NIST Special Publication 1190

Community Resilience Planning Guide for Buildings and Infrastructure Systems

Volume I

National Institute of Standards and Technology
U.S. Department of Commerce

Community Resilience

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Community Resilience Planning Guide for Buildings and Infrastructure Systems

Volume I

This publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.SP.1190v1

May 2016

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
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UNITED STATES DEPARTMENT OF COMMERCE
The Secretary of Commerce
Washington, D.C. 20230

Call to Action

All communities face potential disruption from natural, technological, and human-caused hazards. These events can take a high toll in lives, livelihoods, and quality of life. In other words, they become disasters. While these events occur on a local or regional level, the connected nature of our modern society means that their effects may be felt throughout the Nation in our economy, the availability of goods and services, and sometimes in the permanent displacement of people from the places they call home.

In fact, our society is in a constant state of adaptation to many factors and is increasingly reliant on an evolving and interconnected network of buildings, energy, communications, transportation, and water and wastewater systems. Because of the consequences and high cost of recovering from disasters, the need for communities to be more resilient is not just a local issue, but is also important at the regional, state, and national levels.

But what does it mean to be resilient? Resilience is the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Resilience is not merely "bouncing back" to the prior state when an event occurs. Rather, it means having a plan in place that allows the community to "bounce forward" to a better state. Increased community resilience also provides the benefit of making communities more attractive to business investment and new residents.

This *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (the *Guide*) outlines a practical six-step planning process to help communities establish affordable priorities and allocate resources to improve their resilience. It begins by characterizing current social and economic systems and needs–like education, health care, business, as well as the need for food, shelter, and water–in the context of their importance to the community, and the extent of disruption that can be tolerated before there are detrimental effects. The *Guide* helps communities develop their performance goals for the hazards to which they are exposed. These goals determine when buildings and infrastructure systems should recover their functions to support community resilience goals. With the *Guide*, community leaders can incorporate resilience-driven, short- and long-term goals into their existing plans in order to preserve and enhance economic competitiveness.

I urge every community to use the *Guide* to support its own long-term goals and to make our Nation more resilient and competitive.

Sincerely,

Penny Pritzker
U.S. Secretary of Commerce

National Institute of Standards and Technology Special Publication 1190-1
114 pages (May 2016)
CODEN: NSPUE2

This Publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.SP.1190v1

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Revision History

Version	Release Date	Updated
SP 1190	October 2015	Initial Release
SP 1190-1	May 2016	Correction of typographic and formatting errors

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Executive Summary

Community Resilience: The Big Picture. In the United States, there are always communities working to recover from a disaster. Although communities cannot stop natural hazards and have only limited ability to prevent technological and human-caused hazards, they can minimize disastrous consequences.

The extent of recovery and the ultimate outcome depend upon the nature and severity of the event and the community's preparedness to prevent incidents, mitigate risk, protect assets, respond in a timely and coordinated way, and recover community functions. Together, these measures determine the community's resilience.

This *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (Guide) has been developed to help communities address these challenges through a practical approach that takes into account community social goals and their dependencies on the "built environment" – buildings and infrastructure systems.

The Guide recognizes that most communities have limited resources to devote to resilience-related actions and that improving resilience is a process that likely will be achieved over many years. The Guide's six-step planning process provides a way to align priorities and resources with community goals to jump-start or boost the community resilience process. The Guide can help communities build back better in ways that reflect their unique cultures, conditions, and capabilities.

> *Community resilience* is the ability of a community to
>
> - Prepare for anticipated hazards
> - Adapt to changing conditions
> - Withstand and recover rapidly from disruptions

Community Resilience Goals and this Guide. Community resilience, which spans activities ranging from preparing for hazard events, risk mitigation, and post-event recovery, should be proactive, continuous, and integrated into other community goals and plans. Traditional activities, such as disaster preparedness will help and are part of resilience planning when they include prevention, protection, mitigation, response, and recovery.

Some communities are well on their way to achieving resilience. These communities incorporate continuity planning, risk management, and long-term community resilience goals. But many others can do more to improve their resilience to hazards by incorporating more comprehensive and purposeful planning that engages a broad set of stakeholders.

The National Preparedness Goal, developed by the Federal Emergency Management Agency (FEMA) in response to a Presidential Policy Directive, envisions "a secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk" [FEMA 2015a]. The Guide supports that goal by addressing the role buildings and infrastructure systems play in assuring the health and vitality of the social and economic fabric of the community.

Resilience planning and actions do not happen overnight and should be part of a comprehensive, thoughtful process. The Guide offers a six-step planning process for local governments, the logical conveners, to bring stakeholders together and incorporate resilience into their short- and long-term planning. This process will enable communities to improve their resilience over time in a way that is cost effective and consistent with their development goals.

Having a plan in place and undertaking steps to improve resilience before a hazard strikes increases the ability of communities to recover quickly in a way that better prepares them for future events. Even if an extreme event occurs, a resilient community likely will experience reduced disruption and recovery time.

Communities that do not prepare well are more likely to be overwhelmed when hazard events strike. Communities are often not prepared to recover from hazard events, as evidenced by the number of Presidential Disaster Declarations each year [FEMA 2011a]. Poor performance may result from aging infrastructure, dependencies between physical systems, poor siting, or lack of maintenance. Truly transformative planning for resilience is often assigned a low priority unless a recent event grabs community interest. Even then, communities tend to focus on restoration to previous conditions and capacities rather than building back better.

Some communities have taken significant steps to develop, implement, and update their plans to improve resilience. Cedar Rapids, Iowa, for example, developed and exercised an evacuation plan for dealing with a potential incident at an upstream nuclear power plant. Cedar Rapids executed that plan during 2008 flooding, when the Cedar River crested well above its predicted 500-year flood level (Figure ES-1). No lives were lost, despite the tremendous economic damage.

Figure ES-1: Downtown Cedar Rapids, Iowa, during the 2008 floods [Source: FEMA 2009]

Realizing the benefit and importance of resilience planning, in the following four months the City Council and City Manager instituted a community engagement process and developed a broader Recovery and Reinvestment Plan, being implemented today, that is receiving national recognition. Figure ES-2 shows a community plan with floodways, levees, floodwalls, and dams to improve the resilience of the community to flood events. That plan aims to improve overall quality of life within the community, including resilience to flooding events. Communities with a vision for growth, stability, and resilience encourage economic development, as Cedar Rapids has, even as they recover from a disaster.

The Community Resilience Planning Guide: How can it help? While more and more organizations – domestic and international, public and private – are promoting community resilience to lower disaster tolls, transforming this important concept to practice remains a work in progress. Working with public and private stakeholders, the National Institute of Standards and Technology (NIST) developed this voluntary Guide as a component of the President's Climate Action Plan. It offers a process for communities to incorporate short- and long-term measures to enhance resilience.

This Guide helps connect good ideas and constructive actions for long-term community prosperity. In addressing the *how* of resilience, the Guide is a tool that will help communities unify disaster risk management, emergency response planning, and long-term community and economic development planning.

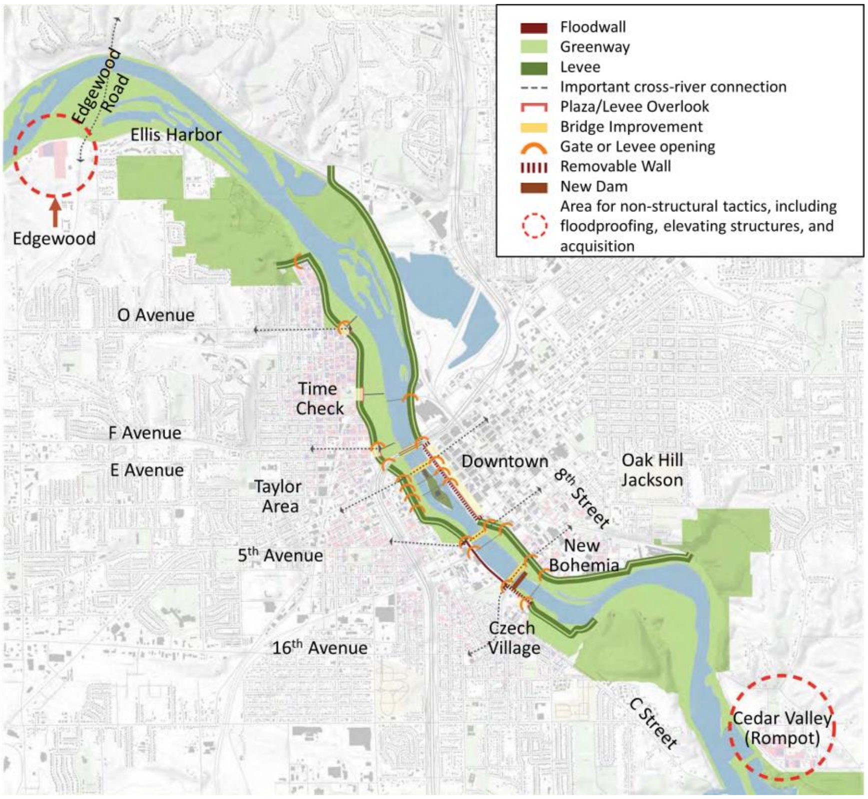

Figure ES-2: Cedar Rapids, Iowa Resilience Plan [adapted and redrawn, Cedar Rapids 2014]

The Guide describes a six-step planning process that helps communities develop customized resilience plans by bringing together all relevant stakeholders, establishing community-level performance goals, and developing and implementing plans to become more resilient. This approach focuses on the roles buildings and physical infrastructure systems play in assuring social functions resume when needed after a hazard event. (Social functions include government, business, healthcare, education, community services, religion, culture, and media communications.) If a catastrophic event does occur, resilience planning encourages and enables the community to have plans in place to recover and rebuild in a thoughtful way. Such plans include coordinating with nearby communities as well as with state, regional, and federal agencies.

The Guide can help a community take specific actions:

- Build on, broaden, bridge, and integrate its current plans (e.g., economic, emergency preparedness, land use) with community resilience plans, particularly for the built environment.
- Identify risks, priorities, and pre- and post-event costs, including the consequences of not taking certain actions.
- Prioritize resilience actions for buildings and infrastructure systems, based on the specific hazards the community is most likely to face and the importance of these buildings and infrastructure systems in supporting key social functions.

