadway aggregate, upsize concrete box culverts, replace curbs and gutters, widen shoulders, white top, striping, and guardrail replacement or reuse, bridge approach replacement, minor bridge deck repairs (non-structural), all signage, lighting, and ITS.
- The project has been STIP'ed for construction, designed and bid, but no notice to proceed (NTP) has been issued for construction.
- Significant spring flooding from the St. Vrain severely damages SH 119C from MM 60-MM 65 and destroys the roadway; the bridge approach at MM 60-MM 60.5 is lost, and the bridge deck is structurally compromised.

- In this case, FHWA might only consider using Emergency Relief funds to pay for a portion of the replacement of the structurally damaged bridge deck and all eligible damages at MM63-MM 65 because the latter segment of the corridor has not been STIP'ed for construction.

Note: Local agency projects selected to receive federal funds that are located in one of the 5 Colorado Metropolitan Planning Organizations (MPOs) are additionally required to be listed in the respective MPO's Transportation Improvement Program (TIP). The TIP is a prioritized listing of transportation projects developed and formally adopted by a MPO as part of the metropolitan planning process and plan This TIP requirement is in addition to the provisions on projects that are STIP'ed for construction (described above). The 5 MPOs include: Denver Regional Council of Governments (DRCOG) for 10 Counties (Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Denver, Douglas, Gilpin, Jefferson, Southwest Weld); Grand Valley Metropolitan Planning Organization (GVMPO) for Mesa County; North Front Range Metropolitan Planning Organization (NFRMPO) for Larimer and Weld Counties; Pikes Peak Area Council of Governments (PPACG) for El Paso and Teller Counties, and Pueblo Area Council of Governments PACOG) for Pueblo County.

Can other funds be added to leverage opportunities, thereby expanding the planned project scope?

While this shows commitment to collaboration and vision, it requires very special handling – and extra time and effort - to clearly segregate project scope funding and may require separate "schedules of values" or even separate invoicing for each source of funds. In addition, some funds – such as insurance - are might not be "additive" since federal disaster funds net out insurance proceeds from eligible funds. In addition, some federal funding sources can be used together; others require special agreement from each involved federal agency.

Are special permissions required to procure, contract or deliver the project?

Once the project is approved within a DDIR, the project should be delivered within scope, as with any project. It is important that any anticipated scope and cost changes that will result in an allowable change order be elevated to CDOT for FHWA consultation. FHWA will determine if the additional scope is eligible for FHWA Emergency Relief funding. If it not, the responsibility for supporting this work falls to CDOT.

Additional funding questions?

See FHWA's ***Emergency Relief Manual*** **(May 2013)** for details on more detailed rules governing funding.

Compliance

FHWA ER funded projects differ very little from other FHWA supported projects except for the compressed timelines for work. FHWA 1273 requirements remain in place such as Davis-Bacon, DBE goals, and Buy America requirements. There is some relief on the procurement of emergency repairs - follow CDOT procurement guidance on emergency contracting in consultation with guidance from 2 CFR Part 200 and *FHWA's Emergency Relief Manual* dated May 2013. CDOT procurement and contracting is hard at work expanding available resources for emergencies to expedite this process.

Despite the fact that compliance is largely the same for disaster and non-disaster projects, compliance is watched very closely by FHWA and FHWA's Office of Inspector General. As such, scrupulous attention must be paid to ensure all compliance requirements are followed and clearly documented. This includes maintaining a detailed decision log.

It is important that the procurement, contracting and project delivery method align with documentation collected in the field. For example, a force account project requires complete Form 10's with certified payrolls as well as detailed invoices describing trucking, equipment utilization and rates, materials types and quantities. As such, it requires a higher level of documentation and field-based validation that a unit price contract supported through Site Manager.

Because some disaster projects can be completed with fewer procurement controls and disaster projects, by nature, involve dynamic conditions, disaster funds are more closely monitored by FHWA's Inspector General to ensure there is no fraud, waste or abuse. That means audits can and should be expected. Records should be kept with this expectation in view.

Involving CDOT Risk Management

CDOT Risk Management is involved in all disasters. They will apply for any applicable insurance proceeds and, therefore, need to be aware of disaster damages. The engineer should ensure s/he is directing information through the engineering or incident command

liaison to CDOT risk management and is responsive to any questions from CDOT Risk Management. All insurance reimbursements made to CDOT will be included in the total costs and said amount will be deducted from any FHWA ER allocation(s).

9

Amplified Glossary, *Order of Appearance*

MP/E&N – Milepost/Easting & Northing: Geographic Cartesian coordinates for a point. Easting is eastward-measured distance (x-coordinate); Northing is northward-measured distance (y-coordinate)

DDIR - Detailed Disaster Damage Report: This windshield damage assessment is co-signed by CDOT and FHWA to establish basis for eligibility on eligible disaster projects and documents preliminary damages and scope

DAR – Damage Assessment Report: Provides details on event, cause, and damage impacts to CDOT asset and provides general scope of project; more detailed than DDIR

FHWA – Federal Highways Administration

FHWA 1273: Federal Highways Administration summary of compliance requirements involving standard contract provisions on all Federal-aid construction projects

NEPA – National Environmental Policy Act: governs compliance with a framework of environmental laws including historic/archaeology and environmental justice

ROW – Right of Way

NPS - Non-Project Specific: professional services contract that can be applied to one or more projects requiring that capability rather than one specified contract

IDIQ - indefinite delivery–indefinite quantity: standby construction contract type competitively bid without a specific project scope that may or may not be awarded and can be applied to a range of projects; requires FHWA approval

N/A - not applicable

T&M with NTE Cap - time and materials with not to exceed: contract type where vendor is paid based on time-based level of effort and actual material costs plus a factor for overhead and profit (v. unit or bid type pricing); typically used as Force Account

CMGC - construction manager/general contractor: combines construction management and construction services in one contract and sometimes up to 30% design

MGT - management

RnR - Risk & Resiliency: method of cost-benefit analysis used to evaluate alternatives proposed for infrastructure resilience

ADT (High ADT/Freight) - average daily traffic

128 (NEPA 128) - Reference to 23 US Code Section 128 governing requirements for NEPA environmental authorization for a project

STIP - statewide transportation improvement program: used to authorize regionally-significant transportation projects

HQ - headquarters (CDOT)

FLAP - Federal lands access program

DBB - Design-Bid-Build: project delivery method using traditional iterative phases of design, construction bid, and construction delivery

DB - Design-Build: Innovative project delivery method that combines design and construction under one contract

RFQ - Request for Qualifications: used to solicit professional services proposals evaluated on professional qualifications

RFP - Request for Proposals: used to solicit proposals evaluated on both qualifications and price or best value

POP - Program of Projects: mechanism used by FHWA to track and authorize approved emergency repairs and permanent repairs for on-system roadways supported through FHWA Emergency Relief program

ITS - intelligent transportation system

NTP – Notice to Proceed: authorization for a vendor to commence work under contract

MPOs - Metropolitan Planning Organizations

MM - mile marker

DBE - disadvantaged business enterprise

2 CFR Part 200 – 2 Code of Federal Regulations: harmonized umbrella regulations governing all federally-funded program and projects

TIP - Transportation Improvement Program - prioritized listing of transportation projects developed/adopted by MPO for construction

Form 10 – Inspector Report for Force Account Work, Construction

Amplified Glossary, *Alphabetical Order*

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T&M with NTE Cap - time and materials with not to exceed: contract type where vendor is paid based on time-based level of effort and actual material costs plus a factor for overhead and profit (v. unit or bid type pricing); typically used as Force Account

TIP - Transportation Improvement Program - prioritized listing of transportation projects developed/adopted by MPO for construction

G.12 CDOT Damage Assessment Report Example

SH 119C

Site Repairs: Mileposts 61.8-63.2

Weld County
COLORADO

Damage Assessment Report

Prepared For:
FEDERAL HIGHWAY ADMINISTRATION

COLORADO
Department of Transportation

Prepared By:
COLORADO DEPARTMENT OF TRANSPORTATION

100% DRAFT
Revised: May 16, 2014

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Appendices

APPENDIX A – SIGNED DDIR's

APPENDIX B – ECONOMIC JUSTIFICATION OF RISK AND RESILIENCE ALTERNATIVES *(to be added at a later date)*

