FEMA Benefit-Cost Analysis Re-engineering (BCAR)

Development of Standard Economic Values

Version 6.0

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Introduction

This document describes the methodologies for developing the standard economic values used in the Federal Emergency Management Agency (FEMA) Benefit-Cost Analysis (BCA) Version 5 software. This document is intended to describe how the standard default values were developed; it is not intended as guidance on using the values in the software. Guidance on how to use the values in the software can be found in the BCA Student Training Manual or by contacting the FEMA BCA Helpline (BCHelpline@dhs.gov or 866-540-6744). This report consolidates the individual papers originally prepared in 2008 to document the economic values used in the BCA Version 5 software. The economic values in this report are used in the current version of the BCA Tool. To stay current with economic conditions, values in this report are updated regularly. However, any value citing 2008 has not been updated in this report since the original document was created.

Value of Lost Time

Assessing the value of lost time is straightforward and consistent with economic theory applied in a variety of fields, including recreational and transportation economics. Lost time can be incurred by individuals who must take pre-disaster preventative measures, evacuate their homes or business, clean up or repair damage, manage insurance claims, experience increased travel time due to bridge or road closures, and deal with other disaster-related matters. The basic economic concept is that personal time has value, regardless of formal employment compensation. Therefore, it can be argued that one hour of work is equal to one hour of leisure time because the "opportunity cost"[1] of a leisure hour is equal to the wage earned for an hour of work time.

Table 1 shows the progression of how the Value of Lost Time economic value has changed over time. In Version 4.5 of the BCA Tool, FEMA uses a lost time value of $28.11, which is the national average employer cost for employee compensation per hour for 2008. For Version 5, it is recommended that the value be increased to $30.07[2], which is the average employer cost for employee compensation per hour for the quarter ending March, 2011, the latest value released as of the writing of this report.

Table 1: Value of Lost Time Changes

Year Updated	Value	Source
2001	$21.16	US Department of Labor, Bureau of Labor Statistics, 2000
2007	$27.31	US Department of Labor, Bureau of Labor Statistics, 2006
2009	$28.11	US Department of Labor, Bureau of Labor Statistics, 2008
2011	$30.07	US Department of Labor, Bureau of Labor Statistics, 2011 (March)

[1] An opportunity cost is the cost of an alternative that must be foregone in order to pursue a certain action. In other words, the benefits received by taking an alternative action.

[2] Bureau of Labor Statistics, US Department of Labor. "Employer Costs for Employee Compensation – March 2011". News Release dated June 8, 2011. http://www.bls.gov/news.release/pdf/ecec.pdf.

This hourly rate of $30.07 should be used to measure the value of hours spent by individuals on disaster-related activities (i.e., pre-disaster preventative measures, evacuation, clean up or repair of damage, managing insurance claims) that are not accounted for in a separate part of the Benefit-Cost Analysis (BCA) modules. It is recommended that this value be updated every year or two years to account for changes in compensation.

Traffic Delays for Roads and Bridges

This section presents the methodology used in the BCA software to estimate the value of delays due to road and bridge closures. The methodology builds on estimates for the value of lost time (described above) and is consistent with the methodology applied by the U.S. Department of Transportation (DOT) in calculating the benefits of reducing travel time.

The DOT distinguishes between business or commercial travel time and personal and recreational time. While commercial travel time is reimbursed at 100 percent of the wage rate, the DOT values personal travel time (including commute time) at 50 percent of the wage rate (FHWA 2007). Travel time in recreational economics is generally valued at one-third of the wage rate, though some studies use 50 percent of the wage rate, similar to DOT (Champ et al. 2003). The full wage rate is not typically used to measure personal travel or recreation travel because it is assumed that individuals benefit from the travel (e.g., a scenic drive), or they are willing to accept the travel time in order to gain something (e.g., a higher paying job).

FEMA determined that requiring BCA software users to distinguish business/commercial travel delay time from personal/recreational travel delay time would place an unnecessary burden on the user. Additionally, since the value of travel delay is based on a per-person wage rate basis and not a per-vehicle basis, users would have to identify the number of people in each affected vehicle. To simplify this benefit calculation, the BCA software uses an average vehicle occupancy to capture time costs caused by delays due to road and bridge closures. This average should be applied to all vehicles, regardless of the vehicle type, purpose of the trip, and number of persons in each vehicle.

According to the National Household Travel Survey (DOT 2006), 82 percent of vehicles on the road are personal passenger vehicles, with the remaining 18 percent being commercial vehicles. This survey also determined that the average number of persons per vehicle is 2.3. The 2009 National Household Travel Survey (DOT 2009) noted a decrease in average number of persons per vehicle from 2.3 to 1.67. Employing the national average hourly wage of $30.07, average number of persons per vehicle of 1.67 and DOT's methodology for per-hour value of time, the equation below was used to determine the hourly value of time per vehicle:

((%personal_passenger*(wage_rate*0.5)) + (%commercial*wage_rate)) * persons_per_vehicle:
((0.82*($30.07*0.5)) + (0.18*$30.07)) * 1.67 = $29.63

Therefore, a value of $29.63 is applied per vehicle per hour to account for the lost time cost of road and bridge closures or delays as a result of a disaster. This represents a decrease from the 2009 BCA Tool Update value of $38.15.

Displacement Time and Cost

Displacement time is a category of damages that accounts for the duration for which people are forced to evacuate their homes or businesses. The source of the baseline estimates used in the BCA software for displacement time and cost is the Hazards U.S. (HAZUS) software, a risk assessment software for analyzing potential losses from disasters.

The displacement cost consists of a one-time disruption cost along with a recurring monthly rental cost for the duration of the displacement. The rental and disruption costs are calculated based on a building per square-foot/content inventory dataset compiled by a nationally recognized cost-estimating software and Applied Technology Council (ATC) Reports 12 and 25. Table 2 shows both the standard one-time and the monthly per-square-foot values for each of the residential, commercial, and public structure classifications adopted by FEMA and used in the BCA software.

For example, the recovery time from when a structure is damaged by flooding until it can be reoccupied is a function of the physical restoration time, contractor availability, hazardous materials (hazmat) removal processes, inspections, and permits and approvals. HAZUS provides estimates of the flood-specific restoration times for structures of the different occupancy classes based on depth of flooding. In the HAZUS model, flood depths are generally evaluated in increments of 4 feet to coincide with likely physical repair strategies (Table 3).

The total displacement cost is estimated by adding the disruption cost and the rental costs. This can be expressed in the equation below:

Displacement Cost = (Disruption Cost x Sq. Ft.) + (Rental Cost x Sq. Ft. x Displacement Time in Months) (2)

The default displacement time in the BCA software is based on the combination of physical restoration time and recovery time estimates for structures affected by flooding.

Table 2: Rental Costs and Disruption Costs by Occupancy Class

No.	Label	Occupancy Class	Rental Cost (2008) $/square foot/month	Disruption Costs (2008) $/square foot
Residential				
1	RES1	Single-Family Dwelling	0.73	0.88
2	RES2	Mobile Home	0.52	0.88
3	RES3A	Multi-Family Dwelling: Duplex	0.65	0.88
4	RES3B	Multi-Family Dwelling: 3-4 units	0.65	0.88
5	RES3C	Multi-Family Dwelling: 5-9 units	0.65	0.88
6	RES3D	Multi-Family Dwelling: 10-19 units	0.65	0.88
7	RES3E	Multi-Family Dwelling: 20-49 units	0.65	0.88
8	RES3F	Multi-Family Dwelling: 50+ units	0.65	0.88
9	RES4	Temporary Lodging	2.19	0.88
10	RES5	Institutional Lodging	0.44	0.88
11	RES6	Nursing Home	0.81	0.88
Commercial				
12	COM1	Retail Trade	1.25	1.16
13	COM2	Wholesale Trade	0.52	1.01
14	COM3	Personal and Repair Services	1.46	1.01
15	COM4	Professional/Technical/Business	1.46	1.01
16	COM5	Banks	1.82	1.01
17	COM6	Hospital	1.46	1.45
18	COM7	Medical Office/Clinic	1.46	1.45
19	COM8	Entertainment and Recreation	1.82	0.00
20	COM9	Theaters	1.82	0.00
21	COM10	Parking	0.36	0.00
Industrial				
22	IND1	Heavy	0.21	0.00
23	IND2	Light	0.29	1.01
24	IND3	Food/Drugs/Chemicals	0.29	1.01
25	IND4	Metals/Mineral Processing	0.21	1.01
26	IND5	High Technology	0.36	1.01
27	IND6	Construction	0.15	1.01
Agricultural				
28	AGR1	Agriculture	0.73	0.73
Religious/Non-Profit				
29	REL1	Church/Membership Organization	1.09	1.01
Government				
30	GOV1	General Services	1.46	1.01
31	GOV2	Emergency Response	1.46	1.01
Education				
32	EDU1	Schools/Libraries	1.09	1.01
33	EDU2	College/Universities	1.46	1.01

Table 3: Recovery Time by Occupancy Type and Flood Depth

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons (months)				Recovery Time (months)	
				Dry-out and Cleanup	Inspection, Permits, Approvals	Contractor Availability	Hazmat Delay	Min.	Max.
Single-Family Dwelling (No Basement)	0’- 4’		3 to 6	1	2	3		9	12
	4’- 8’		6 to 9	1	2	3		12	15
	8’ +	Outside 100-year FP[‡]	12	1	2	3		18	18
	8’ +	Inside 100-year FP	18	1	2	3		24	24
Single-Family Dwelling (With Basement)	0’- 4’		3 to 6	1	2	3		9	12
	4’- 8’		6 to 9	1	2	3		12	15
	8’ +	Outside 100-year FP	12	1	2	3		18	18
	8’ +	Inside 100-year FP	18	1	2	3		24	24
Mobile Home	0’- 4’		3 to 6	1	2	3		9	12
	4’- 8’		6 to 9	1	2	3		12	15
	8’ +	Outside 100-year FP	12	1	2	3		18	18
	8’ +	Inside 100-year FP	18	1	2	3		24	24
Multi-Family Dwelling (Small) [Duplex (RES3A) and 3-4 units (RES3B)]	0’- 4’		3 to 6	1	2	3		9	12
	4’- 8’		6 to 9	1	2	3		12	15
	8’ +	Outside 100-year FP	12	1	2	3		18	18
	8’ +	Inside 100-year FP	18	1	2	3		24	24
Multi-Family Dwelling (Medium) [5-9 units (RES3C) and 10-19 units (RES3D)]	0’- 4’		5 to 8	1	2	3		11	14
	4’- 8’		8 to 12	1	2	3		14	18
	8’ - 12’		12	1	2	3		18	18
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Multi-Family Dwelling (Large) [20+ units]	0’- 4’		5 to 8	1	2	3		11	14
	4’- 8’		8 to 12	1	2	3		14	18
	8’ - 12’		12	1	2	3		18	18
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Temporary Lodging	0’- 4’		5 to 8	1	2	3		11	14
	4’- 8’		8 to 12	1	2	3		14	18
	8’ - 12’		12	1	2	3		18	18
	12’ +	Outside 100-year FP	12	1	2	3		18	18

Life Safety

Life safety is the value of lives saved and injuries prevented resulting from mitigation measures. A review of existing literature has found different values used by different government agencies (an multiple values used within one agency). The official guideline for determining and using a reason Value of Statistical Life (VSL)[4] is found in Office of Management and Budget (OMB) Circular A-4. L updated in 2003, Circular A-4 uses a literature search to recommend VSL values between $1 milli $10 million. This guidance remains in effect; however, in 2010 OMB further clarified that most fe agencies are using values between $5 million and $9 million and that values outside of this tighte would be difficult to justify (OMB, 2010). In 2008, Version 4 of the the BCA software used a VSL o million provided by the Federal Aviation Administration (FAA). In 2012, the methodology was cha for Version 5 in order to bring a standard methodology rather than using comparative literature r and to incorporate research completed on behalf of the Department of Homeland Security (Robin 2008). The Robinson report depends on the research of W. Kip Viscusi, which established a baseli of $4.7 million in 1997 dollars. Robinson's research established an inflation-adjusted value of $6.1 million in 2007 dollars using the Consumer Price Index (CPI). Using the CPI Inflation Calculator av from the US Bureau of Labor Statistics[5], the $6.1 million value was confirmed by adjusting the $4 million value from 1997 to 2007 dollars. Future updates of the VSL should inflate $4.7 million in 1 dollars to a current-year dollar value, then round that value to the nearest one hundred thousand this methodology, a VSL of $6.6 million was determined for Version 5 of the BCA Tool.