How do resilience plans fit in with other community plans? Many disaster plans are not well integrated with other community plans, including the community's comprehensive general plan or the emergency operations plan. Planning for resilience can and should build on other community plans that are already in place. A general plan addresses the long-range goals and objectives for the local government; emergency operations plans prepare the community response to emergencies. An integrated community-level resilience plan seamlessly incorporates steps for disaster preparedness and recovery actions that will help them to be resilient. Communities should ensure that resilience is a common goal for all of their planning.

Incorporating resilience planning as a common goal usually will involve adding specific performance goals for buildings and infrastructure systems, and much more. It requires detailed input and development by a broad cross section of leaders and stakeholders, both public and private. It calls for understanding the community's social, political, and economic systems, and an understanding of how they are supported by the built environment. What are their vulnerabilities? How will damage to buildings and infrastructure systems impact community recovery? For buildings and infrastructure systems, which may be either publicly or privately owned and operated, understanding their exposure to prevalent hazards, and their anticipated performance or possible improvement, is key.

Who should lead? Who should be involved? Community resilience should be championed by a planning team that provides leadership and engages public, non-profit, and private stakeholders, along with the broader community throughout the process (Figure ES-3). Much of the building stock and infrastructure systems, particularly in the energy and communication sectors, are privately owned, so stakeholder collaboration is essential to successful planning.

The local government is the logical convener for coordinating interests related to community resilience because it is responsible for implementing community building codes,

Figure ES-3: Six-step planning process for community resilience

statutes, and community plans, and can collaborate and coordinate with other entities. Many of the successful community resilience efforts to date have been led by a community official who works with a resilience team, established by the local government that collaborates with other public, non-profit, and private entities. Working groups with representative stakeholders and subject matter experts develop recommendations. A dedicated community resilience office, with a leading official who has supporting staff, can provide strong and consistent leadership. But every community has different capabilities and resources, and each should approach this process in a way that fits best within its style and means. In all cases, community leadership buy-in and community stakeholder engagement are vital.

How does this Guide link a community's social needs to its built environment? In the context of this Guide, communities are places (such as towns, cities, or counties), designated by geographical boundaries, that function under the jurisdiction of a governance structure. It is within these places that most people live, work, find security, and feel a sense of belonging so they can grow and prosper. All communities have social institutions to support the needs of individuals and households. They include family, economic, government, health, education, community service, religious, cultural, and media organizations.

Users of the Guide will assess their social institutions and built environment, focusing on their role and importance in community resilience. Understanding how a community's people, social institutions, and needs depend on the built environment is key. When considering a community's institutions and its reliance on the built environment, it is important to consider the vulnerabilities and needs of all segments of the population. Using this Guide, resilience planners will identify how people in their communities depend on buildings and infrastructure systems to support community recovery. They will establish goals to sequence the recovery of functions after a hazard event.

> *Examples of how community members depend on the built environment:*
>
> - The need for housing and healthcare is universal.
> - Children need school buildings.
> - Neighborhoods need retail districts.
> - Businesses need suitable facilities, functioning supply chains, delivery networks, and a workforce that is readily available.
> - Everyone needs a transportation network, electricity, fuel, water, wastewater systems, and communication/information access.

The built environment can suffer significant damage during a hazard event. Depending on the event's severity, many people could be ill-prepared to manage on their own, especially for an extended period of time. To support vital social needs, such as emergency response and acute/emergency healthcare, communities need to determine in advance which buildings and infrastructure systems are most essential and must be functional during and immediately after a hazard event. They also need to determine if and how the rest of the built environment can return to functionality in the subsequent days, weeks, and months of recovery.

Determining Community Resilience Goals and Objectives. Communities should establish long-term resilience goals to guide resilience planning, prioritize activities, and develop implementation strategies. For example, a community may wish to develop improved infrastructure to attract new business. Or, it may want to increase social well-being by redeveloping a floodplain to become a community park, while also providing natural protection from flooding. With long-term community resilience goals identified, communities can identify related performance goals for those buildings and physical infrastructure systems that are relied upon for important social services.

One key question that this Guide prompts and helps community leaders to answer is, "When do the buildings and infrastructure systems that support each social institution need to be restored before adversely affecting the community's longer-term ability to serve its members?" The Guide assists in determining the desired time and sequence for restoring community functions.

To determine how the community's built environment would fare, planners need to estimate the anticipated performance of the community's existing buildings and infrastructure systems for the most likely hazards. Many communities may have identified prevailing hazards when developing plans for natural hazard mitigation, emergency operations, continuity of operations, or Threat and Hazard Identification and Risk Assessment (THIRA).

This Guide encourages communities to use three hazard levels – *routine*, *design*, and *extreme* – to address a range of potential damage and consequences. Evaluation of these three hazard levels help communities to develop comprehensive resilience plans. When codes do not define design hazard levels (e.g., wildfire or tornadoes), the community may establish a hazard level or scenario based on available guidance. A community's resilience plan should be anchored around the *design* event, but routine and extreme events also should be evaluated to ensure that the community is planning comprehensively for a range of possibilities.

> *Three hazard levels used in this Guide:*
>
> - *Routine* hazard events are more frequent, less consequential events that should not cause significant damage.
> - *Design* hazard events are used to design structures; design loads are specified in building codes for many natural hazards.
> - *Extreme* events may also be defined in building codes for some hazards; they are the most likely to cause extensive damage.

The difference between the built environment's *anticipated* performance today and its *desired* performance in the future constitute the critical gaps in performance. Those gaps, then, guide development of solutions and strategies to meet long-term community goals and specific desired performance goals for the built environment. Simply identifying those gaps is an important outcome for users of this Guide.

Determining feasible, effective solutions to fill those gaps is critical. This Guide encourages considering administrative options, like incorporating resilience principles into other community plans (e.g., land use planning and mutual aid agreements). Such options frequently cost less and often can be put into place more quickly than construction options, which take longer to implement but can be equally important.

Once they identify, evaluate, and recommend potential solutions, users of this Guide will prepare a formal community resilience plan based on the information gathered by the planning team and present that plan for review and discussion by stakeholders and the community. When it is finalized and approved, the resilience plan should be put into action, reviewed periodically, and maintained.

Community Resilience in Six Steps: Figure ES-3 summarizes the six basic planning steps recommended by this Guide, with additional detail available in Table ES-1. Volume I further develops these six basic planning steps and other key activities. The Community Resilience Planning Example in Chapter 9 (Volume I) provides an example of community planning in Riverbend, USA, a fictional city that uses the Guide. That example walks through each of the six steps and illustrates how communities can effectively use the Guide. Volume II presents supporting information and resources regarding the social dimensions of resilience and dependencies between and among buildings and infrastructure systems (e.g., energy systems, transportation systems, communication systems, and water and wastewater systems).

Essential ingredients: time, commitment, and engagement. Improving community resilience takes time to plan and implement and for benefits to accrue – sometimes decades. Because priorities differ from one community to another, resilience should be addressed at varying levels of detail to suit the size, capability, and uniqueness of each community. However, resilience also is furthered when communities cooperate with neighboring and regional jurisdictions, especially when services are shared.

Above all, identifying goals and objectives and achieving community resilience requires initiative and support from community leadership; broad community engagement that includes focus and persistence; and a willingness of public and private stakeholders to assess candidly the interplay of hazard events, social institutions, governance, economics, and the community's buildings and infrastructure systems.

This Guide offers a practical way forward for community leaders. They should review this approach with potential stakeholders – and then take action. Simply beginning the process will advance a community's understanding of its situation, what is possible, and how its resilience can be improved.

Table ES-1: Planning steps and key activities for community resilience

Planning Steps	Key Activities
1. Form a Collaborative Planning Team (Chapter 2)	• Identify resilience leader for the community • Identify team members and their roles and responsibilities • Identify key public and private stakeholders for all phases of planning and implementation
2. Understand the Situation (Chapter 3)	• Social Dimensions – ▪ Identify and characterize functions and dependencies of social institutions, including business, industry, and financial systems, based on individual/social needs met by these institutions and social assets and vulnerabilities ▪ Identify how social functions are supported by the built environment ▪ Identify key contacts and representatives for evaluation, coordination, and decision making activities
	• Built Environment – ▪ Identify and characterize buildings and infrastructure systems, including condition, location, and dependencies between and among systems ▪ Identify key contacts/representatives for evaluation, coordination, and decision making activities ▪ Identify existing plans to be coordinated with the resilience plan
	• Link social functions to the supporting built environment • Define building clusters and supporting infrastructure
3. Determine Goals and Objectives (Chapter 4)	• Establish long-term community goals • Establish desired recovery performance goals for the built environment at the community level based on social needs, and dependencies and cascading effects between systems • Define community hazards and levels • Determine anticipated performance during and after a hazard event to support social functions • Summarize the results
4. Plan Development (Chapter 5)	• Evaluate gaps between the desired and anticipated performance of the built environment to improve community resilience and summarize results • Identify solutions to address gaps including both administrative and construction options • Prioritize solutions and develop an implementation strategy
5. Plan Preparation, Review, and Approval (Chapter 6)	• Document the community plan and implementation strategy • Obtain feedback and approval from stakeholders and community • Finalize and approve the plan
6. Plan Implementation and Maintenance (Chapter 7)	• Execute approved administrative and construction solutions • Evaluate and update on a periodic basis • Modify short or long-term implementation strategy to achieve performance goals as needed

1. Introduction

1.1. Overview

All communities face hazard events. Across the nation, communities experience disruptions from weather, infrastructure failures, cyber-attacks, technological accidents, environmental changes, and other hazards. Hazard events become actual disasters when communities experience extensive disruption in basic functions, when lives and livelihoods are in jeopardy, and when recovery requires a long period of time.

Depending on the magnitude and duration of the recovery, communities may face consequences ranging from temporary interruptions in services to loss of jobs, and businesses. Residents may need to relocate, and precious assets can be lost. That is why strengthening community resilience is so important.