Acronyms

AADT	Average Annual Daily Traffic
ABC	Aggregate Base Course
APE	Area of Potential Effects
cfs	Cubic feet per second
CBC	Concrete Box Culvert
CDOT	Colorado Department of Transportation
CFL	Central Federal Lands
CIP	Complete in Place
CMP	Corrugated Metal Pipe
CR	County Road
CSP	Corrugated Steel Pipe
CY	Cubic Yards
DAR	Damage Assessment Report
DDIR	Detailed Damage Inspection Report
ER	Emergency Repair
FEMA	Federal Emergency Management Agency
FES	Flared End Section
FHWA	Federal Highway Administration
FT	Feet
FWD	Falling Weight Deflectometer
HMA	Hot Mix Asphalt
LF	Linear Feet
LWCFA	Land and Water Conservation Fund Act
MCR	Minor Contract Revisions
MP	Milepost
MSE	Mechanically Stabilized Earth
NEPA	National Environmental Policy Act
NPS	National Park Service
PCCP	Portland Cement Concrete Pavement
PR	Permanent Repair
R4	Region 4
RCP	Reinforced Concrete Pipe
RE	Resident Engineer
ROW	Right of Way
SHPO	State Historic Preservation Office
STR	Structure
USACE	United States Army Corps of Engineers
WCR	Weld County Road

1. OVERVIEW

1.1. Map of State of Colorado Showing Flood Affected Areas

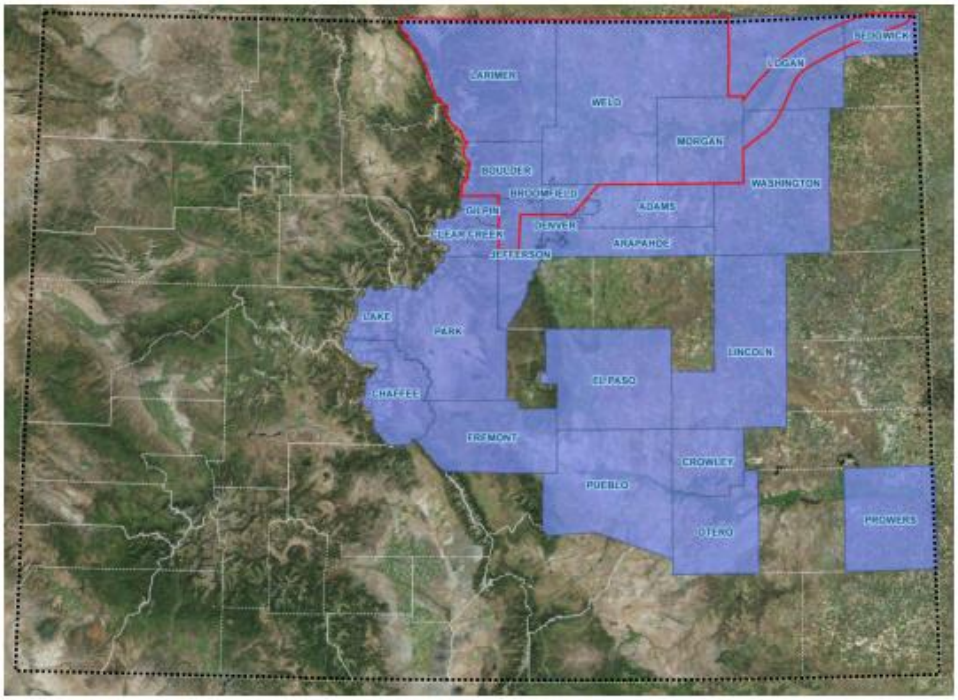


Figure 1 - Flood affected counties in Colorado (shaded) and CDOT highways damage boundary (outlined in red)

1.2. Flood Event Description

During the week starting on September 9, 2013, a slow-moving cold front stalled over Colorado, clashing with warm humid air from the South, resulting in a severe rain event that intensified on September 11th and 12th. The heavy rains caused catastrophic flooding and damages along Colorado's Front Range from Colorado Springs north to Fort Collins. Boulder County, for example, received 9 inches of rainfall on September 12th and the overall event rainfall in this area reached 85 percent of annual precipitation. The rainfall incident period started September 9 and intensified on September 11 and 12 and extended until September 16, 2013. The resulting flood damage occurred through the month of September as the flood water progressed from the mountains to the lower-lying eastern plains along the South Platte River to the Nebraska border.

Damages were widespread across Northern Colorado. The disaster impact area was unprecedented, spanning almost 200 miles (North-South) by approximately 50 miles (East-West), affecting over 400 miles of roadways and adjacent areas and impacting over 120 bridges and structures.

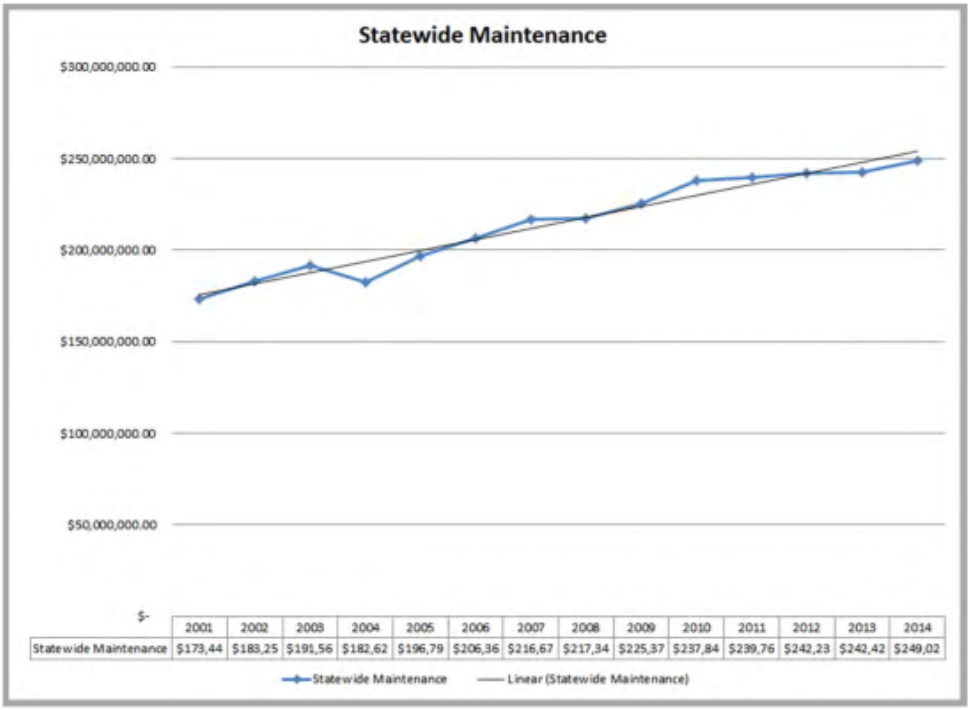
The flood event was estimated to have peaked between a 100-year and 500-year event in numerous locations along the affected streams and rivers. Severe, heavy rainfall caused rockslides, landslides and mudslides onto roadways and washout damages to corridors, bridge structures, slopes and embankments, Rights of Way (ROW), and culverts. Other disaster damages observed included debris-plugged culverts and destroyed abutments and bridges, which contributed to water overflow and roadway overtopping. Destruction of bridges and dam overflows, such as the Lake Estes Dam, contributed an additional 6,000 cubic feet per second (cfs), increasing flood flows to as much as 19,600 cfs into the Big Thompson River near Loveland, CO. Flooding was so severe that, in some locations, it rerouted sections of riverine waterways.

Colorado Governor, John Hickenlooper, declared a disaster emergency on September 12, 2013. A Major (Presidential) Disaster Declaration was issued on September 14, 2013 (DR-4145) for severe storms, flooding, landslides, and mudslides. The declared area includes the following 18 counties: Adams, Arapahoe, Boulder, Clear Creek, Crowley, Denver, El Paso, Fremont, Gilpin, Jefferson, Lake, Larimer, Lincoln, Logan, Morgan, Sedgwick, Washington, and Weld. On October 9, 2013 Governor Hickenlooper signed an Executive Order declaring an additional 6 counties to the declared area: Broomfield, Chaffee, Otero, Park, Prowers and Pueblo. The Governor also directed the Colorado Department of Transportation (CDOT) to make all roadways passable by December 1, 2013 to allow residents to return to their homes and businesses. This goal was accomplished through an intensive, temporary, Emergency Repair (ER) effort.