Nonfatal injuries are far more common than fatalities. In principle, the resulting losses in quality including both pain and suffering and reduced income, should be calculated for various injury lev could be avoided because of a hazard mitigation project. Because detailed willingness-to-pay esti covering the entire range of potential disabilities are unobtainable, a standardized method is use interpolate values of expected outcomes, scaled in proportion to VSL.

Relative value coefficients for preventing injuries of varying severity and duration are based on th Abbreviated Injury Scale (AIS), which categorizes injuries into levels ranging from AIS 1(Minor) to (Critical) with AIS 6 being a Fatal[6]. This valuation technique relied on a panel of experienced phys to relate injuries in each AIS level to the loss of quality and quantity of life. A narrative descriptio the AIS classes is provided in Table 4.

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[4] VLS is defined as the value of improvements in safety that result in a reduction by one in the expected nu fatalities (U.S. DOT).

[5] CPI Inflation Calculator is available at: http://www.bls.gov/data/inflation_calculator.htm

[6] For more information about the research to determine these values, see reports by Miller, Brinkman, and or by Rice, MacKenzie & Associates.

Table 4: AIS Injury Level Categories

AIS Code	Injury Severity Level	Selected Injuries
1	Minor	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).
2	Moderate	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation.
3	Serious	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation.
4	Severe	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).
5	Critical	Spinal cord injury (with cord transection); extensive second- or third-degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).
6	Fatal	Injuries, which although not fatal within the first 30 days after an accident, ultimately result in death.

Source: FAA, 2007

Federal agencies such as the Federal Aviation Administration (FAA), US Department of Transportation (USDOT), and National Highway Traffic Safety Administration (NHTSA) calculate an economic value for avoiding different AIS scale injuries by using the relative value coefficients as a fraction of the VSL. By following this methodology, FEMA is able to establish an economic value for the various injury levels that could be avoided – and therefore counted as benefits – from a hazard mitigation project. These economic values are shown in Table 5. The BCA software uses the following values for the different hazard types.

Table 5: AIS Injury Severity Levels, Fraction of VSL, and Economic Values (2012 Dollars)

AIS Code	Description of Injury	Fraction of VSL	Economic Value
AIS 1	Minor	.0020	$13,000
AIS 2	Moderate	.0155	$102,000
AIS 3	Serious	.0575	$379,000
AIS 4	Severe	.1875	$1,237,000
AIS 5	Critical	.7625	$5,032,000
AIS 6	Fatal	1.0000	$6,600,000

Source for Fraction of VSL: FAA, 2008.

Tornado

The Tornado Module uses a modified version of Table 5. Based on post-disaster research by the Tornado Expert Panel, which is made up of experts on tornadoes and injuries and deaths from hazards, it was determined that the six AIS categories needed to be reduced to four, as shown in Table 6.

Table 6: Injury Classes Used in the Tornado Module

Injury Classes	AIS Code
Death	5,6
Hospitalized	3,4,5
Treat and release	1,2
Self treat	1

The associated costs for each AIS Code from Table 5 was used to develop the cost for injury and death to match the injury classes used in the Tornado Module shown in Table 6. Table 7 lists each of the injury classes and the rounded values based on Table 5 values.

Table 7: Cost of Injury and Death Values Used in the Tornado Module

Injury Severity Levels	AIS Code	Economic Value (rounded)
Fatal	5,6	$ 5,800,000
Hospitalized	3,4,5	$ 1,237,000
Treat and release	1,2	$ 102,000
Self treat	1	$ 13,000

Earthquake

The Earthquake Structural and Nonstructural modules also use a modified version of the AIS Injury Severity Levels. Each module uses injury rates corresponding to the severity of physical damage computed in each module. During development of the FEMA BCA software (Version 4), it was decided that the injury classifications used in the previous version of the FEMA BCA software (Version 3) would remain the same. These injury classes are shown in Table 8.

Table 8: Injury Classes Used in the Earthquake Modules

Injury Classes	AIS Code
Death	6
Major	2,3,4,5
Minor	1

The associated cost for each AIS Code from Table 5 was used to develop the cost for injury and death to match the injury classes used in the Earthquake modules. Table 9 lists each of the injury classes and the rounded values based on Table 5. The "Major" Injury Severity Level value is an average of the economic values of the four listed AIS Code values.

Table 9: Cost of Injury and Death Values Used in the Earthquake Module

Injury Severity Levels	AIS Code	Economic Value (rounded)
Death	6	$ 6,600,000
Major	2,3,4,5	$ 1,687,500
Minor	1	$ 13,000

Wildfire

The Wildfire module uses the statistical value of deaths ($6,600,000) as well as the average statistical value of "major and minor" injuries ($850,250) given in Table 5. The value for injuries is obtained by averaging the dollar value for minor injuries ($13,000) with the mean of all other non-fatal injury categories.

$$\text{Mean Value of Major Injuries} = \left(\frac{102{,}000 + 379{,}000 + 1{,}237{,}000 + 5{,}032{,}000}{4}\right) = \$1{,}687{,}500 \quad (3)$$

$$\text{Statistical Value of All Injuries} = \frac{(13{,}000 + 1{,}687{,}500)}{2} = \$850{,}250 \quad (4)$$

Loss of Fire Station Services

Fire stations may provide a wide range of services, such as firefighting, search and rescue, public shelter, and emergency medical services (EMS). The methodology presented estimates the social cost for a loss of a fire station's services, also referred to as a "loss of function." Specifically, the methodology estimates how the temporary loss of function of a fire station will affect fire losses (human injuries and mortality, direct financial loss to property, and indirect losses). When a fire station offers public shelter during emergencies, a separate category should be added to account for any benefits. The impact of a loss of EMS is discussed in a separate section of this document.

This methodology assumes that if a fire station (for example, Fire Station A) is temporarily shut down, then the closest fire station (Fire Station B) will temporarily serve the population usually served by Fire Station A.

A universal measure used across public safety functions is response time. Intuitively, the relationship between response time and a fire department's success is clear: the sooner a fire company arrives at a fire scene, the better the chance of a successful outcome. Different studies have found a significant relationship between the response time and the resulting fire losses (Tomes 2007, Ignall et al. 1978, Hogg 1973).

Response time has a positive relationship with distance: the shorter the distance between the fire station and the fire scene, the shorter the response time. When Fire Station A is out of service, forcing Fire Station B to serve a larger geographical area, the average response time will increase. With the increase in the response time, fire losses will increase as well.

The steps to estimate the loss-of-function impact of firefighting services are:

1. Determine the fire station that would temporarily replace the fire station that is out of service
2. Establish the distance between the two fire stations
3. Estimate the population served by the non-operating fire station (Fire Station A)
4. Determine the dollar loss expected due to the shutdown

To determine the expected dollar loss (Step 4), a series of calculations need to be performed.

i. *Estimate the number of fire incidents (I) in the area served by the non-operating fire station (Fire Station A).* The population served as determined in Step 3 is used to obtain this number. Since obtaining specific data for a fire station may be difficult, a national average is used. According to the National Fire Protection Association (NFPA), the total number of fires in the United States in 2006 was 1,642,500 (Hall 2007). The 2006 U.S. population estimate given by the U.S. Census Bureau is 298,754,819 (U.S. Census 2007). Therefore, the number of incidents per capita is equal to 0.0055 per year, or 5.5 incidents per 1,000 people.[7]

ii. *Estimate the average response time in the area before and after the fire station shutdown*. For the situation before the fire station shut down, it is assumed that the response time is equal to the national average. According to the U.S. Fire Administration (2006), the median response time for structure fires is 5 minutes.[8] The extra response time will be approximated using the distance between the two fire stations established in Step 2. The following formula developed by the New York City Rand Institute in the 1970s (Chaiken et al. 1975) is used to determine the relationship between expected response time (RT) in minutes and the distance (D) in miles:

$$RT = 0.65 + 1.70D \tag{5}$$

Hence, the response time after the fire station shutdown (RT_{After}) will be estimated to be (in minutes):

$$RT_{After} = 5 + (0.65 + 1.70D) \tag{6}$$

iii. *Determine the probability of a no-loss incident before and after the fire station shutdown.* This is the probability of an event having zero losses as a function of the response time. The estimate was obtained from *Air Force Protection Cost Risk Analysis* (Air Force Civil Engineer Support Agency 1994). The study used data from the National Fire Incident Reporting System (NFIRS) for 760,000 nationwide records from 1989 to investigate the effect of response time on dollar losses and the amount of damages.[9] The probability of a zero dollar loss (P_0) is given by the following formula:

$$P_0 = 0.456 - 0.00264RT \tag{7}$$

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[7] No studies were found regarding how a natural disaster will affect the number of fire incidents.

[8] Since this value has a considerable impact on the benefit estimate, when available, reliable local data may be used instead; proper documentation to justify its use should be provided.

[9] Only data for fixed property was analyzed to obtain these estimates. According to NFPA data for 2006, even though structure fires only account for 32 percent of total fires, they represent 85 percent of property damage, 88 percent of civilian injuries, and 83 percent of civilian deaths.

iv. *Determine the average property dollar loss per incident before and after the fire station shutdown*. This is a function of the response time. The relationship was also obtained from the *Air Force Protection Cost Risk Analysis* study.[10] The dollar loss (DL), in 1993 dollars, is given by:

$$DL = 3{,}845 + 431RT \quad (8)$$

v. *Calculate the increase in the property dollar loss due to the fire station shutdown*. This is done using the following formula:

$$\Delta\$\,property\ loss = \left[\left(1 - P_{0After}\right)DL_{After} - \left(1 - P_{0Before}\right)DL_{Before}\right] \times I \quad (9)$$

Where:

P_{0After} and $P_{0Before}$ are the probabilities of a no-loss incident after and before the fire station shutdown, respectively

DL_{After} and DL_{Before} are the average dollar loss per incident after and before the fire station shutdown, respectively

I is the number of fire incidents in the area served by the fire station. Since the number of incidents is in per-year terms, the increase in the dollar loss is also in per-year terms

vi. *Add indirect losses*. NFPA adds 10 percent for indirect loss as a fraction of direct loss in residential fires (Hall 2008). Indirect losses refer to the costs of temporary housing, missed work, and lost business:

$$\Delta\$\,total\ property\ loss = \Delta\$\,property\ loss \times 1.10 \quad (10)$$

vii. *Estimate the losses related to mortality and human injuries.* According to NFPA estimates, in 2005 direct and indirect property losses due to fire totaled $12.7 billion, while the total dollar losses for deaths and injuries were estimated to be $41.9 billion (Hall 2008).[11] That gives a ratio of $3.30 in losses for deaths and injuries per dollar of property loss. The losses for mortality and human injuries can be obtained by multiplying the total property loss calculated in Step v by 3.3:

$$\Delta\$\,mortality\ and\ injuries = \Delta\$\,total\ property\ loss \times 3.3 \quad (11)$$

viii. *Update the values to current-year dollars.* Since the relationships used to estimate the dollar losses are in 1993 dollars, it is necessary to adjust this value for inflation variation between 1993 to the current year.

ix. *Obtain the total dollar loss due to the fire station shutdown.* This is done by adding the estimates obtained in Steps vi (total property loss) and vii (mortality and human injuries losses):

$$\Delta\$\,total\ loss = \Delta\$\,total\ property\ loss + \Delta\$\,mortality\ and\ injuries \quad (12)$$

[10] This relationship was calculated using data for residential structures. NFPA data show that residential structure fires represent 79 percent of all structure fires.