Community resilience is the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Activities, such as disaster preparedness – which includes prevention, protection, mitigation, response, and recovery – are key steps to resilience. But many communities can do more, especially by focusing on the ingredients necessary for recovery.

The National Preparedness Goal [FEMA 2015a] developed by Federal Emergency Management Agency (FEMA) envisions "a secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk." This Guide supports that goal by addressing the role buildings and infrastructure systems play in assuring the health and vitality of the social and economic fabric of the community. It offers a six-step planning process for local governments, who are the logical conveners, to bring stakeholders together and incorporate resilience into their short- and long-term planning. This will enable communities to improve their resilience over time in a way that is cost effective and consistent with their development goals.

Having a plan in place *before* a potential disaster strikes increases the ability of communities to move quickly in a way that better prepares them for future events. Even if an extreme event occurs, a resilient community likely will experience reduced disruption and recovery time. There are other benefits of resilience planning: communities with well-developed resilience plans are more likely to be more attractive to employers and residents alike. These communities can increase their ability to achieve broader goals of economic development and social advancement that improve the quality of life. And, they are more likely to use hazard events as an opportunity to build back better.

Resilient communities demonstrate common characteristics: community leaders' commitment to resilience, continual improvements in preparedness and response to threats and disruptions, a collaborative approach, and appreciation of internal and external dependencies. Many of these communities employ risk management, business continuity methods, and other management practices that enable them to be adaptable and flexible when confronting changing conditions.

This *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (Guide) helps communities determine customized resilience goals based on the long-term community goals and the corresponding performance goals for buildings and infrastructure systems. Resilience plans that follow this Guide are based on a community-level assessment of social needs and functions supported by the built environment. These social functions are fundamental. They include government, economics, health, education, community services, religion, culture, and media. The built environment includes buildings and infrastructure systems, such as energy, communication, water and wastewater, and transportation systems. Buildings and infrastructure systems are vital to social functions and to a community's overall prosperity and health. If these systems fail or are damaged, essential services can be interrupted over a wide geographic area. This Guide helps communities plan how to rapidly prioritize and restore civil and social functions.

While all disaster preparedness steps (prevention, protection, mitigation, response, and recovery) must be addressed to achieve community resilience, this Guide primarily focuses on *planning for recovery* of community functions, for which there is less published guidance. The Guide does not repeat the guidance already available on prevention, protection, mitigation, and response activities, all of which are part of resilience planning and activities. Instead, the Guide provides a step-by-step planning process that helps communities understand issues relating to community-level damage and, especially, to prioritize recovery planning. In essence, the recovery process completes resilience planning, and informs other preparedness steps. For instance, when comparing alternative mitigation strategies, evaluating recovery plans associated with each mitigation strategy provides a more informed basis for selecting an approach.

Communities can and should integrate resilience into their long-term community planning process. A resilient community can also offer day-to-day community benefits by reducing daily disruptions through improved planning, design, and construction practices. Even if it is many years before a hazard event occurs, implementing the community's resilience plan can continue to improve the performance of its buildings and infrastructure systems and improve its attractiveness as a place to work and live.

The Guide helps communities prioritize improvements to buildings and infrastructure systems based on the role of these structures in supporting social institutions' functions during recovery. The Guide addresses infrastructure dependencies and the cascading effects of system failures. It is organized around six planning steps (Figure 1-1) outlined in the Comprehensive Preparedness Guide [FEMA 2010] and associated key activities:

1. Form a collaborative planning team
2. Understand the situation
3. Determine goals and objectives

Figure 1-1: Six-step planning process for community resilience

4. Plan development
5. Plan preparation, review, and approval
6. Plan implementation and maintenance

Community planning for resilience of the built environment needs input from all stakeholders, including local government offices for community development, emergency response, social services, public works, and buildings. Other government agencies with facilities or infrastructure, as well as public and private developers, owners and operators of buildings and infrastructure systems, should be involved, as should representatives of local business and industry along with social organizations. Where communities are already working on aspects of planning to achieve resilience (e.g., land use planning, long-term economic development, mitigation, building inspections, or emergency management), these efforts should be understood and coordinated with the overall planning effort.

When all interests and needs are addressed in a comprehensive plan at the community level, a transparent, supportable path forward can emerge with consensus support. Resources can then be allocated based on community-wide goals and priorities.

1.2. Defining Communities

The National Preparedness Goal asserts that "Individual and community preparedness is fundamental to our success." There are varying definitions of community. In this Guide, *community* refers to a place designated by geographical boundaries that functions under the jurisdiction of a governance structure, such as a town, city, or county. It is within these places that most people live, work, play, and build their futures. Each community has its own identity based on location, history, leadership, population, and available resources. Successful communities provide its members with the means to meet essential needs and to pursue their interests and aspirations.

Communities are highly diverse in terms of geography and populations. They range from small, rural communities to large, dense, urban communities. Communities have different histories, cultures, social make-up, businesses, and access to and availability of resources. They also are subject to varying hazards, and have different degrees of risk tolerance. An effective community resilience plan will be customized and take into account each of these factors.

Communities can identify and describe their resources and assets as *capital*. This approach is based on The Community Capitals Framework (Figure 1-2): financial (economic), built (physical), political, social, human, cultural, and natural. These forms of capital are interrelated and give each community its unique character.

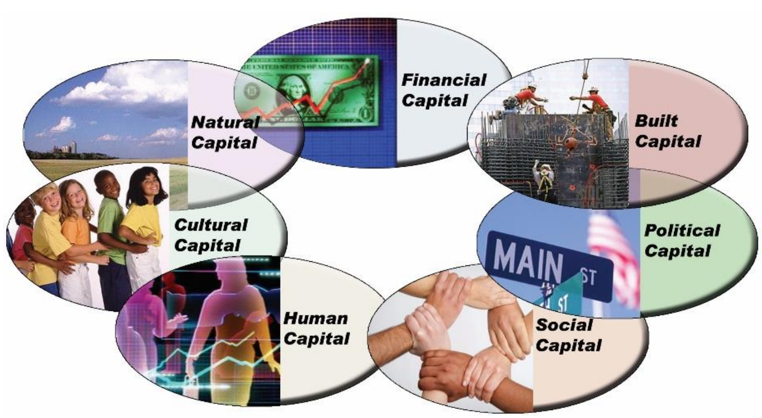

Figure 1-2: The Community Capitals Framework [adapted and redrawn, Flora et al, 2008]

Community capitals can be classified into the following categories [Ritchie and Gill 2011]:

- ***Financial.*** Financial savings, income, investments, and available credit at the community-level
- ***Built.*** Buildings and infrastructure systems within a community
- ***Political.*** Access to resources and the ability/power to influence their distribution; also, the ability to engage external entities in efforts to achieve goals
- ***Social.*** Social networks, associations, and the trust they generate among groups and individuals within the community
- ***Human.*** Knowledge, skills, health, and physical ability of community members
- ***Cultural.*** Language, symbols, mannerisms, attitudes, competencies, and orientations of local community members/groups
- ***Natural.*** Resources, such as air, land, water, minerals, oil, and the overall stability of ecosystems

Knowledge about each type of capital contributes to understanding the community's capacity for resilience planning and investments. All capacities can provide important inputs and resources from which to draw.

While all types of capital are important to each community, this Guide focuses primarily on built capital (i.e., buildings and infrastructure systems), with a strong emphasis on how built capital supports other capitals within a community, especially social capital. Social capital has the potential to contribute to resilience by enhancing sense of belonging and strengthening bonds between individuals and groups within communities. The needs of community members and social institutions – including government, industry, business, education, and health – help define functional requirements for a community's buildings and infrastructure systems (Figure 1-3). For instance, after a significant event, can residents remain in their homes? Can governments communicate with residents to inform them and support recovery efforts? Can businesses and factories resume operations within a reasonable period? These types of social needs determine the performance expected from a community's buildings and infrastructure systems.

Figure 1-3: The social functions of a community define the functional requirements of a community's buildings and infrastructure systems.

For communities to function and prosper, they need buildings and infrastructure systems that are operational. When buildings and infrastructure systems are damaged, social services frequently are interrupted, economic losses soar, and resources must be re-allocated to repair and rebuild. When damage is extensive, the recovery process can be a significant drain on local residents and their resources, and may be drawn out over years. Sometimes, full recovery is not possible.

1.3. Community Resilience

The term *resilience* is used in many ways by community stakeholders. Presidential Policy Directive (PPD)-8 [2011] defines resilience as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies." PPD-21 [2013] expanded the definition to "the ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents." *Disaster* refers to "a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources" [National Science and Technology Council 2005]. Under these definitions, resilience includes activities already conducted by some communities as a part of disaster preparedness.

In the context of this Guide, the phrase "prepare for and adapt to changing conditions" refers to preparing for conditions that may occur within the lifetime of a facility or infrastructure system. That could be a hazard event or physical conditions that change over time. Depending on location, preparation may include planning for sea level rise in coastal areas or for the effects of drought, or include improving design and performance requirements for a hazard event, such as a hurricane or earthquake. Changing conditions also may include alterations in the use of infrastructure systems. For example, increased use of communication devices – like wireless systems that need an array of cell towers – may lead to new dependencies between infrastructure systems. Aging also affects infrastructure. If buildings and infrastructure systems are designed, maintained and operated properly, the likelihood of disruption to community functions from deterioration will be reduced.

The second part of the definition of resilience, "withstand and recover quickly from disruptions," requires that a range of possible hazard events be considered. In a more resilient community, a hazard event that occurs at the intensity that the affected structures were designed to meet under relevant codes and standards may cause local disruptions tolerated by the community without long-term detrimental effects (e.g., permanent relocation of residents or business). If an unanticipated or extreme event occurs, planning and preparation for planned events likely will reduce the extent of disruption and time for recovery. Moreover, communities that have a well-developed resilience plan in place are better prepared for the recovery process.