1.3. Description of CDOT Roadway Maintenance/State of Good Repair

CDOT takes its stewardship responsibilities seriously and performs regular maintenance on all infrastructure facilities in order to maintain a State of Good Repair. CDOT assesses the conditions of highway pavements annually. In support of this commitment, CDOT employs 1,500 full time maintenance staff to maintain 23,000+ lane miles of infrastructure.

Major capital investments for high priority corridors occur on a 10-20 year life cycle, depending upon the original highway design and other site conditions. For low traffic volume corridors, pavement surfaces are treated via thin surface seals (e.g. chip seals, thin overlays) every 10 years. In fiscal year 2014, CDOT invested $249M in its infrastructure. CDOT's historic expenditures on Statewide Maintenance are illustrated below:



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Statewide Maintenance	$173,44	$183,25	$191,56	$182,62	$196,79	$206,36	$216,67	$217,34	$225,37	$237,84	$239,76	$242,23	$242,42	$249,02

Figure 2 - CDOT Statewide Maintenance Historical Expenditures

1.4. General Overview: The Damage Assessment Report and Post-Flood CDOT Activities

1.4.1. Damage Assessment Report (DAR)

This Damage Assessment Report (DAR) serves to describe a specific milepost (MP), or mileposts, of a roadway and damage sustained at those mileposts as a result of the September 2013 flood event. It also describes:

- What ER work was performed to restore essential traffic, minimize the extent of damage and/or protect remaining facilities;
- What Permanent Repairs (PR) are recommended to restore the highway in-kind to its pre-disaster conditions to meet CDOT standards and specifications;
- What Resiliencies, if any, can be introduced to prevent similar flood damages in the future.

The data within this DAR was derived from information gathered by two (2) CDOT led field assessment teams mobilized from November 4 to December 6, 2013. Each 12-15 person team included professional roadway engineers and specialists in the fields of environmental, structures, ROW, materials, stream morphology, hydraulics, and utilities. Additionally, the teams included representatives from the Federal Highway Administration (FHWA) and Central Federal Lands (CFL).

The Appendix of this report includes the signed Detailed Damage Inspection Reports (DDIR) and costs of ER work performed, PR work proposed and resiliencies proposed as they apply to the subject roadway. DDIR documents, PR and Resiliency cost estimates were developed based on quantities obtained by roadway Assessment Teams.

Only major items such as earthwork, structures and pavement were quantified. Minor construction items were quantified by using typical project percentages. Unit costs were developed based on CDOT bid histories. Similar projects in scope and location were used to determine unit costs.

The following section describes general considerations of ER and PR, as well as typical construction methods for PR.

1.4.2. Emergency Repair (ER)

ER work was conducted as a stop gap measure to remove debris from the roads and temporarily repair corridors in order to re-open the roads for vehicles to pass. During ER, every attempt was made to adhere to the *CDOT Standard Specifications for Road and Bridge Construction* (2011) to the greatest practical extent. In many cases, due to road opening deadlines, weather conditions, site conditions, availability of repair materials and equipment, and availability of labor resources, CDOT Standards could not be followed in total.

Performance of Work

CDOT Maintenance performed ER work at various locations. Force account compensation procedures per CDOT specifications Section 109.04 were used to document and compensate the work for all emergency projects except for two sites on State Highway 72A at MP 5.446 and MP 14-18.

Prevailing Conditions at Time of Repair

Complex conditions existed when performing ER work, including such situations as: debris across the roadway, partial and complete roadway washouts and high water remaining for more than a week, making the use of Force Account tracking and payment the most effective means for payment in lieu of unit bid prices. With winter fast approaching, work took place 7 days a week, in most cases, to get roadways open and minimize winter/cold weather rework in the PR phase.

Plans or Design Drawings

No plans or design drawings were developed specifically for the ER phase projects. Some corridors, however, may have had associated shop drawings. They are included in this report if available.

Final ER Costs

ER phase projects have been finalized and all documentation, including costs, can be found in the Emergency Repair Project Notebook.

1.4.3. Permanent Repair (PR)

PR work will be needed in the future to restore the line and grade of the roadway, restore pavement surfaces, reconstruct damaged bridges and culverts, and replace signs, guardrails, fences and other highway appurtenances to their pre-disaster condition. Special considerations will be taken for environmental concerns, river morphology, structures, and utilities.

For PR, ER work must be evaluated on a case-by-case basis, using available ER documentation and re-testing those areas for materials suitability and conformance to CDOT standards.

Quantities and Dimensions

All quantities and dimensions included in this report are approximations only, based on direct observation at the site and best engineering judgment. More exact measurements will be developed during the Project Development phase.

Compliance

CDOT and all its contractors, sub-contractors, and agents will comply with all Federal, State and Local laws in performance of recommended PR work or approved resiliencies as described in this document.

‘

1.4.4. Typical Repair Methodologies (PR)

This section includes typical repair methodologies as they apply to the development of PR DDIR quantities.

Embankment Repair Adjacent to an Existing Embankment

A common type of damage that occurred as a result of the flood event was damage to roadway embankments. It is not considered good construction practice to build new roadway embankment adjacent to existing embankment using a vertical or nearly-vertical face, as this provides a weak plane that is prone to failure. A better practice is to "key" the new construction into the old, either using a stair-step technique, or a flatter joint. For PR quantity estimating purposes, it is assumed that the entire width of the pavement, subgrade and embankment will be removed and replaced to avoid a potential failure plane as described.

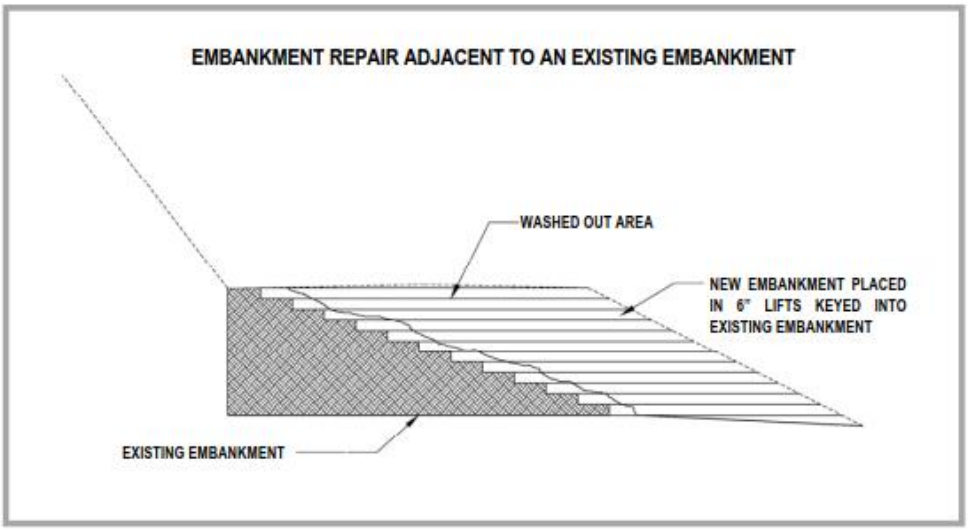


Figure 3 - Roadway Embankment Repair Adjacent to an Existing Embankment (Typical)

Typical Embankment Repair End Conditions

The illustrations in Figure 4 below represent the different typical embankment repair end condition configurations used in the repair process.