[11] This estimate was obtained using the values of $5 million per death and $166,000 per injury as 1993 values, inflated to 2008 dollars.

Application of the Methodology: An Example

Consider a situation where Fire Station A is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. Fire Station B will cover the geographical area usually covered by Fire Station A.
2. The population served by Fire Station A is 30,000 people.
3. The distance between the two fire stations is 5 miles.

These are the steps to determine the increase in the dollar losses due to the shutdown:

i. The *number of fire incidents* (I) in the affected area will be equal to:
30,000 x 0.0055 = 165 incidents per year.

ii. *Response time* will be equal to:
before the shutdown (RT_{Before}): 5 minutes

after the shutdown (RT_{After}): [5 + (0.65 + 1.70 x 5 miles)] = 14.15 minutes

iii. The *probability of a no-loss incident* (P_0) will be equal to:
before the shutdown ($P_{0Before}$): (0.456 – 0.00264 x 5) = 0.4428

after the shutdown (P_{0After}): (0.456 – 0.00264 x 14.15) = 0.4186

iv. The *dollar loss per incident* will be equal to:
before the shutdown (DL_{Before}): (3,845 + 431 x 5) = $6,000

after the shutdown (DL_{After}): (3,845 + 431 x 14.15) = $9,944

v. The *increase in the dollar loss due to the fire station shutdown* will be equal to: [(1 – 0.4186) x 9,944 – (1 – 0.4428) x 6,000] x 165 = $402,204 per year, or $1,102 per day of lost service (in 1993 dollars).

vi. After adding the *indirect losses*, the daily dollar loss will be equal to:
$1,102 x 1.10 = $1,212 per day in 1993 dollars.

vii. *Updating* this value to 2011 dollars gives:
$1,212 x 1.57 = $1,903 per day of lost service.

viii. The *losses for deaths and human injuries* will be equal to:
$1,903 x 3.30 = $6,280 per day of lost service.

ix. Total losses will be equal to:
$1,903 + $6,280 = $8,183 per day of lost service.

Loss of Emergency Medical Services

In a life-threatening situation, timely emergency care is a key factor that affects the chances of survival. If the shutdown of an EMS provider such as a fire station causes a considerable increase in the EMS response time, there may be a cost in lives. The methodology presented estimates the social cost for a loss of an EMS provider, which is the potential cost in lives resulting from the increased response time.

To measure changes in EMS response times, the methodology assumes that if an EMS provider (for example, Fire Station A) is temporarily shut down, then the closest EMS provider (Fire Station B) will temporarily serve the population served by Fire Station A.

Different medical studies have analyzed the link between mortality and EMS response times (for example, see Blackwell and Kaufman 2002). However, all the studies that estimated a "survival function" focus on cardiac arrests.[12] As suggested by Erkut et al. (2007), the reason for choosing cardiac arrests in this type of study is that cardiac arrest calls are of the highest priority, and, according to the researchers, those victims are the most "savable"; the response to cardiac arrest calls is the most accurate measure of emergency medical performance. Current EMS response time standards are based on cardiac arrest survival studies, and these calls account for a considerable portion of high-priority EMS calls.

This methodology uses the results obtained by Valenzuela et al. (1997). This particular study was selected because it is based on data from the United States and used a larger database compared to other studies.[13] The study used data from the EMS systems of Tucson, AZ (population, 415,000; area, 406 km^2), and King County, WA (population, 1,038,000; area, 1,399 km^2). The Tucson data were collected from 1988 through 1993, and the King County data were collected from 1976 through 1991. The authors estimated a survival function that included the time interval from collapse to cardiopulmonary resuscitation (CPR), and the time interval from collapse to defibrillation. The estimated survival function is the following:

$$Survival\ probability = \left(1 + e^{-0.260+0.106 I_{CPR}+0.139 I_{Defib}}\right)^{-1} \qquad (13)$$

Where:

Survival probability = survival probability after out-of-hospital cardiac arrest due to ventricular fibrillation

I_{CPR} = time interval from collapse to CPR

I_{Defib} = time interval from collapse to defibrillation

The steps to estimate the impact of losing an EMS provider are the following:

1. Determine the EMS provider that will temporarily replace the EMS provider that is out of service
2. Establish the distance between the two
3. Estimate the population served by the non-operating EMS provider
4. Determine the dollar loss expected due to the shutdown

To determine the expected dollar loss (Step 4), a series of calculations need to be performed.

a. *Estimate the number of cardiac arrests treated by EMS in the affected area.* These numbers were obtained using the population served as determined in Step 3.[14] Since obtaining specific

[12] A "survival function" measures the probability of survival for a patient as a function of the response time of an EMS vehicle to the patient.

[13] Some of the mentioned studies used data from Canada, the Netherlands, and the United Kingdom.

[14] No studies were found regarding how a natural disaster will increase the mortality rate from cardiac arrests. Even if that data were available, it would need to be established how an increased distance to a hospital would affect the increase in the mortality rate.

data for an area may be difficult, a national average was used instead. The American Heart Association estimates that in the United States, EMS treats 36 to 81 out-of-hospital cardiac arrests per 100,000 people (American Heart Association 2004).[15] The middle point of that estimate is 58.5 per 100,000 people. Therefore, the number of cardiac arrests treated in the affected area (e.g., the area served by EMS Provider A) can be approximated as:

$$\text{Number of cardiac arrests per year treated by EMS} = \frac{\text{population served}_{\text{Fire Station A}} \times 58.5}{100{,}000} \quad (14)$$

b. *Estimate the average EMS response time in the area before and after the shutdown*. In the United States, response times are typically different for urban and rural areas. For the situation before the shutdown, it is assumed that the response time is equal to the national average. According to the National EMS Information System (NEMSIS 2008), the national median response time for cardiac arrest calls is 7 minutes for urban, 8 minutes for suburban, 8 minutes for rural, and 9 minutes for wilderness.[16] The extra response time will be approximated using the distance between the EMS providers established in Step 2. The following formula, developed by the New York City Rand Institute in the 1970s (Chaiken et al. 1975), is used to determine the relationship between expected response time (RT) in minutes and the distance (D) in miles:

$$RT = 0.65 + 1.70D \quad (15)$$

Hence, the response time after the EMS provider shutdown (RT_{After}) will be estimated to be (in minutes):

$$RT_{After} = 7 + (0.65 + 1.70D) \text{ for urban} \quad (16)$$

$$RT_{After} = 8 + (0.65 + 1.70D) \text{ for suburban} \quad (17)$$

$$RT_{After} = 8 + (0.65 + 1.70D) \text{ for rural} \quad (18)$$

$$RT_{After} = 9 + (0.65 + 1.70D) \text{ for wilderness} \quad (19)$$

[15] No national data could be obtained about EMS calls. In 2001, the National Association of State EMS Directors, in conjunction with the National Highway Traffic Safety Administration (NHTSA) and the Trauma/EMS Systems program of the Health Resources and Services Administration's (HRSA) Maternal Child Health Bureau created a national EMS database known as NEMSIS (National EMS Information System). It is expected that in future years national data related to EMS would be available through this system.

[16] The definition of each category is based on an "Urban Influence" coding system used by the United States Department of Agriculture (USDA) and the Office of Management and Budget (OMB). These codes take into account county population size, degree of urbanization, and adjacency to a metropolitan area or areas. The categories are defined as follows:

Urban: counties with large (more than 1 million residents) or small (less than 1 million residents) metropolitan areas.

Suburban: micropolitan (with an urban core of at least 10,000 residents) counties adjacent to a large or small metropolitan area.

Rural: non-urban core counties adjacent to a large or small metropolitan area (with or without town).

Wilderness: non-core counties that are adjacent to micropolitan counties (with or without town).

c. *Determine the probability of survival before and after the shutdown.* This is done using the survival function given in equation (6). It is assumed that a call is placed to EMS as soon as the patient experiences cardiac arrest, and that all EMS units are equipped with defibrillators and staff who are trained to use them. Following Valenzuela et al. (1997), it is also assumed that the time interval to EMS-initiated CPR (I_{CPR}) is equal to the EMS response interval plus 1 minute, and the time interval to defibrillation (I_{Defib}) is equal to the EMS response time plus 2 minutes. The survival probabilities before and after the shutdown are given by the following formulas:

- Before shutdown:

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(7+1)+0.139\times(7+2)}\right)^{-1} \text{ for urban} \quad (20)$$

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(8+1)+0.139\times(8+2)}\right)^{-1} \text{ for suburban} \quad (21)$$

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(8+1)+0.139\times(8+2)}\right)^{-1} \text{ for rural} \quad (22)$$

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(9+1)+0.139\times(9+2)}\right)^{-1} \text{ for wilderness} \quad (23)$$

- After shutdown:

$$Survival\ probability_{After} = \left(1 + e^{-0.260+0.106\times(RT_{After}+1)+0.139\times(RT_{After}+2)}\right)^{-1} \text{ for urban, suburban, rural, and wilderness} \quad (24)$$

d. *Calculate the increase in the number of deaths from cardiac arrests due to the increased EMS response time.* The survival probabilities obtained in Step iii, and the number of cardiac arrests estimated in Step i, will be used to approximate the potential increase in the number of deaths:

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} = Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS \times \left(1 - survival\ probability_{Before}\right) \quad (25)$$

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} = Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS \times \left(1 - survival\ probability_{After}\right) \quad (26)$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest = Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} - Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} \quad (27)$$

e. *Assign a dollar value to the potential cost in lives due to the increased EMS response time*. This methodology uses the Value of Statistical Life from the Life Safety section above. The December 2011estimate for the value of a life is $6,600,000. Hence, the potential cost in lives can be estimated using the following formula:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ EMS\ response\ time = \frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest)}{365} \times \$6{,}600{,}000 \quad (28)$$

Application of the Methodology: An Example

Consider a situation where EMS Provider A in a suburban area is shut down due to a flood event. The information needed to estimate the social cost of the shutdown related to EMS is the following:

1. EMS Provider B will cover the geographical area usually covered by EMS Provider A.
2. The population served by EMS Provider A is 30,000 people.
3. The distance between the two providers is 5 miles.

These are the steps to estimate the potential dollar losses due to the EMS loss of function:

a. The *number of cardiac arrests treated by EMS* in the affected area is equal to:

$$Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS = \frac{30{,}000 \times 58.5}{100{,}000} = 17.6 \quad (29)$$

b. The *average EMS response time in the area before and after the EMS provider shutdown* are equal to:

$$RT_{Before} = 8\ \text{min} \quad (30)$$

$$RT_{After} = 8 + (0.65 + 1.70 \times 5) = 17.2\ \text{min} \quad (31)$$

c. The *probabilities of survival before and after the shutdown* are equal to:

$$\begin{aligned} Survival\ probability_{Before} &= \left(1 + e^{-0.260+0.106\times(8+1)+0.139\times(8+2)}\right)^{-1} = 0.1107 \\ Survival\ probability_{After} &= \left(1 + e^{-0.260+0.106\times(17.2+1)+0.139\times(17.2+2)}\right)^{-1} = 0.0129 \end{aligned} \quad (32)$$

d. The *increase in the number of deaths from cardiac arrests due to the increased EMS response time* is equal to:

$$\begin{aligned} &Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} = 17.6 \times (1 - 0.1107) = 15.6 \\ &Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} = 17.6 \times (1 - 0.0129) = 17.3 \\ &Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest = 17.3 - 15.6 = 1.7 \end{aligned} \quad (33)$$

e. The *dollar value* of the potential cost in lives due to the increased EMS response time is equal to:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ EMS\ response\ time = \frac{1.7}{365} \times \$6{,}600{,}000 = \$30{,}740\ per\ day \quad (34)$$

Loss of Hospital Services

The methodology presented estimates how the temporary loss of function of a hospital affects the users of the Emergency Department (ED). This methodology assumes that if a hospital (for example, Hospital A) is temporarily shut down, then its users will choose the second nearest hospital (Hospital B) in case of an emergency. It also assumes that only patients using the ED, whether they are admitted to the hospital or not, will be affected by the temporary hospital shutdown. This is because most non-emergency patients will likely reschedule their hospital admission if the hospital is temporarily closed. For this reason, the impacts estimated in this paper should be allowed only for mitigation activities that sustain emergency room services, rather than the whole hospital building.