1.4. Community Resilience and the Built Environment

Resilience and functionality. Figure 1-4 depicts the concept of resilience for a building or infrastructure system, collectively referred to as *the built environment* in terms of *functionality* versus the performance goal of *time to recovery of function*. Functionality is a measure of how well a building or infrastructure system operates and delivers its service or meets its intended purpose. Time to recovery of function is a measure of how long it takes before a building or infrastructure system is functioning. Recovery time can also indirectly measure the pre-event condition of the system, because longer recovery times indicate a less resilient system. To more thoroughly characterize resilience of the built environment, the Guide uses the recovery phases defined by the FEMA National Disaster Recovery Framework [FEMA 2011b]: short-term, intermediate, and long-term.

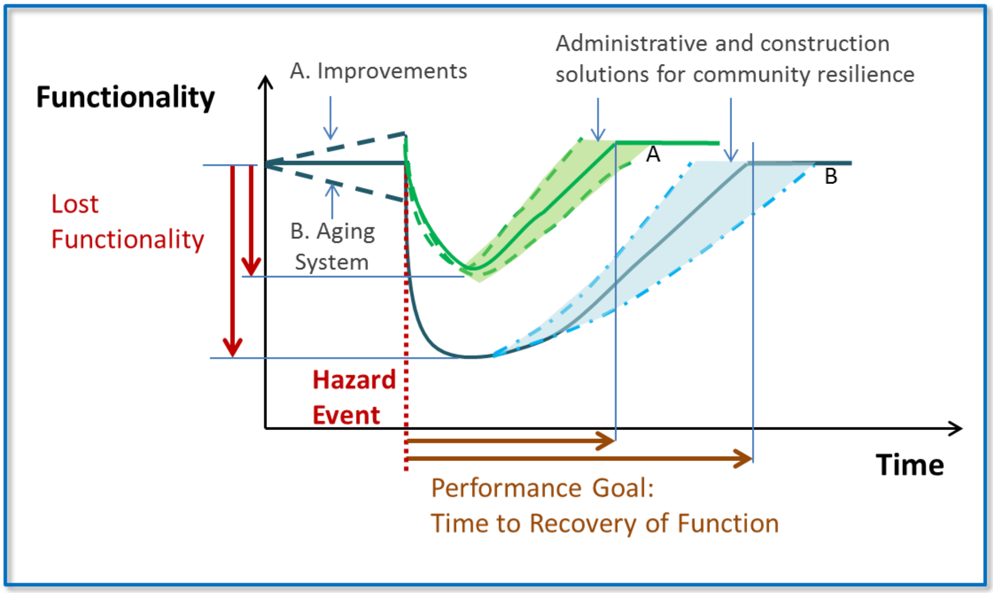

Figure 1-4: Resilience can be expressed simply, in terms of system functionality and the time to recover functionality following a disruptive hazard event [McAllister 2013].

Two contrasting building conditions are considered, as described in Table 1-1. Figure 1-4 illustrates how each of these conditions can impact the performance of a building, and recovery of its functionality. At the time of the hazard event, the system condition affects the degree of damage and lost functionality. Recovery of function can be highly variable, as it depends on the damage incurred, dependencies on other systems, availability of resources, and the owner's ability to rapidly execute recovery plans that are 'ready to go.'

Table 1-1: System condition at the time of the hazard event affects the degree of damage and lost functionality.

Condition A **Experiences modest loss of functionality after the event**	**Condition B** **Increased vulnerability to the hazard relative to Condition 'A'**
• Well maintained • Benefitted from good design and mitigation projects • Improved level of functionality before hazard event • Modest loss of functionality after event	• Degradation of functionality • Deterioration in the physical system • Lack of adequate maintenance

Planning for resilience and putting those plans into action can minimize or even eliminate loss of functionality, depending on the degree of damage, available solutions, resources, and priorities. When hazard events occur, loss of functionality can occur suddenly – in minutes or over days – due to physical damage to one or more systems. Recovering functionality may take anywhere from a few hours to years. In most instances, systems that experience less loss of functionality after a hazard event recover more rapidly.

Why are community resilience and planning important? Hazard events can disrupt community functions so extensively that they become disasters and result in permanent changes. Hurricane Katrina (2005) and Hurricane Sandy (2012) are recent examples of hazard events that were followed by economic decline in localities that experienced significant damage and slow rates of recovery. The slow recovery in some areas affected by Hurricane Katrina also led to population relocation between communities. Even lesser events inflict significant damage on communities across our country each year. Between 2000 and 2014, there were between 84 and 242 Presidential disaster declarations each year from the combined effects of floods, hurricanes, tornadoes, earthquakes, fires, and other events. Severe storms accounted for the majority of those declarations [FEMA 2011a].

Communities reduce vulnerabilities by adopting and enforcing appropriate codes, standards, and regulations; by good land use planning; and by disaster preparedness activities. These activities are necessary and prudent, but are not enough, by themselves, to make a community resilient. Across the nation, communities continue to experience significant damage and losses, despite robust adoption and enforcement of best practices, regulations, and codes and standards. There are a number of reasons for this apparent contradiction.

Many existing buildings and infrastructure systems were built before the modern standards, codes, and practices that are now in place existed. Adoption of modern standards and codes is a necessary but insufficient step, especially because the positive effects can be slow to accumulate. Buildings and infrastructure systems are replaced over decades. Also, standards and codes for buildings and each infrastructure system frequently are developed independently and do not address dependencies between systems or community-level performance goals, including recovery of function. Some states have codes that preclude modifications by local jurisdictions. Communities may need to coordinate with state officials to facilitate local adoption of code criteria that are more stringent than those of the statewide code.

Community resilience requires that the built environment maintain acceptable levels of functionality during and after events. Communities need to ensure their built environment operates within a specified time period to support recovery of functions. Recovery times should be based on the role and importance of each facility or infrastructure system within the community, and the extent of disruption that can be tolerated. Not all facilities need to be restored within the same timeframe.

This Guide recognizes that buildings and infrastructure systems are built to different codes with varying degrees of enforcement over time, and that this mixture of construction will remain in place in most communities for a long time. Nevertheless, those structures eventually will degrade and deficiencies will become apparent, including after a hazard strikes. That process provides an opportunity to develop and implement a new paradigm – community resilience – when planning for and envisioning the future of each community.

Developing a resilience plan offers communities a rational basis for considering alternative measures to meet community goals through improvements in the performance of the built environment. Not every aspect of resilience planning needs to happen at once. Multiple solutions or stages may be proposed, including temporary solutions to meet immediate needs, as well as long-term steps to upgrade or replace buildings or infrastructure systems.

1.5. Developing a Plan for Community Resilience

Disruptive events are best addressed by a community resilience plan that includes performance goals for the built environment based on the social functions of the community, and preparedness strategies that incorporate activities related to prevention, protection, mitigation, response, and recovery. Plans to improve community resilience through the built environment may include land use policy, temporary measures (e.g., interim requirements for repair or retrofit), and other structural and non-structural approaches. Other aspects of a resilient community, such as business continuity and issues related to human health, safety, and general welfare, also may inform performance goals for the built environment.

To ensure understanding and support by the community and all stakeholders, an active community engagement process needs to be developed and continuously implemented throughout the planning process.

Planning steps and key activities for community resilience. Figure 1-1 (page 10) and Table 1-2 summarize this Guide's six planning steps and associated key activities for achieving community resilience.

1. ***Form a collaborative planning team.*** Strong but inclusive leadership is needed to promote and coordinate resilience. Management commitment and clear designation of roles, responsibilities and authorities are essential. The planning team likely will include representatives from local government (e.g., community development, emergency management, public works, and building departments) and county, state, or federal government agencies responsible for facilities or infrastructure systems in the region. Other entities to be included are public and private owners and operators of buildings and infrastructure systems, as well as local businesses and industry.

   Organizations representing significant community groups and populations, including those that are especially vulnerable, are also important participants. Some of these stakeholders will already be working on aspects of planning for resilience, such as land use planning, long-term economic development, business continuity, hazard mitigation, building inspections, or emergency management.

2. ***Understand the situation.*** Understanding the situation involves characterizing both the social dimensions and built environment of a community.

   Social dimensions. Identifying important social functions and services, as well as key contacts or representatives who can provide information about systems and decision making, is essential. Social dimensions encompass the needs of individuals and social institutions, including those representing government, business and industry, finance, health, education, community service, and those representing particular religious and cultural beliefs, and the media. Shelter, food, and water during and after a hazard event are examples of the most fundamental social needs of individuals and families.

   Built environment. Identifying buildings and infrastructure systems that support the community's social functions, and identifying key contacts or representatives who can provide information about physical systems is also essential. Buildings and infrastructure systems can be grouped into clusters that support common functions vital to social systems.

   Link functions. Additionally, the dependencies between social services and the supporting built environment are identified. Linking buildings and infrastructure systems to desired social services is an important step in a plan to achieve community resilience.

3. ***Determine goals and objectives.*** When planning, leaders should consider the needs of the community and stakeholders, and identify risks and opportunities associated with desired outcomes, determine how to prevent or reduce undesired effects, and take steps to achieve continual improvement. Identifying and agreeing on long-term *community* goals are essential in guiding community resilience plans and carrying out strategies to achieve greater resilience. For example, in response to persistent flooding, a community may want to redevelop a floodplain to become a community park. At the same time, it should consider the impact of needing to relocate residences and businesses. Also, establishing clear community goals is necessary to prioritize resilience activities. The community's goals and objectives set by the team should be measurable, take into account any requirements that apply, and be monitored and updated as appropriate.