- Fill layer placed
- Cut with ditch within embankment
- Retaining wall to protect embankment
- Riprap (Boulders) placed against slope embankments for protection

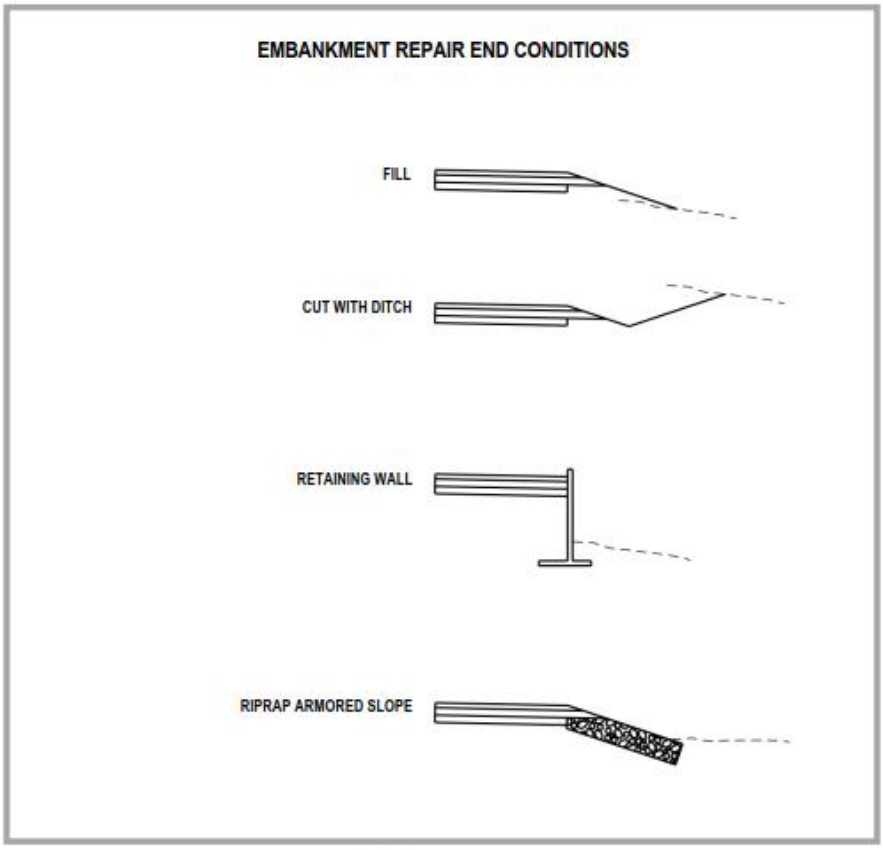


Figure 4 - End Conditions (Typical)

Typical Roadway Section

Many roadway sections were overtopped, undermined or breached during the flood event. A typical pavement section is shown in Figure 5. The example dimensions shown below are the basis for calculating quantities included in the DDIRs.

- 1st layer at top – Assumed 6 inch asphalt/Assumed 9 inch concrete pavement
- 2nd layer – Assumed 6 inch Aggregate Base Course (ABC)
- 3rd layer – Embankment fill material
- 4th layer – Existing ground

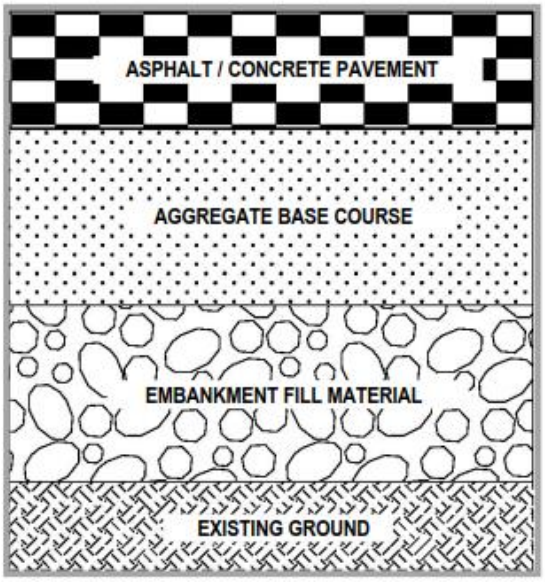


Figure 5 - Pavement Section (Typical)

1.5. Environmental Considerations

All flood-related projects are required to comply with FHWA and CDOT environmental laws, regulations, processes and procedures. While not inclusive or applicable to all projects, the following environmental considerations are highlighted due to longer coordination timeframes that need to be planned in setting schedules for permanent repairs. This overview is intended to provide guidance for project teams to coordinate environmental compliance requirements into project schedules. It is not intended to supersede, replace, or otherwise interfere with CDOT and FHWA's established processes, which apply for all permanent repairs.

- National Environmental Policy Act (NEPA) compliance is required for all flood-recovery projects. NEPA provides an umbrella for CDOT's compliance with environmental laws and regulations for transportation projects, and CDOT's NEPA Manual (http://www.coloradodot.info/programs/environmental/nepa-program/nepa-manual) provides guidance for both NEPA processes and resource-specific compliance. In most cases, projects will fall under Categorical Exclusions (categories of small-scale projects that have been shown by experience to have limited environmental impacts) that can be completed within one (1) to three (3) months. For more complicated Categorical Exclusions (such as those involving Section 4(f) evaluation as outlined below), the process can take six (6) months or longer. For projects where repairs are occurring outside of ROW or involve substantial road (or stream) modifications/realignments, an Environmental Assessment may be required, which can take a minimum of six (6) months up to two (2) years or longer.
- Section 4(f) of the US Department of Transportation Act of 1966 protects publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites from use in transportation projects unless no other feasible and prudent alternative to the use of those protected lands exists. Agencies such as CDOT that receive money (and approvals) from FHWA must demonstrate that there is no feasible and prudent alternative to the use of such lands, and must include all possible planning to minimize harm to the property. For proposed improvements that require use of Section 4(f) properties, the coordination process can take six (6) weeks to more than six (6) months.
- Section 6(f) lands are those that have been developed using funds provided by the Land and Water and Conservation Fund Act (LWCFA) to develop recreational facilities – either land or amenities. If acquisition of any properties that received LWCFA monies is required, CDOT must coordinate with the Colorado Department of Game and Parks and the National Park Service (NPS) in determining the impacts and appropriate mitigation for the affected portion of the property. At a minimum, the LWCFA requires a minimum replacement of lands at a 1:1 ratio, for both quality and quantity. If proposed improvements impact 6(f) properties, the coordination process can take three (3) months to more than six (6) months. Additionally, if ROW acquisition is required for replacement properties, the process can take even longer.

- Section 106 of the National Historic Preservation Act of 1966 requires federal agencies to take into account the effects of their undertakings on historic properties. The Section 106 process consists of four basic steps:
    - Define the Area of Potential Effects (APE) for the undertaking
    - Identify historic properties within the APE
    - Determine project effects on historic properties. Effects fall into three categories:
        - No Historic Properties Affected
        - No Adverse Effect
        - Adverse Effect
    - Mitigate any Adverse Effects through a negotiated Memorandum of Agreement.

Each of these steps requires coordination with the State Historic Preservation Office (SHPO), Native American tribes, and any interested consulting parties. The Advisory Council on Historic Preservation must be provided an opportunity to comment on Adverse Effects and Memoranda of Agreement. CDOT complies with Section 106 for both its Federal Aid projects and for state-led projects. If there is no effect on any Section 106 property ("no historic properties affected"), it can take approximately two (2) months for coordination under normal non-emergency circumstances. Coordination for a No Adverse Effect determination can take approximately four (4) months. If a Section 106-eligible property is adversely affected by a project ("adverse effect"), coordination can take six (6) months or more. Both No Adverse Effect and Adverse Effect determinations also require Section 4(f) evaluation. A No Adverse Effect determination qualifies as a de minimis use and requires only a minimal additional coordination with FHWA (approximately two (2) weeks). Adverse effects require a full Section 4(f) evaluation, which requires additional analysis, documentation and review that can take an additional three (3) months to more than six (6) months on top of the Section 106 consultation timeframes.

- Section 404 of the Clean Water Act regulates dredging and filling of wetlands and other waters of the United States. Each activity affecting wetlands or other waters of the U.S. will require a 404 permit issued by the US Army Corps of Engineers (USACE). Many flood-related projects will fall under Nationwide Permits, which can take approximately one (1) to three (3) months to coordinate. For projects that fall outside the criteria for a Nationwide Permit (generally impacts of greater than 0.5 acres in area or stream modifications greater than 300 linear feet), an Individual Permit will be required, which can take three (3) month or longer to coordinate. Additionally, wetland delineations can only be performed and accepted when vegetation is visible, so seasonal restrictions can further delay permitting.
- CDOT Region 4 (R4) Environmental strongly recommends that the Resident Engineer (RE) determine the maximum disturbance limits as soon as possible and allow R4 Environmental to begin clearance and coordination. Some clearances (Preble's Meadow Jumping Mouse, Ute Ladies' Tresses Orchids, migratory birds, etc.) have seasonal restrictions, which can further impact schedules.