It should be noted that this methodology does not cover the emergency response actions taken by the hospital (e.g., evacuation procedures) to reduce the potential loss of property or life of patients (e.g., intensive care unit [ICU] patients who require specialized care). The actions taken by the hospital and associated impacts should be addressed separately when estimating the total impacts of an event.

The cost to users in this methodology can be disaggregated into three parts:

I. *The cost of the extra distance to get to the hospital*: If Hospital A is temporarily shut down, the population served by this hospital will have to use Hospital B instead. This implies driving a longer distance, and consequently incurs a higher cost in terms of time, fuel, and other costs of the trip.
II. *The cost of additional waiting time at the hospital*: The increased patient load at Hospital B will cause delays in treatment. This extra time affects users of both Hospital A and Hospital B.
III. *The potential cost in lives of the extra time to get to the hospital*: In a life-threatening situation, timely emergency care is a key factor that affects the chances of survival. If the increase in distance to the nearest hospital is long enough, the cost in lives may need to be considered in the analysis.

The steps to estimate the impacts of losing hospital services are the following:

1. Determine which alternate hospital (Hospital B) will temporarily replace the hospital that is out of service (Hospital A)
2. Establish the distance between the hospitals
3. Estimate the population served by each hospital
4. Determine the dollar loss due to the shutdown in terms of:
    I. The cost of traveling the extra distance to Hospital B
    II. The cost of extra waiting time at Hospital B
    III. The potential cost in lives due to the increased distance to Hospital B for Hospital A's patients

To estimate the dollar loss (Step 4), a series of calculations need to be performed:

I. Cost of traveling the extra distance to the hospital:

a. *Estimate the extra travel time due to the hospital shutdown*: It is assumed that, on average, the additional travel distance for the non-operating hospital (Hospital A) patients will be equal to the distance between the non-operating hospital and the second nearest hospital (Hospital B). Hence the extra travel distance will be approximated through the distance between both hospitals established in Step 2. It is assumed that the trip to the hospital implies a round trip (a trip to the hospital and a trip from the hospital), so the travel time is multiplied by 2 (based on Capps et al. 2006). The extra travel time can be approximated using the formula developed by the New York City Rand Institute in the 1970s (Chaiken et al. 1975) to estimate the relationship between time (T) in minutes and distance (D) in miles:

$$T(minutes) = 0.65 + 1.70\,D(miles) \tag{35}$$

Then the formula to estimate the extra distance will be:

$$Extra.travel\ time\ (hours) = \frac{0.65 + 1.70 \times Distance\ between\ hospitals\ (miles)}{60} \times 2 \tag{36}$$

b. *Estimate the number of daily ED visits to the non-operating hospital:* The population served determined in Step 3 will be used to obtain this number. Since obtaining specific data for a hospital may be difficult, a national average will be used instead. According to the National Center for Health Statistics of the U.S. Department of Health and Human Services (2009), the number of visits to EDs in 2005 was 115.3 million, or 39.6 visits per 100 persons. Additionally, during an emergency (such as a hurricane or tornado) the number of ED visits may increase. There are different studies analyzing the effect of natural disasters on the use of EDs. The results vary depending on the event magnitude. For this analysis, the results obtained by Smith and Graffeo (2005) on the impacts of Hurricane Isabel (a Category 2 hurricane that hit the mid-Atlantic region in 2003) were used. The purpose of this study was to investigate the impact of the hurricane on the number and type of ED patient visits. The results showed that during the subsequent 4 days post-landfall, there was an increase in average daily aggregate ED visits of 25 percent. This number will be used to increase the number of visits per day for both hospitals.

Therefore, the number visits to the non-operating hospital can be approximated as:

$$Number\ of\ visits\ per\ day_{Hospital.A} = \frac{0.396 \times population\ \ served_{Hospital\ A}}{365} \times 1.25 \tag{37}$$

c. *Determine the cost of the extra distance to get to the hospital:* It is assumed that the trip to the hospital will involve two people per patient (patient and companion). Additionally, the cost of time is estimated using the average employer cost for employee compensation per hour from the U.S. Department of Labor. The employer cost in March 2011 was $30.07 per hour. Finally, the cost of the extra mileage is estimated using the Federal government 2008 mileage reimbursement rate, which is equal to $0.505 per mile for passenger vehicles.[17] The cost of traveling the extra distance to the hospital is given by the following formula:

$$\begin{aligned} &Cost\ of\ extra\ distance = Extra\ travel\ time \times \$30.07 \times (number\ of\ visits\ per\ day \times 2) \\ &+ \$0.505 \times (distantace\ between\ hospitals \times 2) \times number\ of\ visits\ per\ day \end{aligned} \tag{38}$$

[17] The extra mileage cost is included because only 4.2 percent of the patients visiting EDs use emergency medical transport (Institute of Medicine of the National Academies 2006).

II. Cost of extra waiting time at the hospital:

a. *Estimate the number of ED visits per year for both hospitals.* These numbers can be estimated using the population served as determined in Step 3, the average number of ED visits per year (39.6 per 100 people in 2005, as discussed in Step I.b.), and the increase in the number of visits during the disaster:

$$Number\ of\ ED\ visits\ per\ year_{Hospital\ A} = Population\ served_{Hospital\ A} \times 0.396 \times 1.25 \quad (39)$$

$$Number\ of\ ED\ visits\ per\ year_{Hospital\ B} = Population\ served_{Hospital\ B} \times 0.396 \times 1.25 \quad (40)$$

b. *Estimate the waiting time increase at the replacing hospital for both groups of patients*: This can be obtained using a relationship between the number of ED users and waiting time. Such a relationship was estimated using data from the survey *Emergency Department Pulse Report* (Press Ganey Associates 2007). This survey analyzes the experiences of more than 1.5 million patients treated at more than 1,500 hospitals in the United States. The survey shows that the average waiting time at the ED increases as the number of patients increases. Using that information, a regression analysis was conducted to obtain the relationship between waiting time and the number of patients, measured as the number of annual visits to EDs:[18]

$$Waiting\ time\ per\ patient\ (in\ hours) = 2.49 + 0.000042 \times number\ of\ visits\ per\ year \quad (41)$$

The extra waiting time for both groups of patients (Hospital A users that will have to use Hospital B due to the shutdown, and Hospital B users) can be estimated using the following formulas:

$$Waiting\ time\ per\ patient_{Hospital\ A} = 2.49 + 0.000042 \times number\ of\ visits\ per\ year_{Hospital\ A} \quad (42)$$

$$Waiting\ time\ per\ patient_{Hospital\ B} = 2.49 + 0.000042 \times number\ of\ visits\ per\ year_{Hospital\ B} \quad (43)$$

$$Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} = 2.49 + 0.000042 \times \begin{pmatrix} number\ of\ visits\ per\ year_{Hospital\ A} \\ +\ number\ of\ visits\ per\ year_{Hospital\ B} \end{pmatrix} \quad (44)$$

The waiting time increases per patient are then calculated:

$$Waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} = Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} - Waiting\ time\ per\ patient_{Hospital\ A} \quad (45)$$

$$Waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} = Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} - Waiting\ time\ per\ patient_{Hospital\ B} \quad (46)$$

[18] The regression R^2 is equal to 0.9910.

c. *Calculate the cost of the extra waiting time*: As in Step I.c., it is assumed that the trip to the hospital involves two people per patient, and that the cost of time is estimated using the average employer cost for employee compensation per hour from the U.S. Department of Labor ($30.07 per hour in March 2011). The cost per day of the extra waiting time at the hospital would be:

$$\begin{aligned} &Cost\ of\ waiting\ time\ increase = waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} \\ &\times \left(\frac{number\ of\ visits\ per\ year_{Hospital\ A}}{365} \right) \times 2 \times \$30.07 \\ &+ waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} \\ &\times \left(\frac{number\ of\ visits\ per\ year_{Hospital\ B}}{365} \right) \times 2 \times \$30.07 \end{aligned} \tag{47}$$

III. Potential cost in lives due to the increased distance to hospital:

After conducting an extensive literature search, only one study could be found that analyzed the link between mortality and distance to a hospital (Buchmueller et al. 2005). The study uses data from the Los Angeles County Health Surveys for 8,000 cases between 1997 and 2003 to test the effect of distance on mortality from emergency (Acute Myocardial Infarction [AMI] and unintentional injuries)[19,20] and non-emergency conditions (such as cancer or chronic heart disease). The results show that increased distance to the nearest hospital is associated with an increase in deaths from AMI and unintentional injuries, but not from the other causes for which timely emergency care is less important. The results are the presented in Table 10:

Table 10: Percentage Change in Number of Deaths Due to a Mile Increase in Distance to the Hospital

	AMI	Unintentional Injuries
Increase in the number of deaths due to a 1-mile increase in distance	6.04 percent	6.14 percent

Source: Buchmueller et al. (2005).

The steps to determine the potential cost in lives are the following:

a. *Estimate the number of deaths from AMI and unintentional injuries in the affected area:* These numbers were obtained using the population served as determined in Step 3.[21] Since obtaining specific data for an area may be difficult, a national average was used. The National Center for Health Statistics of the U.S. Department of Health and Human Services publishes the *National Vital Statistics Report* (NVSR), which contains data on death rates and

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[19] AMI are covered by the *International Classification of Diseases*, Tenth Revision (ICD-10) codes I21-I22, and unintentional injuries are covered by codes V01-X59 and Y85-Y86.

[20] Unintentional injuries are: 1) transport accidents and their consequences, and 2) other external causes of accidental injury and their consequences.

[21] No studies were found regarding how a natural disaster will increase the mortality rate from AMI and unintentional injuries. Even if that data were available, it would need to be established how an increased distance to a hospital would affect the increase in the mortality rate.

causes of death. The last report available contains data for 2005 (National Center for Health Statistics 2008). The death rate in 2005 was 825.9 per 100,000 population, while the death rates for AMI and unintentional injuries were 50.9 and 39.7 per 100,000 population, respectively. Therefore, the number of deaths in the affected area (i.e., the area served by Hospital A) can be approximated as:

$$Number\ of\ deaths\ per\ year\ due\ to\ AMI = \frac{population\ served_{Hospital\ A} \times 50.9}{100{,}000} \tag{48}$$

$$\begin{aligned} &Number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = \\ &\frac{population\ served_{Hospital\ A} \times 39.7}{100{,}000} \end{aligned} \tag{49}$$

b. *Calculate the increase in the number of deaths from AMI and unintentional injuries due to the increased distance to the hospital*: The percentages provided in Table 10, the estimates obtained in the previous step, and the distance between Hospital A and Hospital B will be used to approximate the potential increase in the number of deaths:

$$\begin{aligned} &Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI = \\ &number\ of\ deaths\ per\ year\ due\ to\ AMI \\ &\times 0.0604 \times distance\ between\ Hospital\ A\ and\ Hospital\ B \end{aligned} \tag{50}$$

$$\begin{aligned} &Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = \\ &number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries \times 0.0614 \\ &\times distance\ between\ Hospital\ A\ and\ Hospital\ B \end{aligned} \tag{51}$$

c. *Assign a dollar value to the potential cost in lives due to the increased distance to the hospital:* This methodology uses the Statistical Value of Life developed in the Life Safety section above. The December 2011 estimate for the value of a life is $6,600,000. Hence, the potential cost in lives can be estimated using the following formula:

$$\begin{aligned} &Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ distance\ to\ hospital = \\ &\frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI)}{365} \times \$6{,}600{,}000 \\ &+ \frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries)}{365} \times \$6{,}600{,}000 \end{aligned} \tag{52}$$