Table 1-2: Planning steps for community resilience

Planning Steps	Key Activities
1. Form a Collaborative Planning Team (Chapter 2)	• Identify resilience leader for the community • Identify team members, and their roles and responsibilities • Identify key public and private stakeholders for all phases of planning and implementation
2. Understand the Situation (Chapter 3)	• Social Dimensions – ▪ Identify and characterize functions and dependencies of social institutions, including business, industry, and financial systems, based on individual/social needs met by these institutions and social assets and vulnerabilities ▪ Identify how social functions are supported by the built environment ▪ Identify key contacts and representatives for evaluation, coordination, and decision making activities
	• Built Environment – ▪ Identify and characterize buildings and infrastructure systems, including condition, location, and dependencies between and among systems ▪ Identify key contacts/representatives for evaluation, coordination, and decision making activities ▪ Identify existing plans to be coordinated with the resilience plan
	• Link social functions to the supporting built environment • Define building clusters and supporting infrastructure
3. Determine Goals and Objectives (Chapter 4)	• Establish long-term community goals • Establish desired recovery performance goals for the built environment at the community level based on social needs, and dependencies and cascading effects between systems • Define community hazards and levels • Determine anticipated performance during and after a hazard event to support social functions • Summarize the results
4. Plan Development (Chapter 5)	• Evaluate gaps between the desired and anticipated performance of the built environment to improve community resilience and summarize results • Identify solutions to address gaps including both administrative and construction options • Prioritize solutions and develop an implementation strategy
5. Plan Preparation, Review, and Approval (Chapter 6)	• Document the community plan and implementation strategy • Obtain feedback and approval from stakeholders and community • Finalize and approve the plan
6. Plan Implementation and Maintenance (Chapter 7)	• Execute approved administrative and construction solutions • Evaluate and update on a periodic basis • Modify short or long-term implementation strategy to achieve performance goals as needed

Performance goals for the *built environment* are based on the role buildings and infrastructure systems play in the community. For a community to be resilient following a disruptive event, those structures need to function as required to support community recovery. In this Guide, the performance goals for the built environment are expressed in terms of the time needed to recover the function and role in the community.

Two recovery times need to be established for the built environment: the desired long-term performance goal and the anticipated performance for existing systems. First, goals for the desired performance (recovery of function) should consider the social needs of the community and the functions that each group, or cluster, of buildings and infrastructure systems must provide to meet those needs. They also should reflect dependencies between and among systems or the cascading effects caused by failures. Desired performance goals for resilience are set independently of hazards; they are driven by social needs, not by a particular hazard event. Then, the anticipated performance of building clusters and infrastructure systems are evaluated for specified hazard events to determine the expected time to recover function. Prevailing hazards and the effects of changing conditions, such as sea level rise or drought, are used to determine anticipated performance.

This Guide recommends using three hazard levels: *routine*, *design*, and *extreme*. These address a range of potential damage and consequences, and are helpful in formulating response and recovery scenarios. *Routine* hazard events can lead to the more frequent, less consequential events but they may still be damaging for a community. Where defined by building codes, the *design* hazard event (e.g., earthquake, high winds) is the level used to design structures. *Extreme* events may also be defined in codes for some hazards, such as earthquakes; they are the most likely to cause far-reaching damage. Where codes do not define hazard levels, the community may establish a hazard level or scenario based on available guidance or the predicted frequency of hazards.

A community's resilience plan should be anchored around the *design* event, but a community should also evaluate routine and extreme events to ensure that they are planning comprehensively for a range of possibilities. This approach helps communities understand performance, consequences, and recovery needs across a range of hazard levels. By understanding how the built environment will perform and recover over this range, communities will be better informed about priorities and potential implementation strategies.

4. ***Develop the Plan.*** The team should compare the desired and anticipated performance of the built environment to identify gaps in performance. Then, it should prioritize gaps in achieving the desired performance based on community goals. Next, the team would develop possible solutions. These should include administrative and construction options to mitigate damage and to improve recovery of functions across the community.

   Land use planning is an example of an administrative tool. Options may include either or both of the following: (a) implement land use planning and redevelopment strategies before a hazard event occurs to reduce potential damage and disruption, and (b) develop plans for alternate land use and redevelopment strategies as part of the recovery process. These options often are part of community development processes, particularly in seismic and flood-prone hazard areas.

   There may be multiple solutions or phases needed to achieve desired performance, including temporary or short-term solutions to meet immediate needs an addition to long-term, permanent solutions. These solutions can be prioritized, based on resources necessary to meet the desired performance goals established in the previous step.

5. ***Prepare, Review, and Approve the Plan.*** Once the team develops a resilience plan, it needs to document the elements of the process: community goals, desired performance goals for social functions and the built environment, prevailing hazards, anticipated performance for the existing building clusters and infrastructure systems, prioritized gaps, and short- and long-term implementation strategies and solutions. The plan should be broadly disseminated among stakeholders and their organizations, as well as with community members. Seeking their review and comment is critical to gain support, as is providing feedback to them to maintain their support. The review process will differ from community to community. After review, the plan should be finalized and adopted by the community.
6. ***Implement and Maintain the Plan.*** The community then executes the administrative and construction solutions in the approved plan. It is important that the community evaluate the plan periodically, and update or adjust it as needed. Updates may include modifying the goals or short- or long-term implementation strategies. This work can be led by the designated lead official or by successors charged with implementing and maintaining the plan.

1.6. Other Federal Guidance Supporting Community Resilience

The Guide complements other federal guidance that supports resilience ranging from local to national levels. Many federal programs and initiatives support resilience, not all of which can be addressed here. Key guidance programs managed by the Department of Homeland Security (DHS) – the National Preparedness Goal [FEMA 2015a] and the National Infrastructure Protection Plan (NIPP) – are outlined briefly to provide the context for the Guide and its role in supporting resilience across the nation. Two assessment documents by FEMA that address community assessments are also presented.

1.6.1. National Preparedness Goal

The National Preparedness Goal developed by FEMA identifies core capabilities that the "whole community" needs to strengthen to ensure the security and resiliency of the United States. The "whole community" includes individuals, communities, the private and nonprofit sectors, faith-based organizations, and federal, state, and local governments. The Goal stresses the importance of preparedness efforts, uses a risk-based approach to preparedness, and integrates the activities across five preparedness mission areas through the National Planning Frameworks [FEMA 2015b]: Prevention, Protection, Mitigation, Response, and Recovery. The National Preparedness Goal defines success in the following way:

> *"A secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk."*

These risks may include a number of hazards: natural hazards, such as hurricanes or floods, disease outbreak and other pandemics, technological or accidental hazards, such as a chemical spill or dam failure, and terrorist attacks. The National Preparedness Goal identifies core capabilities necessary to achieve a secure and resilient nation under each of the five mission areas, as shown in Table 1-3. The top row lists the five mission areas. Planning, public information and warning, and operational coordination are addressed across all five mission areas. The Guide directly supports many of the core capabilities of the Goal. Use of the Guide by local jurisdictions supports all mission areas and indirectly informs a variety of core capabilities.

Table 1-3: Core capabilities. The core capabilities indicated in bold/italic type below directly relate to the Guide content and guidance.

Prevention	Protection	Mitigation	Response	Recovery
Planning				
Public Information and Warning				
Operational Coordination				
• **Forensics and attribution** • **Intelligence and information sharing** • **Interdiction and disruption** • **Screening, search, and detection**	• Access control and identity verification • Cybersecurity • Intelligence and information sharing • Interdiction and disruption • Physical protective measures • Risk management for protection programs and activities • Screening, search, and detection • Supply chain integrity and security	• Community resilience • Long-term vulnerability reduction • Risk and disaster resilience assessment • Threats and hazard identification	• Critical transportation • Environmental response/health and safety • Fatality management services • Fire management and suppression • Infrastructure systems • Mass care services • Mass search and rescue operations • On-scene security, protection, and law enforcement • Operational communications • Logistics and supply chain management • Public health, healthcare, and emergency medical services • Situational assessment	• Economic recovery • Health and social services • Housing • Infrastructure systems • Natural and cultural resources

1.6.2. National Preparedness System

The National Preparedness System is the instrument employed to build, sustain, and deliver core capabilities and achieve the goal of a secure and resilient Nation. The guidance, programs, processes, and systems that support each component of the National Preparedness System enable a collaborative, whole community approach to national preparedness that engages individuals, families, communities, private and nonprofit sectors, faith-based organizations, and all levels of government. The Guide is a tool that supports the National Preparedness System by building and sustaining capabilities through multi-year resilience planning.

1.6.3. National Infrastructure Protection Plan

The National Infrastructure Protection Plan (NIPP) outlines how government and private sector owners and operators in the critical infrastructure community collaborate to manage risk and to advance security and resilience outcomes. The NIPP encourages partners to identify critical functions and resources that impact their businesses and communities to support preparedness planning and capability development. The NIPP addresses 16 critical infrastructure sectors, as identified in PPD-21 and presented in Table 1-4. The 16 critical infrastructure sectors address both facilities and assets with specific services and resources that are important to national security.

Table 1-4: NIPP Critical Infrastructure Sectors

• Chemical	• Food and agriculture
• Commercial facilities	• Government facilities
• Communications	• Healthcare and public health
• Critical manufacturing	• Information technology
• Dams	• Nuclear reactors, materials, and waste
• Defense industrial base	• Transportation systems
• Emergency services	• Water and wastewater systems
• Energy	
• Financial services	

The Guide highlights several key sectors in the built environment, and it is applicable across the critical sectors at the community scale. Volume II of the Guide outlines several specific infrastructure systems (e.g., energy, communications, water and wastewater, transportation), identifies applicable standards and codes, and lists implementation strategies for community resilience plans. Chapter 12 (Buildings), includes generic guidance applicable to many other building-dependent infrastructure sectors.

1.6.4. Disaster Mitigation Assessment

Nearly 24,000 communities, representing 80 % of the people in the United States, have developed mitigation plans in accordance with FEMA Disaster Mitigation Assessment guidance, based on the Disaster Mitigation Act of 2000 [DMA 2000]. Because mitigation is a component of resilience, these communities are also taking substantive steps toward planning for resilience. A planning process that includes a detailed consideration of the built environment as outlined in the Guide and incorporates ongoing mitigation planning demonstrates a comprehensive understanding of community resilience.

Expanding the scope of existing community mitigation planning efforts, to resilience is the next logical step. Those who are already involved in mitigation activities have roles and responsibilities similar to those needed for resilience. For example, the mitigation planning process emphasizes public participation in vetting mitigation strategies with targets, actions, and priorities.