1.6. Additional Considerations

1.6.1. Sediment Removal

Sediment removal is eligible for FHWA ER funding if sediment on the roadway or under a bridge is removed and reused in ER or PR work or must be pushed out of the way in order to perform the necessary ER work.

1.6.2. Debris Removal

Debris removal is not eligible for FHWA ER funding. However, some debris removal has the potential to be eligible for *FEMA Category A: Debris Removal* which states:

> Debris Removal is the clearance, removal, and/or disposal of items such as trees, woody debris, sand, mud, silt, gravel, building components, wreckage, vehicles, and personal property.
>
> For debris removal to be eligible, the work must be necessary to:
>
> - Eliminate an immediate threat to lives, public health and safety
> - Eliminate immediate threats of significant damage to improved public or private property
> - Ensure the economic recovery of the affected community to the benefit of the community-at-large
> - Mitigate the risk to life and property by removing substantially damaged structures and associated appurtenances as needed to convert property acquired through a FEMA hazard mitigation program to uses compatible with open space, recreation, or wetlands management practices
>
> Examples of eligible debris removal activities include:
>
> - Debris removal from a street or highway to allow the safe passage of emergency vehicles
> - Debris removal from public property to eliminate health and safety hazards
>
> Examples of ineligible debris removal activities include:
>
> - Removal of debris, such as tree limbs and trunks, from natural (unimproved) wilderness areas
> - Removal of pre-disaster sediment from engineered channels
> - Removal of debris from a natural channel unless the debris poses an immediate threat of flooding to improved property
>
> Debris removal from private property is generally not eligible because it is the responsibility of the individual property owner. If property owners move the disaster-related debris to a public right-of-way, the local government may be reimbursed for

curbside pickup and disposal for a limited period of time. If the debris on private business and residential property is so widespread that public health, safety, or the economic recovery of the community is threatened, FEMA may fund debris removal from private property, but it must be approved in advance by FEMA.

Source: http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit/categories-work

1.6.3. Repair /Replacement of Damage/Missing ROW Fence

Some sites include repair/replacement of damaged/missing ROW fence. Many sites are included in a multi-site fencing contract to systematically repair/reset fence damage. In such cases an amended FHWA form 1547 will be issued to address and include quantity changes to adequately place and complete the final PR.

1.7. Map of Whole Corridor/Roadway & Key Map

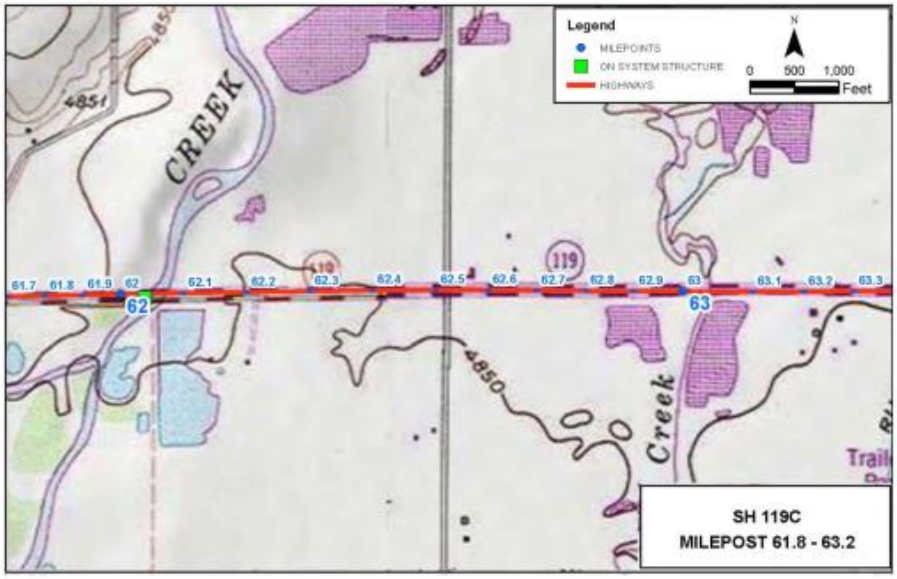


Figure 6 - SH 119C, MP 61.8 - 63.2, Weld County

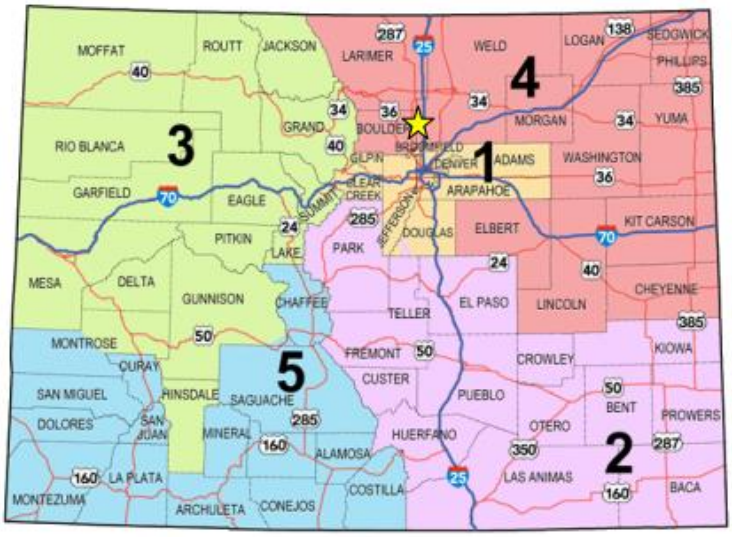


Figure 7 - CDOT Region Map and Project Location

2. MILEPOSTS 61.8 – 62.55, STRUCTURES D-16-CG & D-16-DR

2.1. Roadway Facility Description/Dimensions

- This roadway segment is a divided highway consisting of two 12 ft lanes with 12 ft outside shoulders and 4 ft inside shoulders in each direction separated by a 12 – 18 ft wide grass median. The road is functionally classified as a Principal Arterial with an average annual daily traffic (AADT) of 35,000 with 7.2 percent being trucks.
- SH 119 intersects with Weld County Road (WCR) 7 at about MP 62.53. The intersection is signalized with 12 ft turns lanes and acceleration/deceleration lanes in each direction.
- The ROW at this site is approximately 200 ft wide.
- The topographic condition at the site is classified as rolling terrain.
- No bike/pedestrian facilities exist at this site.
- Utilities at the site include overhead electric, underground fiber optic, gas, water and sanitary sewer. Ownership, relocation, and repairs need to be identified and coordinated during initial planning and design.
- Gravel pit ponds exist on both sides of the highway.
- Currently there is an upcoming project to resurface the existing asphalt pavement with Portland Cement Concrete Pavement (PCCP) from I-25 west to US 287.

2.2. Hydraulic/Structural Facility Description/Dimensions

- The highway crosses the St. Vrain River on two parallel structures, Structure D-16-DR and Structure D-16-CG.
- MP 62.04 – Structure D-16-DR was built in 2008. It is 4 spans, 247 ft long and 52 ft wide with northbound lanes over the Saint Vrain Creek. The design storm frequency for the bridge is a 25-year storm event.
- MP 62.04 – Structure D-16-CG was built in 1973. It is 7 spans, 213 ft long and 42 ft wide with southbound lanes over the Saint Vrain Creek. The design storm frequency for the bridge is a 25-year storm event.
- MP 62.18 – A median area inlet and twin 36 inch cross-culverts with end sections exists; one culvert is corrugated metal pipe (CMP) and the other is reinforced metal pipe (RCP). These culverts collect runoff from the south roadside ditch and median and convey it to the north.
- MP 62.27 – A median area inlet and 24 inch RCP cross-culvert with end sections exists. This culvert collects runoff from the south roadside ditch and median and conveys it to the north.
- MP 62.52 – An 18 inch RCP cross-culvert conveys runoff from the southwest corner of the intersection with WCR 7 to the north and discharges it into the west roadside ditch along WCR 7.
- Immediately south of the WCR 7 intersection, there is an 18 inch CMP under WCR 7 which conveys flows from west to east.