The total dollar loss due to the hospital shutdown then is obtained as the sum of items I, II, and III:

$$\begin{aligned} &Total\ dollar\ loss = Cost\ of\ extra\ distance + Cost\ of\ waiting\ time\ increase \\ &+ Cost\ in\ lives\ due\ to\ the\ increased\ distance\ to\ hospital \end{aligned} \tag{53}$$

Application of the Methodology: An Example

Consider a situation where Hospital A is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. Hospital B will serve the geographic area usually served by Hospital A.
2. The distance between the hospitals is 10 miles.
3. The population served by Hospital A is 10,000 people, and the population served by Hospital B is 30,000 people.
4. These are the steps to determine the dollar losses due to the shutdown:

   I. Cost of travelling the extra distance to the hospital

   a. The *extra travel time due to the hospital shutdown* is equal to:

$$Extra\ travel\ time = \frac{0.65 + 1.7 \times 10}{60} \times 2 = 0.6\ hours \tag{54}$$

   b. The *number of daily ED visits to Hospital A* is equal to:

$$Number\ of\ visits\ per\ day_{Hospital\ A} = \frac{0.396 \times 10{,}000}{365} \times 1.25 = 13.56\ visits\ per\ day \tag{55}$$

   c. The *costs of traveling the extra distance to the hospital* is equal to:

$$\begin{aligned} &Cost\ of\ extra\ distance = 0.6 \times \$30.07 \times (13.56 \times 2) \\ &+ \$0.505 \times (10 \times 2) \times 13.56 = \$626\ per\ day \end{aligned} \tag{56}$$

   II. Cost of extra waiting time at the hospital

   a. The *number of ED visits per year for both hospitals* are equal to:

$$\begin{aligned} &Number\ of\ ED\ visits\ per\ year_{Hospital\ A} = 10{,}000 \times 0.396 \times 1.25 = 4{,}950 \\ &Number\ of\ ED\ visits\ per\ year_{Hospital\ B} = 30{,}000 \times 0.396 \times 1.25 = 14{,}850 \end{aligned} \tag{57}$$

   b. The *waiting time increase at the replacing hospital* for both groups of patients is calculated following these steps:

$$\begin{aligned} &Waiting\ time\ per\ patient_{Hospital\ A} = 2.49 + 0.000042 \times 4{,}950 = 2.7\ hours \\ &Waiting\ time\ per\ patient_{Hospital\ B} = 2.49 + 0.000042 \times 14{,}850 = 3.1\ hours \\ &Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} = 2.49 + 0.000042 \\ &\times (4{,}950 + 14{,}850) = 3.3\ hours \\ &Waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} = 3.3 - 2.7 = 0.6\ hours \\ &Waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} = 3.3 - 3.1 = 0.2\ hours \end{aligned} \tag{58}$$

   c. The *cost of the extra waiting time* is equal to:

$$Cost\ of\ waiting\ time\ increase = 0.6\times\left(\frac{4{,}950}{365}\right)\times 2\times \$30.07 + 0.2\times\left(\frac{14{,}850}{365}\right)\times 2\times \$30.07 \quad (59)$$

$$= \$978\ per\ day$$

III. Potential cost in lives due to the increased distance to hospital

a. The *number of deaths from AMI and unintentional injuries* in the affected area is equal to:

$$Number\ of\ deaths\ per\ year\ due\ to\ AMI = \frac{10{,}000\times 50.9}{100{,}000} = 5.09 \quad (60)$$

$$Number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = \frac{10{,}000\times 39.7}{100{,}000} = 3.97 \quad (61)$$

b. The *increase in the number of deaths from AMI and unintentional injuries* due to the increased distance to the hospital is equal to:

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI = 5.09\times 0.0604\times 10 = 3.074$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = 3.97\times 0.0614\times 10 = 2.43 \quad (62)$$

c. The *dollar value* of the potential cost in lives due to the increased distance to the hospital is equal to:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ distance\ to\ hospital = \frac{3.074}{365}\times \$6{,}600{,}000 + \frac{2.43}{365}\times \$6{,}600{,}000 = \$99{,}525\ per\ day \quad (63)$$

The total dollar loss due to the hospital shutdown is equal to:

$$Total\ dollar\ loss = \$626 + \$978 + \$99{,}525 = \$101{,}129\ per\ day \quad (64)$$

Loss of Police Services

The methodology presented estimates the cost to society of a temporary loss-of-function of a police station. The estimation of this cost has two main components. The first is to measure how a reduced police presence would affect the population of that area. The second is to assign a dollar value to those effects.

It should be noted that this method only accounts for the effects of a reduced police presence resulting from the loss of a police station. In many situations, activities typically conducted at a police station can be assigned to another police station with no apparent loss of service to the community. However, during a catastrophic event, such as a flood in the community, there may be an increased cost for emergency response activities, including an increase in overtime for police officers. This method does not account for emergency response activities; these costs should be considered separately with proper documentation.

It is widely accepted that impaired police activity could potentially result in an increase in crime. The first component mentioned above can be approximated by the relationship between the number of police officers per capita and the crime rate. Many studies tried to estimate the impact of police force size on crime (New York City Area Consortium for Earthquake Loss Mitigation 2003, Levitt 1998). This methodology uses the results obtained by Evans and Owens in 2007. The Evans and Owens study used panel data for 2,074 cities and towns for the period 1990–2001. They found a statistically significant relationship between the number of police officers and both property crime (such as burglaries, auto thefts, and larceny) and violent crime (such as murders, rapes, robberies, and aggravated assaults). Table 11 shows the estimated elasticities; that is, the percentage change in different types of crime generated by a percentage change in police force. For example, a value of -2 means that a 1 percent reduction in the number of police officers will cause an increase of 2 percent in that type of crime.

The second component is the cost of crime to society. This methodology uses the costs of crime estimated by McCollister in 2004. The approach used for estimating the cost of crime to society includes tangible costs and intangible costs. Tangible costs may include direct victim costs, mental health costs, and criminal justice system costs. Intangible costs include estimates of pain and suffering. Table 12 shows the costs of crime that were used.

Table 11: Impact of Number of Police Officers on Crime Rate

Type of Crime	Percent Change in Crime Rate Generated by a 1-percent Change in Police Force
Property Crimes	
Burglary	-0.59
Auto Theft	-0.85
Larceny	-0.08
Violent Crimes	
Robbery	-1.34
Murder	-0.84
Rape	-0.42
Assault	-0.96

Source: Evans and Owens 2007.

Table 12: Total Cost of Crime in 2004 Dollars

Type of Crime	Total Cost
Property Crimes	
Burglary	$3,974
Auto Theft	$8,328
Larceny	$1,344
Violent Crimes	
Robbery	$46,484

Type of Crime	Total Cost
Murder	$8,492,905
Rape	$200,037
Assault	$111,801

Source: McCollister 2004.

The steps to estimate the loss-of-function impact of police services are the following:

1. Determine the number of police officers working at the police station before shutdown
2. Estimate the population regularly served by the police station
3. Establish the number of police officers that would serve the affected area after the police station shutdown
4. Determine the expected dollar loss due to the shutdown

To determine the expected dollar loss (Step 4), a series of calculations need to be performed:

i. *Determine the number police officers per capita in the area served by the police station before the station shutdown (Ppc_{Before}):* The number of police officers and the population served, determined in Steps 1 and 2, respectively, will be used to obtain these numbers:

$$Ppc_{Before} = \frac{Police\ officers_{Before}}{Population} \tag{65}$$

ii. *Obtain the number of police officers per capita after the police station shutdown (Ppc_{After}):* To calculate this value, the number of police officers determined in Step 3 *($Police\ officers_{After}$)* will be used:

$$Ppc_{After} = \frac{Police\ officers_{After}}{Population} \tag{66}$$

iii. *Calculate the percent change in the number of police officers per capita*: This is done using the values obtained in Steps i and ii:

$$\Delta\%Ppc = \frac{Ppc_{After} - Ppc_{Before}}{Ppc_{Before}} \times 100 \tag{67}$$

iv. *Calculate the percent change in the number crimes per capita (Cpc):* For each crime, this is done using the crime elasticities (i.e., the percent change in crime generated by a 1 percent change in the police force) provided in Table 11 and the percent change in the number of police officers obtained in Step iii:

$$\Delta\%Cpc = \Delta\%Ppc \times crime\ elasticity \tag{68}$$

v. *Estimate the number of crimes in the area*. This can be calculated using data from the Uniform Crime Reporting (UCR) Program, provided yearly by the U.S. Department of Justice, Federal Bureau of Investigation (FBI). Since crime rates vary considerably across and within States, it is suggested to use data from Table 5 of the UCR Program (FBI 2006), which provides crime data by State disaggregated between metropolitan and non-metropolitan areas. For every State, the data are presented as shown in Table 13.[22]

The following are the steps to determine the number of crimes in the area:

1. Determine if the affected area is in a metropolitan statistical area (MSA), a city outside a metropolitan area, or a nonmetropolitan county.[23]
2. For each of the crimes, obtain the crime rates per 100,000 inhabitants per year using the "estimated total" number of crimes in Table 5 of the UCR Program:

$$Crime\ rates\ (per\ 100{,}000\ inhab.) = \frac{Estimated\ total}{Population} \times 100{,}000\ per\ year \quad (69)$$

   Using the example in Table 13, if the area is in an MSA, then the robbery rate would be equal to:

$$Crime\ rate\ (per\ 100{,}000\ inhab.)_{Robbery} = \frac{6{,}313}{3{,}258{,}752} \times 100{,}000 = 193.7\ per\ year \quad (70)$$

3. For each of the crimes, calculate the number of crimes per year that occur in the affected area:

$$Number\ of\ crimes\ per\ year = \frac{Crime\ rate \times population\ served}{100{,}000} \quad (71)$$

vi. *Calculate the change in the number of crimes*: For each crime, this is obtained by multiplying the number of crimes estimated in Step v and the percent change in crime estimated in Step iv:

$$\Delta number\ of\ crimes = Number\ of\ crimes\ per\ year \times \Delta\%Cpc \quad (72)$$

Table 13: Example of Crime Statistics

State	Area	Population	Violent Crime	Murder and nonnegligent manslaughter	Forcible rape	Robbery
Alabama	Metropolitan Statistical Area	3,258,752				
	Area actually reporting	88.0%	14,007	300	1,144	5,824
	Estimated total	100.0%	15,414	318	1,256	6,313
	Cities outside metropolitan areas	587,537				
	Area actually reporting	55.8%	1,641	23	141	379
	Estimated total	100.0%	2,920	41	249	670

[22] Only violent crime data are shown in this example.

[23] An MSA contains a principal city or urbanized area with a population of at least 50,000 inhabitants. MSAs include the principal city, the county in which the city is located, and other adjacent counties that have, as defined by the OMB, a high degree of economic and social integration with the principal city and county as measured through commuting. In the UCR Program, counties within an MSA are considered metropolitan. Nonmetropolitan (rural) counties are those outside MSAs that are composed of mostly unincorporated areas.