1.6.5. Threat and Hazard Identification and Risk Assessment

The Threat and Hazard Identification and Risk Assessment (THIRA), outlined in Comprehensive Preparedness Guide 201, Second Edition [FEMA 2013], is a process that helps communities to understand the risks and capability requirements to address anticipated and unanticipated hazards. The THIRA process helps communities map their risks to the core capabilities identified in the National Preparedness Goal. This informs a variety of emergency management efforts, including emergency operations planning and mutual aid agreements. Results of the THIRA process can help with many preparedness activities, including mitigation opportunities that may reduce resources required in the future. Through THIRA, communities can identify opportunities to employ mitigation plans, projects, and insurance to reduce the loss of life and damage to property. The THIRA process can assist in carrying out Step 2 of the Guide, which focuses on understanding the situation.

1.7. Other Community Resilience Guidance

A number of resilience initiatives have focused on improving community resilience by developing guidance or assessment methodologies. In the United States, guidance documents that are often cited for use by communities include the SPUR Framework [2009], Baseline Resilience Indicators for Communities (BRIC) [Cutter et al 2014], the Community and Regional Resilience Institute's (CARRI) Community Resilience System [2013], the Oregon Resilience Plan [Oregon Seismic Safety Policy Advisory Commission 2013], NOAA's Coastal Resilience Index [Sempier et al. 2010], and the Communities Advancing Resilience Toolkit (CART) [Pfefferbaum et al 2013]. International initiatives include the United Nations International Strategy for Disaster Reduction Resilience Scorecard [UNIDSR 2014] and The Rockefeller Foundation's 100 Resilient Cities [Arup 2014]. There are additional programs and initiatives that support community resilience that are not addressed here.

Both qualitative and quantitative approaches to resilience are available, many with scorecards or dashboards that reflect measurements of key resilience aspects. These visual representations provide a direct and simple way of presenting information for experts in the field or for decision makers. In general, most of these methodologies focus on social issues; in some cases, the focus is on one particular social service or system.

Each of the initiatives cited above provides a set of dimensions or categories of community disaster resilience and, in many cases, includes a list of indicators or variables for each dimension. In cases where the methodologies involve engaging community stakeholders, process-oriented guidelines for implementation are included. For methodologies that are heavily quantitative—typically involving readily available data —details are provided about strategies for data analysis and modeling.

Most of these resilience initiatives only minimally integrate infrastructure systems and how they support social needs. They do not address dependencies between and among the social and built environments. This Guide is designed to address this critical issue. So even if a community is already engaged in resilience planning, this Guide can enhance those efforts.

The American Planning Association document, *Planning for Post-Disaster Recovery: Next Generation* [APA 2014], discusses a recovery planning process and related issues. The APA reports that most disaster plans are standalone plans and are not integrated into other existing plans such as the community's Comprehensive (General) Plan. Standalone plans are easier to develop, update, and implement. But an integrated plan brings resources together and links community resilience to other plans, which is essential for understanding performance and issues at a community level. This Guide supports development of a comprehensive understanding of what is needed from the built environment for community resilience.

Like all plans, a community resilience plan provides a starting point and a path forward. The community resilience plan should become a working document that is referenced and revised as needed. Many communities are starting to develop more comprehensive resilience plans as guidance and supporting tools become available. Figure 1-5 describes The Rockefeller Foundation's 100 Resilient Cities initiative that is supporting resilience planning in cities around the world.

100 Resilient Cities. Pioneered by The Rockefeller Foundation, 100 Resilient Cities is dedicated to helping cities around the world become more resilient to physical, social and economic challenges caused by "shocks and stresses" that range from earthquakes, fires, and floods to high unemployment, violence, and chronic food and water shortage. By addressing both shocks and stresses, a city becomes more able to respond to adverse events and is better able to function by using the following four techniques.

1. Establish a fully funded Chief Resilience Officer in city government to lead the city's resilience efforts
2. Solicit expert support for development of a robust resilience strategy.
3. Develop and implement resilience strategies with the help from public and private service providers, partners, and non-governmental organization (NGO) sectors.
4. Network with other member cities and learn from each other.

For more information, see www.100resilientcities.org.

Figure 1-5: Community resilience planning initiatives.

1.8. Guide Scope and Limitations

This Guide helps communities to set customized, long-term goals and develop implementation strategies for improving the resilience of their buildings and infrastructure systems. The plans are informed by a community-level assessment of social needs, and the focus of this document is on buildings and infrastructure systems within a community.

Risk assessment methodologies are not explicitly addressed in the document, but the six-step process for achieving community resilience is compatible with those approaches. Risk assessments can help to identify significant hazards and to understand associated vulnerabilities and consequences, which will support the development of a community resilience plan. There are several other important aspects of community resilience that fall outside the scope of this Guide:

- Roles and responsibilities of federal, state, and local departments/agencies addressed through the National Preparedness Goal
- Social, political, and economic solutions or strategies to achieve a more resilient community
  - Methods for engaging and informing stakeholders and community members
  - Political processes that support development and adoption of community plans and laws, statutes, and ordinances

  - Methods for obtaining financial resources and evaluating investment options to support community resilience strategies
- Specifics on community services that are essential for community response and recovery: for example, banking and finance. Community services are discussed only to the extent they are supported by the built environment
- Specifics on vulnerable populations and the ways in which they might be affected by a disaster event
- Natural resources and the environment (natural capital), and the linkages to the built environment (built and physical capital), as well as other capitals (e.g., financial or economic, human, social, political, and cultural)
- Cyber security and its role in the function of buildings and infrastructure systems.
- Financial aspects of community resilience, including financing, insurance, policies, allocation, or management of such resources.

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2. Step 1: Form a Collaborative Planning Team

A robust community resilience plan represents the interest of all stakeholders in the community and benefits from collaboration among community leaders, public and private stakeholders, and other interested community members. Active engagement by community stakeholders is vital in formulating and carrying out a successful resilience plan.

The planning team may include a breadth of representatives:

- Local government, such as community development, public works, and building departments
- Public and private developers
- Owners and operators of buildings and infrastructure systems
- Local business and industry representatives
- Representatives of the community's social institutions (e.g., community organizations, non-governmental organizations, business/industry groups, health, education)
- Other stakeholders or interested community groups

Much of the building stock and infrastructure systems, especially energy and communication systems, are privately owned, so collaboration among stakeholders is a necessity for success. As shown in Figure 2-1, while the planning team is focused at the community level, stakeholders in the planning process may range from individuals and families to national stakeholders, depending on the community's resources and characteristics. For instance, roads and bridges typically are addressed at the county and state level, energy systems may range from the community to the regional level, and mitigation support may be provided at the state or national level.

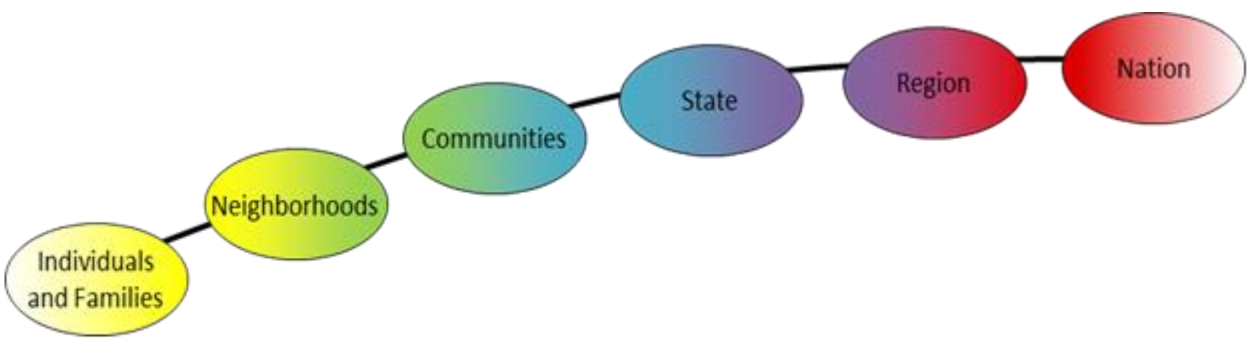


Figure 2-1: Levels of government and organization (adapted from John Plodinec [CARRI 2013]).

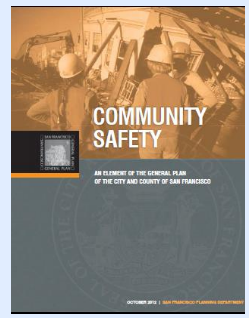
Successful planning efforts to date have been led by a community official working with a planning team that develops recommendations through working groups of stakeholders and subject matter experts.

As community resilience is an ongoing, long-term process, leadership by a dedicated community official is needed to provide continuity, elevate the importance of resilience, provide authority for convening stakeholders, and engage public support. The recent designation of a Chief Resilience Officer in many cities illustrates the type of leadership needed. Strong support and endorsement from elected officials ensures that the planning process will have visibility, and is more likely to lead to community engagement through stakeholder participation.

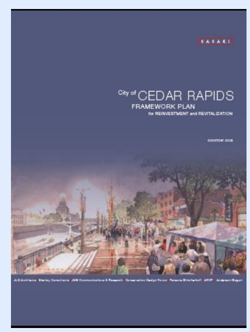
Important contributors include local champions who are highly connected and engaged with neighborhood, business, or community groups, or who are actively engaged in other community-based activities. They can advocate for support from and participation by other community stakeholders, and can help reach out to and develop an understanding with groups representing diverse views and experiences within the community and with the public at large. They can be influential in rallying the community around planning for resilience.

Community engagement is essential to the success of community resilience planning and implementation. The activities highlighted in Figure 2-2 illustrate active community engagement in their resilience planning.

Resilient San Francisco (SF). Resilient SF was organized within the Mayor's office and solicited support from the Harvard Kennedy School. It is a citizen's advisory group formed by the Chief Building Inspector, and it accepted guidance from a self-appointed planning group from the San Francisco Planning and Urban Research Association [SPUR 2009]. SPUR contributed a Resilient City Plan to the advisory group that developed a Community Action Plan for Seismic Safety that lead to the creation of the Earthquake Safety Improvement Program and a 30-year program for achieving resilience within the city's privately owned buildings. This program, in conjunction with the City's Capital Planning Process and Lifelines Council, established a holistic effort toward resilience. It is now overseen by a Chief Resilience Officer and the Earthquake Safety Implementation Program Office, which is a part of the City's Executive Branch.