2.3. Causation

2.3.1. Aerial views

Figure 8 - MP 62.10, Pre-disaster aerial photo

Figure 9 - MP 62.10, Post-disaster aerial photo

2.3.2. Severity of damages

FHWA has reviewed this site and has determined that the damage was ☒ severe ☐ not severe.

Due to the limited hydraulic capacity of Structures D-16-DR and D-16-CG, flood waters exceeded the banks of the main channel of the Saint Vrain River. The overbank flows upstream of the site expanded to the east and cascaded into the gravel pit ponds located between the river and the highway. The flood waters continued to rise and spread to the east/northeast and were impounded along the upstream roadway embankment until they eventually rose to the point in which they overtopped the roadway from the east end of the bridges to the intersection with WCR 7. The roadway overtopping resulted in headcutting scour as water cascaded off the roadway, down the downstream embankment and onto the downstream fluvial plain. Ultimately, the roadway shoulder pavement was undermined, the roadway embankment and ditch scoured exposing existing utilities and cross culverts and roadway embankment material was displaced along the north side of the site.

Based on the memorandum *CDOT/CWCB Hydrology Investigation, Phase 1 – 2013 Flood Peak Flow Determinations* and observed flows at this site during the September 2013 flood event, the flood frequency of the Saint Vrain Creek at this location during the flood is assumed to be the 100-year storm event.

2.3.3. Detailed damage description

- The St. Vrain River exceeded its banks upstream of SH 119, breached the adjacent gravel pit ponds, and overtopped the roadway and the bridge on the north side, Structure D-16-CG. Approximately 1 mile of roadway was overtopped.
- At Structures D-16-DR and D-16-CG the bridge abutments experienced scour damage that caused the displacement of riprap armoring along the west abutment of the structure D-16-CG and the development of a scour hole at the NW corner of the structure.
- Large amounts of debris were trapped between the structures and under and on Structure D-16-CG.
- The approach guardrail on the north side of Structure D-16-CG was undermined at each end of the bridge from the overtopping flows.
- From MP 62.1 – 62.27 approximately 500 ft of the north shoulder was undermined causing displacement of the shoulder pavement and roadway embankment to the north.
- Twin 36 inch cross-culverts (one CMP & one RCP) at MP 62.18 lost their end sections and approximately 20 ft of the culverts were exposed on the north side of the road. A large scour hole resulted from the overtopping and the high velocities coming from the culverts. This caused the exposure of several utilities at this location (i.e. fiber optic, gas, water and sanitary sewer) in addition to the undermining of power poles in the area. Additionally, due to the deposition of embankment material in the roadside ditch and to the north these culverts are no longer free draining.
- Minor scour was found around the outlet of the reinforced concrete pipe at MP 62.27.
- There are several locations within this segment where the roadway embankment experienced scour damage due to the overtopping flows but there was no damage to the roadway pavement.
- Water mains, gas lines and fiber optic lines were exposed along the north side of the roadway between MP 62.37 and MP 62.48.

- The 18 inch RCP west of the intersection of SH 119 and WCR 7 developed a scour hole at the outlet end and eventually clogged with sediment at the inlet end.
- As the flood waters progressed east along the south roadside ditch to the WCR 7 intersection, the culverts at the intersection under SH 119 and WCR 7 were overwhelmed and the flow was directed south along the west embankment of WCR 7. The water eventually rose to the point in which it overtopped WCR 7. Due to the turning of the flows, the southwest corner of the intersection developed a large scour that undermined a portion of the southbound lane of WCR 7 and exposed utilities. The SW corner of the intersection received 2-4 ft of sediment deposition related to the overtopping flows.
- The ROW fence was knocked down, covered with debris, or missing in sections along the entire length of the site.

2.3.4. Damage Photos

Figure 10 - MP 62.03, Facing East, Debris on south side of Structure D-16-CG to the north of Structure D-16-DR

Figure 11 - MP 62.52, Damage to roadway drainage, ditch and embankment at WCR 7 intersection south of SH 119, facing East

Figure 12 - MP 62.18, Facing west, Damaged twin culverts into gravel pond north of SH 119

Figure 13 - MP 62.10, Facing south, Damaged 18 inch corrugated metal pipe (CMP)

Figure 14 - MP 62.18, Facing east, Scour, embankment damage and exposed utilities

Figure 15 - MP 62.09, Structure D-16-CG, Debris underneath bridge structure

Figure 16 - MP 62.09, Structure D-16-CG, Exposed piles at west abutment

Figure 17 - MP 62.09, Structure D-16-CG: Roadway erosion at northeast approach rail

Figure 18 - MP 62.09, Structure D-16-CG, Debris up to the structure

Figure 19 - MP 62.09, Structure D-16-CG, Erosion at approach

Figure 20 - MP 62.09, Structure D-16-CG, Erosion at approach

2.4. Emergency Repair (ER)

2.4.1. Descriptions of ER work performed

- Roadway embankment was repaired in areas outside of exposed utilities.
- The undermined roadway shoulder pavement was repaired.
- Damage at the roadway approach of Structure D-16-CG was repaired.
- Scour damage at the west abutment of Structure D-16-CG was backfilled and riprap was placed.

2.4.2. Photos of ER work during construction and after completion

Figure 21 - MP 62.09, Facing east, Repaired embankment at Structure C-16-CG on the north side of SH 119 (looking east)

Figure 22 - MP 62.09, Facing south, Repaired west abutment on the north side of Structure D-16-CG.

Figure 23 - MP 62.03, Facing south, Repaired roadway section at west abutment on Structure D-16-CG

2.5. Permanent Repair (PR)

2.5.1. Description of recommended PR work

No planned PR work at this time for this site since the highway already has a resurfacing project scheduled for this segment of the roadway.

2.5.2. Description of Resiliency

The proposed resiliencies described below extend from MP 62.0 to MP 63.1 and therefore encompass both sites described within this report. These proposed improvements will help mitigate overtopping of the roadway during similar future flood events. *(See Appendix B)*

- Raise the roadway 3 ft from the existing structures to the east approximately one mile.
- Add 12-48 inch RCPs with flared end sections and riprap outlet protection between MP 62.1 and MP 63.0 to add hydraulic capacity to the facility and convey flows to the north more effectively.
- Lengthen existing double 9 ft x 5 ft CBC at MP 63.03 to accommodate extended roadway embankment as a result of raising the road.

2.5.3. PR/Resiliency Detailed Damage Inspection Reports (DDIR)

See Appendix A

3. MILEPOSTS 62.55 – 63.20

3.1. Roadway Facility Description/Dimensions

- This roadway segment consists of two 12 ft lanes with 12 ft outside shoulders and 4 ft inside in each direction and a 12 ft to 18 ft median. The road is functionally classified as a Principal Arterial with an AADT of 35,000 with 7.2 percent being trucks.
- SH 119 intersects with WCR 7 at about MP 62.53 on the west end of the site. The intersection is signalized with 12 ft turns lanes and acceleration/deceleration lanes in each direction.
- SH 119 intersects with WCR 7.5 at about MP 63.2 on the east end of the site. It is a 'T'-intersection with WCR 7.5 extending to the south. The intersection is signalized with 12 ft acceleration/deceleration lanes on the south side of the roadway.
- The ROW at this site is approximately 200 ft wide left and right of the centerline of the roadway.
- The topographic condition at the site is classified as rolling terrain.
- St. Vrain State Park is adjacent to the north side of the highway. There is potential for Section 4(f) and Section 6(f) compliance at this site. *(See Section 1.5)*
- No bike/pedestrian facilities exist at this site.
- Utilities at the site include overhead electric, underground fiber optic, gas, water and sanitary sewer. Ownership, relocation, and repairs need to be identified and coordinated during initial planning and design.
- Currently there is an upcoming project to resurface the existing asphalt pavement with PCCP from I-25 west to US 287.