	Nonmetropolitan counties	752,741				
	Area actually reporting	60.6%	741	14	87	46
	Estimated total	100.0%	1,223	23	144	76
	State Total	**4,599,030**	**19,557**	**382**	**1,649**	**7,059**
	Rate per 100,000 inhabitants		425.2	8.3	35.9	153.5

vii. *For each crime, assign a dollar value to the change in the number of crimes*: This is done by multiplying the change in the number of crimes obtained in Step vi and the cost of crime provided in Table 12:

$$Cost\ of\ crime\ increase_i = \Delta number\ of\ crimes_i \times cost\ of\ crime_i \quad (73)$$

viii. *Obtain the total dollar loss due to the police station shutdown:* The total cost per year is obtained by adding the costs of each of the crimes:

$$Total\ cost\ per\ year = \sum_i cost\ of\ crime\ increase_i \quad (74)$$

$$\Delta\%Cpc_{Burglary} = -20\% \times (-0.59) = 12\%$$
$$\Delta\%Cpc_{Auto\ Theft} = -20\% \times (-0.85) = 17\%$$
$$\Delta\%Cpc_{Larceny} = -20\% \times (-0.08) = 2\%$$
$$\Delta\%Cpc_{Robbery} = -20\% \times (-1.34) = 27\%$$
$$\Delta\%Cpc_{Murder} = -20\% \times (-0.84) = 17\%$$
$$\Delta\%Cpc_{Rape} = -20\% \times (-0.42) = 8\%$$
$$\Delta\%Cpc_{Assault} = -20\% \times (-0.96) = 19\%$$

The total cost per day is equal to:

$$Total\ cost\ per\ day = \frac{Total\ cost\ per\ year}{365} \quad (75)$$

ix. *Update the total dollar loss to 2008 values:* Since the estimates for the cost of crime are in 2004 dollars, it is necessary to adjust them to 2008 dollar values.

Application of the Methodology: An Example

Consider a situation where Police Station A, located in an MSA in Missouri, is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. The number of police officers working at the police station before the shutdown was 100;
2. The population regularly served by the police station is 50,000;
3. The number of police officers that would serve the affected area after the police station shutdown is 80.

These are the steps to determine the increase in the dollar losses due to the shutdown:

i. The *number of police officers per capita before* the station shutdown (Ppc_{Before}) is equal to:

$$Ppc_{Before} = \frac{100}{50,000} = 0.002 \ police\ officers \tag{76}$$

ii. The *number of police officers per capita after* the police station shutdown (Ppc_{After}) is equal to:

$$Ppc_{After} = \frac{80}{50,000} = 0.0016 \ police\ officers \tag{77}$$

iii. The *percent change in the number of police officers per capita* is equal to:

$$\Delta\%Ppc = \frac{0.0016 - 0.002}{0.002} \times 100 = -20\% \tag{78}$$

iv. Using the elasticities provided in Table 11, the *percent changes in the number of crimes per capita (Cpc)* are the following:

v. The *number of crimes in the area* is estimated using the crime data published by the UCR Program from the FBI. The latest data available is for 2006. Table 5 (FBI 2006) includes the following data for the State of Missouri:

State	Area		Population	**Property crime**	Burglary	Larceny-theft	Motor vehicle theft
MISSOURI	Metropolitan Statistical Area		4,268,725				
		Area actually reporting	99.9%	183,778	35,361	125,192	23,225
		Estimated total	100.0%	183,866	35,375	125,259	23,232
	Cities outside metropolitan areas		686,656				
		Area actually reporting	100.0%	26,877	4,885	20,810	1,182
	Nonmetropolitan counties		887,332				
		Area actually reporting	100.0%	12,827	4,387	7,421	1,019
	State Total		**5,842,713**	**223,570**	**44,647**	**153,490**	**25,433**
		Rate per 100,000 inhabitants		3,826.5	764.1	2,627.0	435.3

State	Area		Population	**Violent crime**	Murder and nonnegligent manslaughter	Forcible rape	Robbery	Aggravated assault
MISSOURI	Metropolitan Statistical Area		4,268,725					
		Area actually reporting	99.9%	26,738	316	1,479	7,261	17,682
		Estimated total	100.0%	26,747	316	1,480	7,263	17,688
	Cities outside metropolitan areas		686,656					
		Area actually reporting	100.0%	2,934	29	155	272	2,478
	Nonmetropolitan counties		887,332					
		Area actually reporting	100.0%	2,199	23	129	52	1,995
	State Total		**5,842,713**	**31,880**	**368**	**1,764**	**7,587**	**22,161**
		Rate per 100,000 inhabitants		545.6	6.3	30.2	129.9	379.3

1) The affected area is in an MSA.
2) The *crime rates* (per 100,000 inhabitants) are estimated to be:

$$
\begin{aligned}
Crime\ rates_{Burglary} &= \frac{35{,}375}{4{,}268{,}725} \times 100{,}000 = 828.7\ per\ year \\
Crime\ rates_{AutoTheft} &= \frac{23{,}232}{4{,}268{,}725} \times 100{,}000 = 544.2\ per\ year \\
Crime\ rates_{Larceny} &= \frac{125{,}259}{4{,}268{,}725} \times 100{,}000 = 2{,}934.3\ per\ year \\
Crime\ rates_{Robbery} &= \frac{7{,}263}{4{,}268{,}725} \times 100{,}000 = 170.1\ per\ year \\
Crime\ rates_{Murder} &= \frac{316}{4{,}268{,}725} \times 100{,}000 = 7.4\ per\ year \\
Crime\ rates_{Rape} &= \frac{1{,}480}{4{,}268{,}725} \times 100{,}000 = 34.7\ per\ year \\
Crime\ rates_{Assault} &= \frac{17{,}688}{4{,}268{,}725} \times 100{,}000 = 414.4\ per\ year
\end{aligned} \tag{79}
$$

3) The *number of crimes per year* in the affected area is calculated as:

$$
\begin{aligned}
Number\ of\ crimes\ per\ year_{Burglary} &= \frac{828.7 \times 50{,}000}{100{,}000} = 414.4\ per\ year \\
Number\ of\ crimes\ per\ year_{Auto\ Theft} &= \frac{544.2 \times 50{,}000}{100{,}000} = 272.1\ per\ year \\
Number\ of\ crimes\ per\ year_{Larceny} &= \frac{2{,}934.3 \times 50{,}000}{100{,}000} = 1{,}467.2\ per\ year \\
Number\ of\ crimes\ per\ year_{Robbery} &= \frac{170.1 \times 50{,}000}{100{,}000} = 85.1\ per\ year \\
Number\ of\ crimes\ per\ year_{Murder} &= \frac{7.4 \times 50{,}000}{100{,}000} = 3.7\ per\ year \\
Number\ of\ crimes\ per\ year_{Rape} &= \frac{34.7 \times 50{,}000}{100{,}000} = 17.3\ per\ year \\
Number\ of\ crimes\ per\ year_{Assault} &= \frac{414.4 \times 50{,}000}{100{,}000} = 207.2\ per\ year
\end{aligned} \tag{80}
$$

vi. The *change in the number of crimes* is equal to:

$$
\begin{aligned}
\Delta number\ of\ crimes_{Burglary} &= 414.4 \times 12\% = 48.9\ per\ year \\
\Delta number\ of\ crimes_{Auto\ Theft} &= 272.1 \times 17\% = 46.3\ per\ year \\
\Delta number\ of\ crimes_{Larceny} &= 1{,}467.2 \times 2\% = 23.5\ per\ year \\
\Delta number\ of\ crimes_{Robbery} &= 85.1 \times 27\% = 22.8\ per\ year \\
\Delta number\ of\ crimes_{Murder} &= 3.7 \times 17\% = 0.6\ per\ year \\
\Delta number\ of\ crimes_{Rape} &= 17.3 \times 8\% = 1.5\ per\ year \\
\Delta number\ of\ crimes_{Assault} &= 207.2 \times 19\% = 39.8\ per\ year
\end{aligned} \tag{81}
$$

vii. Using the estimates provided in Table 12, the *dollar values for the change in the number of crimes* are the following:

$$Cost\ of\ crime\ increase_{Burglary} = 48.9 \times \$3{,}974 = \$194{,}318$$
$$Cost\ of\ crime\ increase_{Auto\ Theft} = 46.3 \times \$8{,}328 = \$385{,}286$$
$$Cost\ of\ crime\ increase_{Lacerny} = 23.5 \times \$1{,}344 = \$31{,}553$$
$$Cost\ of\ crime\ increase_{Robbery} = 22.8 \times \$46{,}484 = \$1{,}059{,}890 \quad (82)$$
$$Cost\ of\ crime\ increase_{Murder} = 0.6 \times \$8{,}492{,}905 = \$5{,}281{,}523$$
$$Cost\ of\ crime\ increase_{Rape} = 1.5 \times \$200{,}037 = \$291{,}312$$
$$Cost\ of\ crime\ increase_{Assault} = 39.8 \times \$111{,}801 = \$4{,}447{,}666$$

viii. The *total dollar loss due to the police station shutdown* would be equal to:

$$Total\ cost\ per\ year_{2004\ dollars} = \$11{,}691{,}548\ per\ year\text{; or} \quad (83)$$

$$Total\ cost\ per\ day_{2004\ dollars} = \frac{\$11{,}691{,}548}{365} = \$32{,}032\ per\ day \quad (84)$$

ix. *Updating* this value to 2008 dollars gives:

$$Total\ cost\ per\ day_{2008\ dollars} = \$32{,}032 \times 1.14 = \$36{,}516\ per\ day \quad (85)$$

Loss of Electric Services

The methodology currently used by FEMA for calculating the direct economic impacts of losing electricity services follows five steps to perform benefit-cost analysis of hazard mitigation projects for electric power systems:

1. Estimate the physical damages to the electric power system in dollars,
2. Estimate the functional downtime (system days of lost service),
3. Obtain the number of people served by the electric power utility, and
4. Calculate the economic impacts of lost electric power service, using the per capita economic impacts and the affected population.

In the 2009 Tool update, an additional step of determining the revenue loss to the electric power utility was discontinued because of the concern it was double-counting impacts. As a general rule, double-counting can be avoided by not attributing losses to more than one entity in the case of private goods[24] (e.g., avoiding counting utility sales as a loss to both the utility company and its customers).

The sections below discuss the methodology used to estimate the economic impacts of the lost electric power service (step 4 above) to economic activity and residential customers.

[24] See Rose, A. 2004. "Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation," in Y. Okuyama and S. Chang (eds.), *Modeling the Spatial Economic Impacts of Natural Hazards*, Heidelberg: Springer, 2004, pp. 13-36.

Impacts to Economic Activity

In general, the original methodology outlined in FEMA's original economic valuation document *What Is a Benefit?* is similar to the methodologies employed in other studies of the electricity industry.[25,26,27,28]

The 2009 BCA Tool update changed the way the direct economic impact of loss of electric service was calculated. The new process used 2006 national Gross Domestic Product dollar values and then inflating that number to a 2008 dollar value in order to estimate the economic impact to commercial and industrial customers. The dollar numbers were combined with importance factors for each economic sector, which are published by the ATC-25 (Applied Technology Council, *Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous United States*, 1991). The importance factors published by the ATC-25 are widely used in this type of study, and the values in the document have not been updated since 1991.

Table 14 shows the estimation of the impact to economic activity per capita per day using Gross Domestic Product data and the ATC-25 factors. The table contains GDP sector value added figures for 2010[29]. It is noteworthy that a small change in methodology was used for the Nondurable Goods and Durable Goods sectors. For the 2010 GDP values, only the total economic numbers were given for these sectors, while the previous BCA methodology had a full dataset for all sub-sectors for these two sectors. It is uncertain whether the BEA will keep this as a reporting practice or if the sub-sector data will be added at a later date. For the purpose of this report, the methodology used for determining the weighting for the total Durable and Nondurable Goods sectors was to take an average of the weighting values of the sub-sector values. The sub-sectors and their weighting values are given in the footnotes of Table 14. This methodology was tested using the 2009 GDP values, and the result showed a difference of 17 cents, which was not considered significant.

The total economic impact of electric service per person per day is $106.27, an increase from the $102.33 value from the 2009 Tool update.