Cedar Rapids, Iowa. The Cedar Rapids Framework Plan for Reinvestment and Revitalization [Cedar Rapids 2014] was initiated and led by the City Council following the 2008 floods, and was an expansion of their ongoing citywide planning efforts. Early in the process, three open houses for the *River Corridor Redevelopment Plan* were organized to receive feedback from the residents on the preliminary community analysis. The planning process included all the related City departments and received input from a Recovery and Reinvestment Coordinating team, various coordinating groups, committees, and organizations, representatives from the medical community, the railroads, and other industrial stakeholders. The plan is being implemented and has already generated significant improvements in the City.



Oregon Resilience Plan. The Oregon Plan was initiated by the Oregon State Legislature and led by the Oregon Seismic Safety Policy Advisory Commission [OSSPAC 2013]. The commission includes 19 appointees of the Governor who represent the various disciplines related to seismic safety policy including emergency managers, transportation, land conservation, housing and buildings, architects, engineers, and stakeholders from businesses, schools, the Port of Portland, and the construction industry. Planning work was organized around a number of task groups to address the seismic and tsunami hazards, business and workforce continuity, coastal communities, critical and essential buildings, and transportation, energy, water and wastewater systems. The report was accepted by the State legislature in 2014 as a framework for communities to implement.

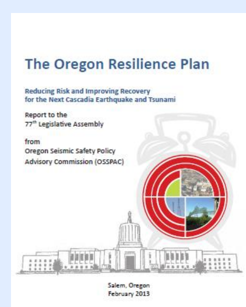


Figure 2-2: Examples of community resilience activities with strong community engagement

The involvement of community members is a measure of a community's social capital. The community's social assets and resources can facilitate information sharing, provide a conduit for social support, and enhance the capacity for collective action through social networks, associations, and the reciprocity and trust generated by them among individuals and groups. Engagement of community members can contribute to resilience by enhancing the sense of belonging and strengthening bonds between individuals and groups within communities (see Chapter 10, Volume II). Similar to cultural capital, social capital reflects the convergence of shared values in a community. It is especially valuable because it enhances a community's ability to work toward collective goals—many of which may increase other forms of capital.

Community engagement facilitates understanding by the community, raises awareness of resilience activities, and can foster buy-in and support for important resilience projects, bond issues, and legislation. In the short-term, understanding of and support for resilience efforts can promote increased perceptions of safety and security within the community. In the long-term, these perceptions can lead to stronger community identity and a higher quality of life.

The planning team and its related working groups will vary in size and breadth depending on the community. Team members from agencies with authority to plan, regulate development and the built environment, and make recommendations and decisions can provide valuable input to the planning process and offer knowledge about executing strategies. Stakeholders from particular interests may join working groups with the intent of developing specific recommendations for consideration by the planning team. Their input will be complemented by subject matter experts.

Table 2-1 through Table 2-3 provide examples of those that may be included on the planning team or in the stakeholder working groups. The importance and potential contributions of these stakeholders to the resilience planning are described briefly. Their roles may vary among communities, depending on each stakeholder's envisioned role and their current authorities or responsibilities. All will need to share information and collaborate to develop a shared understanding of the community.

Guidance related to building a planning team is documented in the FEMA Local Mitigation Planning Handbook [FEMA 2013]. Many departments, businesses, and groups may already be working on aspects of planning to achieve resilience, such as land use planning, long-term economic development, mitigation, building inspections, or emergency management, and business continuity management [ISO 2015].

Leadership that promotes collaboration among all stakeholders is needed to promote and embed resilience at all levels in the community. Public and private stakeholders need to work together to successfully plan, implement, and achieve community resilience and long-term goals.

Table 2-1: Examples of local government stakeholders who could be included in planning team

Office of the Chief Executive (e.g., Mayor)	Provides leadership, encourages collaboration among departments, and serves as the link to the stakeholders in organizing, compiling, and vetting the plan throughout the community. Also serves as the point of contact for interactions with neighboring communities within the region and the state. A Chief Resilience Officer or other leader within the office should be considered for leading the effort.
City Council or Board of Supervisors	Represents the diversity of community opinion, adopts the needed plans, and enacts legislation for needed mandatory mitigation efforts.
Building Department	Identifies appropriate codes and standards for adoption (where state codes are not mandated); reviews building plans and provides inspection services to assure proper construction; and provides post-event inspection services aimed at restoring functionality as soon as possible. The department also may develop and maintain a geographic information system (GIS)-based mapping database of community physical infrastructure, social institutions, and relationships between the two.
Department of Public Works	Responsible for publicly owned buildings, many roads, and infrastructure, and identifies emergency response and recovery routes.
Fire departments/ districts	Responsible for codes and enforcement of construction standards related to fire safety and brings expertise related to urban fires, wildfires, and fires following hazard events.
Parks and Recreation	Identifies open spaces available for emergency or interim use for housing and other neighborhood functions.
Public Utilities Commission	Responsible for overseeing private and public owned utility systems, setting rates and service levels, and assisting in developing recovery goals.
Planning Department	Identifies pre-event land use and mitigation opportunities and post-event recovery opportunities that will improve the city's layout and reduce vulnerabilities through repair and reconstruction projects and future development.
Emergency Management Agency and Emergency Operations Center (EOC)	Identifies what is needed from the physical infrastructure to streamline response and recovery of social functions and institutions within the community.
Boards of Education, Trustees and Regents	Represents all levels of education and clarifies the system's tolerance for disruptions and its ability to operate under temporary conditions.
Human Services Department (or equivalent)	Identifies services vital to support community member needs, including senior, youth, people with disabilities, and family services and programs (including childcare).

Table 2-2: Examples of business and service professionals who could be included on planning team

Chambers of Commerce and industry associations	Represents business and industry interests and includes business leaders who will bring a clear perspective on the economic impact of potential disasters as well as the impact of resilience plans.
Community business districts	Represents large and small businesses that support the neighborhoods, provide jobs, and play a key role in community recovery.
Building owners, and managers	Provides building and housing owners' perspective on resilience and recovery in terms of their needs for labor, buildings, utilities, and other infrastructure systems, as well as how their needs influence the performance levels selected.
Utility providers	Include power, communications, water, wastewater, and transportation providers. Key to rapid recovery of functionality, and will bring perspective on changes needed in current regulations and rate limitations. Collaboration among providers is essential to understand the community needs and priorities for recovery, as well as shared dependencies. Infrastructure systems may be represented by staff from outside the community.
Health	Includes public health officials, providers of acute, sub-acute, rehabilitation, mental health, behavioral and end-of-life care. Brings clarity to healthcare services that are being provided before, and those that are needed immediately after, a significant event and throughout the recovery period.
Architects and urban planners	Bring a vision and expertise for an improved community that supports transit, housing, vibrant and livable neighborhoods, and improved quality of life.
Engineers	Determine design and performance capabilities for the built environment and assists in developing suitable standards and guidelines. Can help establish desired performance goals and the likely performance anticipated from the existing built environment.
Developers and construction professionals	Provide perspective on the feasibility and consequences of changing building and housing design and construction practices. Also, offer perspective from their clean up and reconstruction activities after a disaster.
Media	Reflect the needs of a key player in disseminating important information about response and recovery efforts, as well as the resilience process and progress, to the community.

Table 2-3: Examples of community and volunteer organizations that could be included on planning team

Non-governmental Organizations (NGOs)	Bring members' concerns to governments, advocate and monitor policies, and encourage participation in resilience-related efforts by providing information to members. May include non-profit, voluntary groups organized on a local, national, or international level. May perform a variety of service and humanitarian functions that support other social institutions, especially those that provide services to vulnerable and at-risk populations.
National Voluntary Organizations Active in Disaster (VOADs)	Serve as a primary forum where organizations share knowledge and resources throughout the disaster preparedness cycle to help survivors and their communities. These are non-profit, non-partisan, membership-based organizations that help to build resiliency in communities nationwide.
Community associations	Provide neighborhood and resident views, including homeowners, renters, and vulnerable populations
Community Service Organizations (CSOs) and religious/cultural groups	Offer insights based on their role as volunteer, membership-based groups that provide services to the community's members and frequently play an important role in the post-disaster environment.

2.1. References

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San Francisco Planning and Urban Research Association (SPUR 2009) "When is a Building Safe Enough?" *San Francisco Urban Research Association*, Issue 479, February 2009, 654 Mission Street, San Francisco, CA, http://www.spur.org, http://www.spur.org/sites/default/files/publications_pdfs/SPUR_Seismic_Mitigation_Policies.pdf.

3. Step 2: Understand the Situation

This Guide is based upon a fundamental premise: *the social functions and needs of a community should drive the requirements of the built environment for a community to be resilient*.

The built environment is an essential part of a community's resilience. Social functions and institutions, including family/kinship, education, health, government, economy, media, and other community-based organizations rely on buildings and infrastructure systems before, during, and after a hazard event occurs. Key buildings and infrastructure systems must be functional to support neighborhood restoration, to care for vulnerable populations, and to enable the community's economy to recover and thrive.

Gaining a comprehensive understanding of a community is essential for effective resilience planning. That includes identifying and characterizing social and civil components:

- Social dimensions, including community demographics and how social institutions meet community members' needs prior to hazard events and during recovery
- Buildings and the infrastructure systems – the built environment – that supports the functions of these social institutions

In this second planning step, the team identifies and characterizes both components and identifies important links and dependencies between them.

3.1. Identify and Characterize the Social Dimensions

The social needs of a community provide the basis for establishing performance goals for the built environment. Understanding those needs involves identifying and characterizing community members, their needs, and the social institutions that exist to meet those needs. This can be done in four sub-steps:

1. Characterize community members and their present and future needs. This includes population demographics and locations, economic indicators, social vulnerabilities, social capital, and their needs. Short- and long-term needs, including potential growth, should be considered.
2. Identify social institutions and systems within the community, including their functions, the particular needs they meet, and any gaps in institutional and organizational capacity that could be improved by changes to the built environment.
3. Identify dependencies among and within social institutions.
4. Identify key social and economic community metrics, including methods to track the impact of community planning and improvements.

Details and examples appear below.