3.2. Hydraulic/Structural Facility Description/Dimensions

- MP 62.83 – A median area inlet and 36 inch CMP with end section at this location drains runoff from the median to the north.
- MP 62.89 – A median area inlet and 36 inch CMP cross-culvert with end sections is located at this site. The culvert collects runoff from the south roadside ditch and median and conveys it to the north.
- MP 62.93 – A 36 inch CMP cross-culvert with end sections is located at this site. The culvert collects runoff from the south roadside ditch and conveys it to the north.
- MP 63.01 – A 36 inch CMP cross-culvert with end sections is located at this site. The culvert collects runoff from the south roadside ditch and conveys it to the north.
- MP 63.03 – A double 9 ft x 5 ft CBC with headwall and wingwalls at the outlet end is located at this site. The culvert crossing conveys Idaho Creek from south to north into St. Vrain State Park.

3.3. Causation

3.3.1. Aerial views

Figure 24 - MP 62.78, Pre-disaster aerial photo

Figure 25 - MP 62.78, Post-disaster aerial photo

3.3.2. Severity of damages

FHWA has reviewed this site and has determined that the damage was ☒ severe ☐ not severe.

Due to the limited hydraulic capacity of the double 9 ft x 5 ft CBC, flood waters exceeded the banks of Idaho Creek. Additionally, overbank flows from the Saint Vrain River overtopped and breached WCR 7 combining flood waters from both watersheds. The combined overbank flows impounded along the upstream roadway embankment of SH 119 until they eventually rose to the point in which they overtopped the roadway from the east side of the intersection with WCR 7 to the west side of the intersection with WCR 7.5. The roadway overtopping resulted in headcutting scour as water cascaded off the roadway, down the downstream embankment and onto the downstream fluvial plain. Ultimately, the roadway shoulder pavement was undermined. The roadway embankment and ditch scoured; exposing existing utilities, cross culverts and roadway embankment material, which was displaced along the north side of the site.

Based on the memorandum *CDOT/CWCB Hydrology Investigation, Phase 1 – 2013 Flood Peak Flow Determinations*, observed flows at this site during the September 2013 flood event and engineering judgment, the flood frequency of Saint Vrain Creek and Idaho Creek at this location during the flood is assumed to be the 100-year storm event.

3.3.3. Detailed damage description

- From about MP 62.7 to MP 63.1 SH 119 was overtopped by flood waters. Approximately 1,200 ft of the north shoulder was undermined, causing displacement of the shoulder pavement and roadway embankment material to the north.
- There are several locations within this segment where the roadway embankment experienced scour damage due to the overtopping flows, but there was no damage to the roadway pavement.
- Water mains, gas lines and fiber optic lines were exposed on the north side of the highway between MP 62.75 and MP 63.02.
- Gas lines and fiber optic lines were exposed in the south side roadside ditch in the vicinity of MP 62.97 to MP 63.0.
- Approximately 650 ft of curb and gutter was damaged at the southwest corner of the intersection with WCR 7.5.
- The ROW fence was knocked down, covered with debris, or missing in sections along the entire length of the site on both sides of the highway.
- The headcutting scour on the north roadway embankment exposed the culverts and removed the end sections at MPs 62.83, 62.89, 62.93 and 63.01. Additionally, due to the deposition of embankment material in the roadside ditch and to the north, these culverts are no longer free draining.
- Large scour holes developed at the inlet and outlet ends of the 9 ft x 5 ft CBC at MP 63.03. The headwall and wingwalls on the north side of the structure had scour damage behind the walls. Additionally, embankment material moved by the headcutting scour deposited immediately downstream of the CBC preventing positive drainage in the creek to the north.

3.3.4. Damage Photos

Figure 26 - MP 62.8, Aerial photo, Damaged roadway and shoulder with evidence of overtopping

Figure 27 - MP 62.8, Facing South, Scour and damaged CMP

Figure 28 - MP 62.93, Facing north, Scour hole and damage to CMP culvert north side of SH 119

Figure 29 - MP 63.03, Facing West, Scour hole and damage at headwall and wingwalls at outlet of double 9 ft x 5 ft CBC, north side of SH 119.

Figure 30 - MP 63.03, Facing East, Scour hole at the inlet of the double 9 ft x 5 ft CBC, south side of SH 119.

Figure 31 - MP 62.83, Facing west, Deposited roadway embankment material and damaged ROW fence north of SH 119

3.4. Emergency Repair (ER)

3.4.1. Descriptions of ER work performed

- Roadway embankment was repaired in areas outside of exposed utilities.
- The undermined roadway shoulder pavement was repaired.

3.4.2. Photos of ER work during construction and after completion

Figure 32 - MP 62.8, Facing west, Repaired roadway shoulder and partial repair of embankment north of SH 119

Figure 33 - MP 62.8, Facing west. Repaired roadway shoulder and partial repair of embankment north of SH 119

3.5. Permanent Repair (PR)

3.5.1. Description of recommended PR work

No planned PR work at this time for this site since the highway already has a resurfacing project scheduled for this segment of the roadway.

3.5.2. Description of Resiliency

Refer to Section 2.5.2 for a description of the proposed resiliencies for this site.

3.5.3. PR/Resiliency Detailed Damage Inspection Reports

See Appendix A

APPENDIX A – SIGNED DDIR'S

Sheet _____ of _____

U.S. Department of Transportation Federal Highway Administration	**DETAILED DAMAGE INSPECTION REPORT (Title 23, Federal-aid Highways)**	Report Number:
		Inspection Date: 11.5.2013
Location (Name of Road and Milepost)		FHWA Disaster Number: CO-13-1
Route 119C at Mile Post 62.20 to 63.10		Federal-aid Route Number: 119C
Description of Damage (ONLY ONE ITEM MAY BE CHECKED) ☐ Emergency Repair ☑ Permanent Repair ☐ Debris Removal		State: Colorado
Raise roadway 3' and add twelve 48" RCP with FES. Lengthen existing CBC to accommodate new sideslopes.		County: Weld
Project Phase (ONLY ONE ITEM MAY BE CHECKED) ☑ Pre-Construction ☐ Construction		Work Order Number: Not Maintenance Forces

Cost Estimate

Description of Work to Date (Equipment, Labor, and Materials)	Unit	Unit Price	Quantity	Cost Completed	Cost Remaining
Major Earthwork Items	CY	$ 13.02	67470		$ 878,288.00
Aggregate Base Course	CY		0		$ -
Surfacing - HMA	TN		0		$ -
Surfacing - Concrete	SY		0		$ -
Structure Repairs	LS	$ 8,000.00	1		$ 8,000.00
Walls	SF		0		$ -
Drainage	LF	$ 139.57	1932		$ 269,640.00
Misc. Items	LS	$ -	1		$ -
General Construction Items	LS	$ 352,558.04	1		$ 352,558.04
Force Account - Miscellaneous	LS	$ 150,848.60	1		$ 150,848.60
Minor Contract Revisions	LS	$ 165,933.46	1		$ 165,933.46
			Construction Estimate Subtotal		$ 1,825,268.11
			Contingencies		$ 365,053.62
			Preliminary Engineering		$ 328,548.26
			Construction Engineering		$ 219,032.17
			11% Indirects		$ 301,169.24

Method ☐ Local Forces ☐ State Forces ☒ Contract	Estimated Project Total	$ 3,039,100.00
Environmental Assessment Recommendation ☒ Categorical Exclusion ☐ EA/EIS	Prepared By: Carin Groh	Date: 3.4.2014

Concurrence	FHWA Engineer (Print Name):	FHWA Engineer (Signature):	Date:
☒ Yes ☐ No	[redacted]		
Concurrence	State Engineer (Print Name):	State Engineer (Signature):	Date:
☒ Yes ☐ No	[redacted]		
Concurrence	Local Agency (Print Name):	Local Agency (Signature):	Date:
☐ Yes ☐ No			

FHWA USE ONLY
FEMA Eligible: ☐ Yes ☐ No

Form FHWA-1547
CDOT 11.5.2013

Permanent Restoration Project Cost Estimate

Project Location:			Initials: CCG
Name of Road	119C		Date: 3.4.14
Begin MP	62.20	or GPS Coordinates:	
End MP	63.10		
County	Weld		

Description of Work below:

Resiliency A = Raise roadway 3' and add twelve 48" RCP with FES. Lengthen existing CBC to accommodate new sideslopes.