Economic Impacts to Residential Customers

This variable was also updated in the 2009 Tool update by using a contingent valuation method instead of using questionable electric service statistical data. The contingent valuation method relies on consumers' responses to a survey questionnaire to estimate the willingness-to-pay (WTP) for a good or service. In this case, the analysis examines the WTP to avoid power outages. This method has been

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[25] Greenberg, M; Mantell, N; Lahr, M; Felder, F; and Zimmerman, R. 2007. "Short and intermediate economic impacts of a terrorist-initiated loss of electric power: Case study of New Jersey." *Energy Policy*. Vol. 35 (722-733).
[26] Kunruther, H; Cyr, C; Grossi, P; and Tao, W. 2006. *Using Cost-Benefit Analysis to Evaluate Mitigation for Lifeline Systems*. National Science Foundation.
[27] Greenberg, M., 2005. *Impact to New Jersey's Economy of the Loss of Electric Power in New Jersey's Urban Industrial Corridor*. Center for Risk and Economic Analysis of Terrorism Events. Report #05-025, November.
[28] Chang, S., Seligson, H., and Eguchi, R. 1996. "Estimation of the Economic Impact of Multiple Lifeline Disruption: Memphis Light, Gas, and Water Division Case Study," *Multidisciplinary Center for Earthquake Engineering Research (MCEER) Bulletin*, Volume 10, Number 2, April 1996.
[29] BEA (Bureau of Economic Analysis). "BEA: Gross Domestic Product (GDP)", http://www.bea.gov/industry/gdpbyind_data.htm (accessed May 12, 2011). Download "GDPbyInd_VA_NAICS.xls".

Table 14: Loss of Electric Service Impact to Economic Activity

Economic Sector[1]	Electric Power Importance Factor[1]	GDP 2010 (in millions of dollars)[2]	GDP per Capita per Day[3]	Economic Impact per Capita per Day of Lost Service in 2010 Dollars
Agriculture, Livestock	n/a			
Mining	n/a			
Construction	0.40	$505,557	$4.486	$1.79
Manufacturing - Nondurable Goods [4]	0.98	$756,346	$6.712	$6.58
Manufacturing - Durable Goods[5]	0.99	$961,179	$8.529	$8.44
Transportation, Warehousing	0.30	$406,520	$3.607	$1.08
Utilities	0.80	$275,659	$2.446	$1.96
Wholesale Trade	0.90	$807,668	$7.167	$6.45
Retail Trade	0.90	$862,815	$7.656	$6.89
Real Estate, Rental, Leasing	0.90	$1,858,542	$16.492	$14.84
Finance, Insurance	0.90	$1,235,184	$10.961	$9.86
Information	0.90	$670,341	$5.948	$5.35
Professional & Business Services	0.90	$1,771,943	$15.724	$14.15
Education, Healthcare, Social	0.80	$1,274,357	$11.308	$9.05
Arts, Entertainment, Recreation	0.80	$531,116	$4.713	$3.77
Accommodation & Food Service	0.80	$399,877	$3.548	$2.84
Other Services, Except Government	0.90	$343,817	$3.051	$2.75
Government	0.60	$1,963,858	$17.427	$10.46
TOTAL				**$106.27**

[1] Source: Original FEMA methodology; agricultural and mining data excluded as not relevant to municipal systems
[2] Source: Bureau of Economic Analysis
[3] Population data from US Census Bureau – 2010 US population figure: 308,745,538 people
[4] Weighting value of 0.98 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.90), paper products (1.00), printing and related support (1.00), chemical products (0.90), textiles/textile product mills (1.00), apparel/leather/allied products (1.00), petroleum/coal products (1.00), and plastic/rubber products (1.00).
[5] Weighting value of 0.99 averaged the nine sub-sectors with the following values: wood & furniture (1.00), nonmetallic mineral products (1.00), primary metal manufacturing (0.90), fabricated metal products (1.00), machinery (1.00), computer/electronic (1.00), equipment/appliances/etc. (1.00), transportation equipment (1.00), and miscellaneous equipment (1.00).

employed in several studies to measure the impact of lifeline interruptions.[30,31] The data used in this paper was obtained from the study *A framework and review of customer outage costs: integration and*

[30] Layton, D. and Moeltner, K. 2005. "The Cost of Power Outages to Heterogeneous Households – An Application of the Mixed Gamma-Lognormal Distribution," in *Applications of Simulation Methods in Environmental and Resource Economics*, Alberini, A. and Scarpa, R., eds, Kluwer Academic Press, 2005.

analysis of electric utility outage cost surveys prepared by Lawton, Sullivan, Van Liere, Katz, and Eto for the Department of Energy in November 2003. The authors analyzed six large-scale studies conducted by five major electric utilities over 15 years to assess the value of electric service to their residential customers. There were a total of 11,368 respondents that determined the amount they would be willing to pay in order to avoid an outage of a certain duration. The average WTP to avoid a 12-hour outage is $26.27 in 2002 dollars. Projecting that amount for a 24-hour outage, and updating the value to 2010 dollars, the cost per day becomes $63.67. Since the WTP is calculated at a household level, this estimate needs to adjusted so it is expressed in per capita terms. According to the 2010 U.S. Census, the average household occupancy is equal to 2.59 people. Therefore, the per capita WTP can be estimated at $24.58.

In the United States, the average person is heavily dependent upon electricity in his or her daily life, and technological advances make this dependency even more critical. Yet little research – WTP or otherwise – has been done to place an economic value on electric service. The two most relevant research papers in the field are cited in the paragraph above and have publication dates of 2004 and 2005, now at least six years old. Additionally, there is a concern that the methodology outlined in the previous paragraph assumes that the WTP for electric service is a linear function. A residential customer might place an incrementally higher value on avoiding a 24-hour outage versus a doubling factor for a 12-hour outage. There is some research which finds that this is not a linear function[32]; however, more research is needed to determine actual value numbers which could be used in the BCA Tool.

Summary

Table 15 summarizes the proposed values to measure the economic impact of loss of electric power. It is recommended that the total economic impact of $130.85 is rounded up to $131.

Table 15: Economic Impacts of Loss of Electric Power

Per Capita Per Day (in 2010 dollars)

Category	Economic Impact
Impact on Economic Activity	$106.27
Impact on Residential Customers	$24.58
Total Economic Impact	**$131**

Based on changes in methodologies used and changes with updated values, Table 16 summarizes the historical changes in the value of electric service from the initial *What is a Benefit?* value to the updated value proposed by this document.

[31] Devicienti, F., Klytchnikova, I., and Paternostro, S. 2004. "Willingness to Pay for Water and Energy: An Introductory Guide to Contingent Valuation and Coping Cost Techniques", *Energy Working Notes*, No. 3, World Bank, December 2004.

[32] Carlsson, F. and Martinsson, P. 2004. "Willingness to Pay among Swedish Households to Avoid Power Outages - A Random Parameter Tobit Model Approach". *Working Papers in Economics*, No. 154, Gothenburg University.

Table 16: Evolution of Electric Service Value Used in the BCA Tool

Value Category	Initial Value	BCAR Updated Value	2008 Updated Value	Current Updated Value
Average Price per Kilowatt-Hour (national)	6.47 cents	8.72 cents	Discontinued	N/A
Direct Economic Impact on Residents	$30 to 35	Discontinued	N/A	N/A
Disruption of Activity per Day	3 to 4 hours	3 to 4 hours	Discontinued	N/A
Cost of Activity Disruption per Day	$63 to $85	$82 to $109	Discontinued	N/A
Per Capita, Per Day Direct	$93 to $110	$82-$109	Discontinued	N/A
Best Estimate for Residential Customers	$101	$95	Discontinued	N/A
Per Capita, Per Day Direct Regional Economic Impact (Impact on Economic Activity)	$87	$113	$102	$106
Impact on Residential Customers	N/A	N/A	$24	$25
Total Economic Impacts	**$188**	**$208**	**$126**	**$131**

Loss of Wastewater Services

The methodology presented estimates the value of loss of wastewater service. The loss of wastewater service measures the impact to the economic activity of the country as a whole and for residential customers. The methodology applies to the loss of service resulting from the closure of, or damage to, a wastewater treatment facility. It may not be appropriate to use this methodology to estimate the losses from events that affect a localized area (e.g., it is not appropriate to use the Total Economic Impact standard value from Table 17 below for a break in the wastewater line servicing a residential neighborhood). Localized loss of service situations should be evaluated separately to account for the full impacts to both economic activity and residential customers.

Economic Activity

The direct economic impact of loss of wastewater is estimated using GDP data and the importance factors published in ATC-25 (Applied Technology Council 1991). The importance factors published by ATC-25 are widely used in this type of study. These studies typically use GDP data (or Gross State Product data, when studies are focused on a smaller geographic area) to estimate the economic impact to commercial and industrial customers.

Table 17 shows the estimation of the impact to economic activity per capita per day using GDP data and the ATC-25 factors.

Like the electric service value, the 2010 GDP data contained values for the total Durable and Nondurable Goods values and not for each sub-sector, which was the methodology used in the previous update. A

Table 17: Loss of Wastewater Service Impact to Economic Activity

Economic Sector[1]	Wastewater Service Importance Factor[1]	GDP 2010 (in millions of dollars)[2]	GDP per Capita per Day[3]	Economic Impact per Capita per Day of Lost Service in 2010 Dollars
Agriculture, Livestock	n/a			
Mining	n/a			
Construction	0.20	$505,557	$4.486	$0.90
Manufacturing - Nondurable Goods[4]	0.65	$756,346	$6.712	$4.36
Manufacturing - Durable Goods[5]	0.75	$961,179	$8.529	$6.40
Transportation, Warehousing	0.10	$406,520	$3.607	$0.36
Utilities	0.24	$275,659	$2.446	$0.59
Wholesale Trade	0.10	$807,668	$7.167	$0.72
Retail Trade	0.20	$862,815	$7.656	$1.53
Real Estate, Rental, Leasing	0.20	$1,858,542	$16.492	$3.30
Finance, Insurance	0.20	$1,235,184	$10.961	$2.19
Information	0.20	$670,341	$5.948	$1.19
Professional & Business Services	0.20	$1,771,943	$15.724	$3.14
Education, Healthcare, Social	0.80	$1,274,357	$11.308	$9.05
Arts, Entertainment, Recreation	0.80	$531,116	$4.713	$3.77
Accommodation & Food Service	0.80	$399,877	$3.548	$2.84
Other Services, Except Government	0.20	$343,817	$3.051	$0.61
Government	0.20	$1,963,858	$17.427	$3.49
TOTAL				**$44.43**

[1] Source: original FEMA methodology; Agriculture and Mining data excluded as not relevant for municipal systems

[2] Source: Bureau of Economic Analysis (2010).

[3] Population data from U.S. Census Bureau (2010).

[4] Weighting value of 0.65 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.70), paper products (0.80), printing and related support (0.30), chemical products (0.80), textiles/textile product mills (0.70), apparel/leather/allied products (0.50), petroleum/coal products (0.50), and plastic/rubber products (0.50).

[5] Weighting value of 0.75 averaged the nine sub-sectors with the following values: wood & furniture (0.50), nonmetallic mineral products (0.50), primary metal manufacturing (0.80), fabricated metal products (0.80), machinery (0.80), computer/electronic (0.90), equipment/appliances/etc. (0.60), transportation equipment (0.80), and miscellaneous equipment (0.60).

test of this methodology on the 2009 GDP data revealed a difference of 23 cents. Therefore, it is recommended that the methodology be used for manipulating the 2010 GDP data.

Residential Customers

According to current FEMA guidelines, the loss of wastewater service for a short time (a few hours or a few days) does not impose significant economic impacts on residential customers. FEMA assumes that a temporary loss of wastewater service generally entails a total or partial loss of capacity to treat wastewater without affecting the residential disposal of sewage or other wastewater. Although untreated sewage can be passed through the wastewater system directly into the receiving stream, residential customers would most likely have at least a minimal value to prevent this type of water pollution. Additionally, no research value could be found which placed an economic value on wastewater service to customers. Therefore, even though no value was assigned for the loss of wastewater to residential customers, it is unlikely that a real economic value of $0 would be placed on wastewater service. In the BCA Tool, communities are encouraged to include the impacts on residential customers in situations where a cost is incurred or the impacts can be documented. For example, a city may need to provide portable toilets to residents if a sewer line to a residential neighborhood is severed.