PROJECT MAJOR CONSTRUCTION ITEMS

This Section not used in Permanent Repair Cost Estimates

Major Earthwork Items	Length (ft)	Width (ft)	Depth (ft)	Unit	Unit Cost	Quantity	Cost
Rock Fill				CY	$ 29.20	0	$0.00
Excavation & Embankment				CY	$ 12.00	67,300	$807,600.00
Seeding and Blankets (= to or steeper than 2:1 slope)				AC	$ 13,500.00	0.00	$0.00
Seeding and Straw (flatter than 2:1 slope)				AC	$ 3,700.00	14.74	$54,538.00
Str. Backfill (Class 1)				CY	$ 29.79	0	$0.00
Str. Backfill (Flow-fill)				CY	$ 93.41	0	$0.00
Channel Excavation				CY	$ 42.49	0	$0.00
Riprap to protect embankment slopes				CY	$ 95.00	170	$16,150.00
Remove & Recycle Asphalt				SY	$ 9.00	0	$0.00
Remove & Recycle Concrete				SY	$ 12.33	0	$0.00
Rock Scaling				HR	$ 101.86	0	$0.00
							$0.00
							$0.00
							$0.00
					Estimated Cost Earthwork		$878,288

Bases & Pavements	Length (ft)	Width (ft)	Depth (in)	Unit	Unit Cost	Quantity	Cost
6" ABC Class 6				CY	$ 45.00	0	$0.00
HMA (assume 6", but project overrides) area > 500LF				TN	$ 80.00	0	$0.00
PCCP (assume 9", but project specific overrides)				SY	$ 38.31	0	$0.00
HMA Patching - anything less than 500 LF				TN	$ 130.00	0	$0.00
							$0.00
							$0.00
							$0.00
					Estimated Cost Pavement		$0

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Permanent Restoration Project Cost Estimate

Initials: CCG
Date: 3.4.14

Project Location:

Name of Road	119C		
Begin MP	62.20	or GPS Coordinates	
End MP	63.10		
County	Weld		

Structures Replacement Bridge & Major CBC(> 20' span) Str. No.	Length (ft)	Width (ft)	Depth (ft)	Unit	Unit Cost	Quantity	Cost
Bridge Replacement				SF	$ 150.00	0	$0.00
CBC Replacement --->Dimension of CBC:				LF	$ 1,200.00	0	$0.00
Extend CBC (9' x 5')				LF	$ 400.00	20	$8,000.00
							$0.00
							$0.00
							$0.00
					Est'd Cost Str Replace		$8,000

Structures Repair/Rehabilitation Bridge & Major CBC(>20' span)	Length (ft)	Width (ft)	Depth (in) Depth (ft)	Unit	Unit Cost	Quantity	Cost
HMA Patching Bridge Deck				TN	$ 130.00	0	$0.00
HMA Pave Bridge Deck				TN	$ 70.49	0	$0.00
Waterproofing Membrane				SY	$ 15.72	0	$0.00
Approach Slab Replacement				SY	$ 38.31	0	$0.00
Expansion Joint				LF	$ 228.75	0	$0.00
Slope and Ditch Paving				CY	$ 327.86	0	$0.00
Str. Backfill (Class 1)				CY	$ 29.79	0	$0.00
Str. Backfill (Flow-fill)				CY	$ 93.41	0	$0.00
Bridge Drains				EA	$ 3,430.00	0	$0.00
Concrete Class D				CY	$ 508.36	0	$0.00
Reinforcing Steel				LB	$ 1.02	0	$0.00
Structural Embankment				CY	$ 12.04	0	$0.00
Riprap				CY	$ 95.00	0	$0.00
Geotextile (Erosion Control) (Class 1)				SY	$ 4.00	0	$0.00
							$0.00
							$0.00
					Est'd Cost Bridge Repair		$0

Walls	Length (ft)	Width (ft)	Depth (ft)	Unit	Unit Cost	Quantity	Cost
Wing Walls				SF	$ 40.95	0	$0.00
MSE Walls				SF	$ 25.68	0	$0.00
Retaining Walls				SF	$ 40.95	0	$0.00
Str. Backfill (Class 1)				CY	$ 29.79	0	$0.00
Str. Backfill (Flow-fill)				CY	$ 93.41	0	$0.00
Reinforcing Steel				LB	$ 1.02	0	$0.00
							$0.00
					Estimated Cost Walls		$0

Drainage	Length (ft)	Width (ft)	Depth (ft)	Unit	Unit Cost	Quantity	Cost
48" RCP				LF	$ 126.00	1,920	$241,920.00
48" RCP FES				EA	$ 2,310.00	12	$27,720.00
pipe				LF		0	$0.00
36" CMP FES				EA	$ 888.05	0	$0.00
FES				EA		0	$0.00
Other Items						0	$0.00
					Estimated Cost Drainage		$269,640

Misc Items	Length (ft)	Width (ft)	Depth (ft)	Unit	Unit Cost	Quantity	Cost
Detour Pavement (Place & Remove)				SY	$ 36.54	0	$0.00
Guardrail ---> Type:				LF	$ 16.65	0	$0.00
Tensioned Cable Barrier				LF	$ 11.73	0	$0.00
Median Cover				SF	$ 5.76	0	$0.00
Curb & Gutter				LF	$ 16.85	0	$0.00
Sidewalk				SY	$ 38.16	0	$0.00
Bike Path				SY	$ 38.16	0	$0.00
Traffic Signal Light Pole				EA	$ 14,871.31	0	$0.00
Traffic Signal Face 12-12-12				EA	$ 700.47	0	$0.00
Wire Fence (Barbed wire)				LF	$ 5.00	0	$0.00
Removal Culvert				EA	$ 1,307.66	0	$0.00
Remove Guardrail				LF	$ 2.42	0	$0.00
Removal Curb & Gutter				LF	$ 4.92	0	$0.00
Complete description below if applicable to your site							$0.00
Electrical							$0.00
Lighting							$0.00
Utilities							$0.00
ITS							$0.00
Irrigation							$0.00
					Estimated Cost Misc		$0

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Permanent Restoration Project Cost Estimate

Project Location:					Initials: CCG
Name of Road	119C				Date: 3.4.14
Begin MP	62.20	or GPS Coordinates			
End MP	63.10				
County	Weld				
		Total Major Items			**$1,155,928**
		A. Total of Major Items except Debris Removal			**$1,155,928**
B = General Construction Items		**Major Item Cost**			
B-1 Erosion Control	*	8.0%	of A		$ 92,474.24
B-2 Mobilization		6.0%	of A		$ 69,355.68
B-3 Signing & Striping		3.0%	of A		$ 34,677.84
B-4 Traffic Control		10.0%	of A		$ 115,592.80
B-5 Public Information		0.5%	of A		$ 5,779.64
B-6 Construction Survey		3.0%	of A		$ 34,677.84
B-7 TOTAL OF B					$ 352,558.04
B. TOTAL OF A+B				$	1,508,486.04
C-1 Force Account - **Miscellaneous**		10.0%	of B		$ 150,848.60
C. TOTAL OF A+B+C				$	1,659,334.64
D-1 **Minor Contract Revisions**		10.0%	of C		$ 165,933.46
D. TOTAL OF A+B+C+D				$	1,825,268.11
E-1 Contingencies		20.0%	of D		$ 365,053.62
E. TOTAL OF A+B+C+D+E				$	2,190,321.73
F-1 **Design Engineering**		15.0%	of E		$ 328,548.26
F-2 Construction Engineering		10.0%	of E		$ 219,032.17
F-3 Indirects		11.0%	of E+F-1+F-2		$ 301,169.24
F-4 TOTAL OF F					$ 848,749.67
F. TOTAL OF A+B+C+D+E+F				$	3,039,071.40
G. TOTAL PROJECT COST LINE F (Rounded)				$	3,039,100.00

ADDITIONAL COMMENTS/ISSUES:

Notes/Assumptions/Comments by Author:

* 8% was used for Erosion Control due to large amounts of embankment and RCP in the project.

Notes/Assumptions/Comments by Field Assessment Team:

PRINT NAMES OF ALL REPRESENTATIVES PRESENT FOR THIS ASSESSMENT - Approximate scope and quantities have been reviewed

Carin Groh, EIT

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