Summary

Table 18 summarizes the values to measure the economic impact of loss of wastewater services. It is recommended to round the value up to $45 from $44.43 to account for any potential economic value from the impact on residential customers. This represents an increase from the $41 value from the 2009 Tool update.

Table 18: Economic Impact of Loss of Wastewater Service per Capita per Day

Category	Economic Impact (in 2010 dollars)
Impact on Economic Activity	$44.43
Impact on Residential Customers	$0
Total Economic Impact	**$45**

Loss of Water Services

The methodology presented estimates the value of loss of potable water service. The loss of water service measures the impact to the economic activity of the country as a whole and for residential customers.

Economic Activity

The direct economic impact of loss of water is estimated using GDP data and the importance factors published in ATC-25 (1991). The importance factors published by ATC-25 are widely used in this type of study. These studies typically use GDP data (or Gross State Product data, when studies are focused on a smaller geographic area) to estimate the economic impact on commercial and industrial customers.

Table 19 shows the estimation of the impact on economic activity per capita per day using GDP data and the ATC-25 factors.

Like the electric and wastewater service values, the 2010 GDP data contained values for the total Durable and Nondurable Goods values and not for each sub-sector, which was the methodology used in the previous update. A test of this methodology on the 2009 GDP data revealed a difference of 37

Table 19: Loss of Water Service Impact to Economic Activity

Economic Sector[1]	Water Service Importance Factor[1]	GDP 2010 (in millions of dollars)[2]	GDP per Capita per Day[3]	Economic Impact per Capita per Day of Lost Service in 2010 Dollars
Agriculture, Livestock	n/a			
Mining	n/a			
Construction	0.50	$505,557	$4.486	$2.24
Manufacturing - Nondurable Goods[4]	0.60	$756,346	$6.712	$4.03
Manufacturing - Durable Goods[5]	0.70	$961,179	$8.529	$5.97
Transportation, Warehousing	0.20	$406,520	$3.607	$0.72
Utilities	0.40	$275,659	$2.446	$0.98
Wholesale Trade	0.20	$807,668	$7.167	$1.43
Retail Trade	0.20	$862,815	$7.656	$1.53
Real Estate, Rental, Leasing	0.20	$1,858,542	$16.492	$3.30
Finance, Insurance	0.20	$1,235,184	$10.961	$2.19
Information	0.20	$670,341	$5.948	$1.19
Professional & Business Services	0.20	$1,771,943	$15.724	$3.14
Education, Healthcare, Social	0.40	$1,274,357	$11.308	$4.52
Arts, Entertainment, Recreation	0.80	$531,116	$4.713	$3.77
Accommodation & Food Service	0.80	$399,877	$3.548	$2.84
Other Services, Except Government	0.20	$343,817	$3.051	$0.61
Government	0.25	$1,963,858	$17.427	$4.36
TOTAL				**$42.83**

[1] Source: original FEMA methodology; Agriculture and Mining data excluded as not relevant for municipal systems

[2] Source: Bureau of Economic Analysis (2010).

[3] Population data from U.S. Census Bureau (2010).

[4] Weighting value of 0.60 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.70), paper products (0.60), printing and related support (0.30), chemical products (0.80), textiles/textile product mills (0.70), apparel/leather/allied products (0.50), petroleum/coal products (0.50), and plastic/rubber products (0.50).

[5] Weighting value of 0.70 averaged the nine sub-sectors with the following values: wood & furniture (0.50), nonmetallic mineral products (0.50), primary metal manufacturing (0.90), fabricated metal products (0.80), machinery (0.60), computer/electronic (0.90), equipment/appliances/etc. (0.60), transportation equipment (0.60), and miscellaneous equipment (0.60).

cents, or less than one percent difference. Therefore, it is recommended that the methodology be used for manipulating the 2010 GDP data.

Residential Customers

The methodology used to estimate the economic impact of water supply disruptions was to develop a demand curve for potable water and measure the “welfare loss” associated with a loss of supply. The method of this approach is to obtain the WTP to avoid water supply interruptions, which is defined as the amount of money that residential customers would pay to avoid a loss of water service of a given duration. The mechanism to estimate the consumer's WTP is the integration of a demand curve for water services. This method has been employed in several studies to measure the impact of lifeline interruptions (Jenkins et al. 2003, Devicienti et al. 2004). The specification of the demand curve, and hence the welfare loss, was developed in the study *Estimating business and residential water supply interruption losses from catastrophic events* by Brozovic et al. (2007).

The daily welfare loss for a consumer experiencing a loss of water service is given by:

$$W = \frac{\eta}{1+\eta} P_{baseline} Q_{baseline} \left[1 - \left(\frac{BWR}{Q_{baseline}} \right)^{\frac{1+\eta}{\eta}} \right] \tag{86}$$

Where:

W = economic impact per capita per day

$P_{baseline}$ = the average water price when there are no interruptions

$Q_{baseline}$ = the average amount of water consumed when there are no interruptions

BWR = Basic Water Requirement, which represents the minimum amount of water per capita per day required for drinking and basic sanitation

η = the price elasticity of the water demand, defined as $\eta = \left(\frac{dQ}{dP} \right) \frac{P}{Q}$, which measures the change in the quantity demanded of water in response to a change in the price of water

Based on results obtained in different empirical studies, the residential price elasticity of the demand for water is assumed to be equal to -0.41. The average price for water was obtained from a survey conducted by the American Water Works Association (2011) that gathered data from 228 water utility services nationwide. This reports states that the "average" customer pays an average of $27.53 per 1000 cubic feet. This figure converts to $3.68 per 1000 gallons, which is the unit of measurement required for the equation. The average quantity of water consumed was estimated to be 172 gallons per person per day, and was obtained from the *Residential end uses of water study* conducted by the AWWA Research Foundation in 1999.[33] In 2011, the AWWA announced it is updating the 1999 study; however, this is a three-year study, which means a new economic value is not currently available. Finally, the BWR is assumed to be equal to 6.6 gallons per person per day, as defined by Gleick (1996) and the United Nations (UNESCO 2006) as the minimum needed for drinking and basic sanitation. Most research on basic water requirement is grounded in Gleick's work, which recommends a value between 30 and 50 liters per day of basic water need – this equates to 7.9 to 13.2 gallons per day. Gleick recommended 5 liters per day for drinking water and 20 liters per day for sanitation. The combined value of 25 liters per

[33] The study collected data from 12 U.S. cities and included records from a random sample of 1,000 residential customers for each of the cities.

day equals 6.6 gallons per day, which is the value used in the equation. Inserting the values into the equation, the average individual welfare loss equals $47.53 per capita per day.

According to the U.S. Environmental Protection Agency (EPA), the average cost of bottled water in 2003 was between $0.89 and $2.25 per gallon (EPA 2003). Using the midpoint of this range ($1.60 per gallon) and updating it to 2010 dollars, the cost of bottled water is assumed to be $1.89 per gallon[34]. At 6.6 gallons per capita per day, this equates to $12.47 of bottled water required to meet basic water requirements in a post-disaster situation.

The average individual welfare loss equals $47.53 per capita per day. Adding the cost to meet basic water needs of $12.47, the economic impact for residential consumers was estimated as $60 per capita per day.

Summary

Table 20 summarizes the values to measure the economic impact of loss of water service. It is recommended that the value of water service is rounded up to $103 per person per capita. This represents an increase from the $93 value from the 2009 Tool update.

Table 20: Economic Impact of Loss of Water Service per Capita per Day (in 2010 dollars)

Category	Economic Impact
Impact on Economic Activity	$42.83
Impact on Residential Customers	$60.00
Total Economic Impact	**$103**

[34] "2010 Annual" CPI value divided by "2003 Annual" CPI value multiplied by $1.60: ((218.056/184)*$1.60)

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Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons (months)				Recovery Time (months)	
				Dry-out and Cleanup	Inspection, Permits, Approvals	Contractor Availability	Hazmat Delay	Min.	Max.
Institutional Dorm	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Nursing Home	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Retail Trade	0’- 4’		7 to 13	1	2	3		13	19
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		25	1	2	3		31	31
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Wholesale Trade	0’- 4’		7 to 13	1	2	3		13	19
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		25	1	2	3		31	31
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Personal and Repair Services	0’- 4’		3 to 6	1	2	3		9	12
	4’- 8’		6 to 9	1	2	3		12	15
	8’ +	Outside 100-year FP	12	1	2	3		18	18
	8’ +	Inside 100-year FP	18	1	2	3		24	24
Professional/Technical/ Business Services	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Banks/Financial Institutions	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons (months)				Recovery Time (months)	
				Dry-out and Cleanup	Inspection, Permits, Approvals	Contractor Availability	Hazmat Delay	Min.	Max.
Hospital (With Basement)	(-8)'- (-4)'		6	1	2	3		12	12
	(-4)'- 0'		12	1	2	3		18	18
	0'- 4'		18	1	2	3		24	24
	4'- 8'		24	1	2	3		30	30
Medical Office/Clinic	0'- 4'		6 to 10	1	2	3		12	16
	4'- 8'		10 to 15	1	2	3		16	21
	8' - 12'		19	1	2	3		25	25
	12' +	Outside 100-year FP	12	1	2	3		18	18
	12' +	Inside 100-year FP	18	1	2	3		24	24
Entertainment and Recreation	0'- 4'		7 to 13	1	2	3		13	19
	4'- 8'		10 to 15	1	2	3		16	21
	8' - 12'		25	1	2	3		31	31
	12' +	Outside 100-year FP	12	1	2	3		18	18
	12' +	Inside 100-year FP	18	1	2	3		24	24
Theaters	0'- 4'		7 to 13	1	2	3		13	19
	4'- 8'		10 to 15	1	2	3		16	21
	8' - 12'		25	1	2	3		31	31
	12' +	Outside 100-year FP	12	1	2	3		18	18
	12' +	Inside 100-year FP	18	1	2	3		24	24
Parking	> 0'			1				1	1
Heavy Industrial	> 0'		1 to 3	1	2		1	5	7
Light Industrial	> 0'		1 to 2	1	2			4	5
Food/Drugs/Chemicals	0'- 4'		6 to 10	1	2	3	1	13	17
	4'- 8'		10 to 15	1	2	3	1	17	22
	8' - 12'		19	1	2	3	1	26	26
	12' +	Outside 100-year FP	12	1	2	3	1	19	19
	12' +	Inside 100-year FP	18	1	2	3	1	25	25
Metals/Minerals Processing	0'- 4'		6 to 10	1	2	3	2	14	18
	4'- 8'		10 to 15	1	2	3	2	18	23
	8' - 12'		19	1	2	3	2	27	27
	12' +	Outside 100-year FP	12	1	2	3		18	18
	12' +	Inside 100-year FP	18	1	2	3		24	24

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons (months)				Recovery Time (months)	
				Dry-out and Cleanup	Inspection, Permits, Approvals	Contractor Availability	Hazmat Delay	Min.	Max.
High Technology	0’- 4’		7 to 13	1	2	3	2	15	21
	4’- 8’		13 to 19	1	2	3	2	21	27
	8’ - 12’		25	1	2	3	2	33	33
	12’ +	Outside 100-year FP	12	1	2	3	2	20	20
	12’ +	Inside 100-year FP	18	1	2	3	2	26	26
Construction	> 0’		1 to 2	1	2			4	5
Agriculture	> 0’		1 to 2	1	2		2	6	7
Churches/ Membership Organizations	0’- 4’		7 to 13	1	2	3		13	19
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		25	1	2	3		31	31
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
General Services	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Emergency Response	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Schools/Libraries	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24
Colleges/Universities	0’- 4’		6 to 10	1	2	3		12	16
	4’- 8’		10 to 15	1	2	3		16	21
	8’ - 12’		19	1	2	3		25	25
	12’ +	Outside 100-year FP	12	1	2	3		18	18
	12’ +	Inside 100-year FP	18	1	2	3		24	24