Characterize the population. This involves taking stock of the community's demographics (e.g., age, health, education, income, employment status, home ownership/rental/temporary housing, language and culture) and linking these with individuals' geographic locations within the community, determining the community's economic profile or indicators (e.g., the industries present within the community), identifying social assets and capacities (e.g., health clinics and pharmacies, educational programs), and vulnerabilities (e.g., mobility issues, renting, lacking recovery resources, living or working in hazard-prone areas), and defining the needs of different groups in the community. A generalized hierarchy of human needs within a community, presented in Chapter 10 (Volume II), is based on Maslow's approach. Human needs are physiological (e.g., water, food, and shelter), safety and security, belonging, and growth and achievement. Although all needs are important, some are more urgent or time sensitive than others in the context of resilience. The resilience team should focus foremost, but not exclusively, on the more fundamental and time-sensitive needs.

Additionally, because resilience planning can involve long-term measures and modifications to the built environment, changes and trends in community demographics, geographic locations, vulnerabilities, and local needs over time should be considered.

Identify social institutions. These can include family/kinship, economics, government, health, education, community service organizations, religious and cultural organizations (or other organizations that support belief systems), and the media. Institutions are organized in many different ways to serve community needs. It is important for the resilience planning team to identify the community's various social institutions and to understand how they work within the community (i.e., identify the services they provide and their dependencies).

At this stage, the planning team can begin to identify gaps in capacity within the social institutions: situations in which institutions and services would be unlikely or unable to meet all the needs of the community and to maintain services after a hazard event. The team next identifies gaps in social capacity that could be reduced by a change or improvement to the built environment. For example, the community might benefit and be able to better meet its social needs if housing is relocated outside a flood zone or future development is restricted within that flood zone.

Strengths and weaknesses in the ability of social institutions to provide services to the community need to be clearly identified. For example, critical services delivered by healthcare institutions or emergency responders are vital to meet urgent needs during recovery. The capacity of these institutions to function at all times (including recovery) needs to be examined in detail, fully understood, and any improvements that are needed should be agreed upon. The population that commutes into the community to fulfill critical functions and enable business to continue or to resume operations should be identified. Such an analysis should also include consideration of their transportation modes, routes and dependencies (e.g., availability of fuel).

Identify dependencies. Given that social institutions are linked in many ways, a disruption in the built environment that affects one social institution may also affect others. Therefore, planners should identify dependencies among and within social institutions to determine which functions are most critical during recovery. Each community is different. Chapter 10 (Volume II) provides examples of dependencies to consider.

Identify metrics. Communities should identify methods (or measures or metrics) to track the progress of social and economic aspects of community resilience and improvement activities. The basic questions that community metrics may help to answer include:

- How resilient are the community's social and economic institutions?
- Will the community's decisions and investments actually improve resilience? If so, how significant will the difference be?

Social and economic metrics can help community decision-makers understand the implications of community decisions for planning, siting, design, construction, operation, protection, maintenance, repair, and restoration of the built environment. Social and economic-based resilience metrics can be quantitative or descriptive. The result can be presented as an overall resilience-related score or as a set of separately reported scores across a broad spectrum of physical, economic, and social dimensions. Examples of resilience metrics for social and economic systems, and existing community resilience assessment methodologies are provided in Chapter 17 (Volume II).

In understanding the community, the planning team also characterizes the built environment, as discussed in the following section. Characterizing the social dimensions and the built environment may occur in parallel.

3.2. Characterize the Built Environment

Characterizing the built environment includes identifying key attributes and dependencies for existing buildings and infrastructure systems within the community. Depending on their size, community building and public works departments and utilities may have much of the needed information available through their GIS (Geographic Information System) applications or other databases.

Data and information that will be needed to characterize the current condition of the built environment includes the owner, location(s), current use, age, construction types, zoning, maintenance and upgrades, and applicable codes, standards, and regulations, both at the time of design and for current practice. Information about dependence on other systems, subsystems, or branches of systems, will contribute to an understanding of how the built environment is expected to perform if one of the systems, or a branch of the system, stops providing services.

Another important piece of information is the location of these structures throughout the community. GIS-based maps can help communities understand whether their buildings or infrastructure systems are located in higher-risk areas. For instance, many communities were established before flood zones were mapped, and consequently, have buildings and infrastructure systems subjected to flood damage. Other communities have buildings and infrastructure systems located near seismic faults, and may not perform well if a significant seismic event occurs. Alternatively, a period of rapid growth may have exceeded the infrastructure system's capacity or may have resulted in development that lacked adequate adoption or enforcement of local codes and regulations.

Buildings. Buildings can be characterized individually and as groups, or clusters. The term *cluster* refers to a set of buildings—and supporting infrastructure systems—that serve a common function such as housing, healthcare, retail, etc. Clusters are not necessarily geographically co-located, and may be distributed throughout the community. Characterizing a community's building stock involves identifying the number of buildings within the community by building type, occupancy, and use. Additional information important to establishing performance and recovery times may include construction types that might not perform well, such as unreinforced masonry or soft story construction in seismic zones, or a lack of positive ties (e.g., hurricane clips) to avoid wind uplift damage. See Chapter 12 in Volume II for additional considerations in characterizing the building stock.

Transportation. In addition to roads and bridges, community transportation systems may include rail systems, airports, coastal or river ports, pipelines, waterways, or trucking hubs. Many communities maintain their local roads and rely on various owners and operators to maintain other transportation systems. For instance, while counties and states own and maintain most highways, regional authorities may manage airports and shipping ports. Most rail lines are independently owned and operated, sometimes privately or by separate public authorities. Information from owners and operators on the transportation infrastructure is needed to address multiple performance and recovery issues. This information can be used to determine dependencies, meet anticipated usage (e.g., traffic loads on evacuation routes), and provide redundancy for meeting transport needs (e.g., temporary energy sources and alternate routes). Transportation systems may serve different roles in each phase of recovery. For example, emergency response routes, evacuation pathways, and supply routes for restoration may be different. See Chapter 13 in Volume II for additional considerations in characterizing transportation systems.

Energy. Energy systems include electric power and fuel systems. Electric power systems range from municipally owned and operated systems to private regional systems. These systems include power generation, transmission, and distribution; distribution systems are located within the boundaries of communities, but generation and transmission systems are typically located outside the community, unless they are municipally owned. Coordination between owners and operators of energy systems regarding system performance and restoration sequencing during and immediately after an event is fundamental to community resilience planning. For many communities, understanding the sequence of power restoration is key to planning community recovery. Fuel supply mechanisms and distribution systems also need to be characterized. Fuel may be supplied by tankers, trucks, or pipelines. The total amount of fuel required by the community may change during recovery if temporary power sources, such as generators, are used. Recent growth of decentralized energy sources, such as microgrids and home solar energy systems, also should be taken into account over the long-term. See Chapter 14 in Volume II for additional considerations in characterizing energy systems.

Communication. Communication services include internet, cellular, and wireline phone services as well as the cable, satellite, and broadcast modes relied upon by media operations. Communication companies are privately owned and many communities rely on multiple providers. Smaller, regional companies may share infrastructure with a larger, sometimes national, company. Communication infrastructure includes central offices and other equipment-based facilities to direct and process calls and data. It also includes cables, cell towers, and other systems to transmit and distribute calls and data. As is the case with electric power, distribution systems are within community boundaries. Coordination with owners and operators about communication systems performance and recovery is essential to resilience planning. See Chapter 15 in Volume II for additional considerations in characterizing communication systems.

Water and wastewater. Water systems are supplied by either surface or ground water. They include treatment plants and pipelines. Wastewater systems collect waste through a separate system of pipelines and pump stations connected to a wastewater treatment plant, which is located near a body of water used for post-treatment discharge. These systems typically are owned and operated at the local level, by either communities, special authorities, or associations of homeowners. Information on system age, maintenance, location, and service area is readily available in many communities. Many water systems are older and may need replacement; for aging systems with frequent failures, the risk of failure will increase during certain hazard events. The performance of older buried systems may well deserve additional planning options for community recovery. Water sources may be local, or they may be shared with other communities. Having shared water sources may require collaboration with nearby communities for daily water supplies and recovery plans. See Chapter 16 in Volume II for additional considerations in characterizing water and wastewater systems.

Dependencies. Effective resilience planning demands a thorough understanding of building and infrastructure system dependencies to minimize negative impacts while key functions are restored. There are multiple dimensions of dependency. Interactions between and among infrastructure systems can depend on a number of factors. Traditionally, dependencies consider the physical and functional relationship between different systems (e.g., drinking water systems require electricity to operate pumps, communications systems need power to operate, crews needed to repair damage to electrical distribution systems need access via roads that may be blocked). See Chapter 11 in Volume II for additional considerations in characterizing system dependencies.

Identify metrics. Communities should identify methods (ideally including meaningful metrics) to track the progress of buildings and infrastructure systems activities related to community resilience. Most service providers and communities track reliability of service (e.g., power or communication systems) during normal operations or service restoration (e.g., restored transportation route of water line) following system damage (see Chapter 17 in Volume II). This Guide uses *time to recovery of function* as the primary metric for community resilience.

3.3. Link Social Dimensions to the Built Environment

Once the social dimensions and built environment are characterized, communities identify links between the social institutions and their services and the buildings and infrastructure systems during day-to-day operations and during the recovery process. Some institutions rely more heavily on the built environment than others. For example, healthcare institutions may find it difficult to provide services outside of hospitals or other buildings on a longer-term basis because specialized equipment often relies on power and/or water, and controlled (sterile) environments frequently are needed to perform medical procedures.

In this step, a community identifies the ways in which the built environment supports each social institution. This process involves understanding the purpose of the built environment for each institution, how that purpose is actualized, and the direct and indirect consequences for individuals, groups, and the community when the built environment is degraded. Chapter 10 (Volume II) contains examples of linkages between social institutions and the built environment, specifically buildings, transportation, water/wastewater, power/energy, and communication systems. These linkages may differ under normal circumstances and after a hazard event.

Planning teams should identify external and internal dependencies that affect successful implementation of the community resilience plan and desired outcomes. These dependencies need to be taken into account in the next step when the team sets goals and objectives, because those dependencies contribute to the resilience plan's uncertainty and risk.

By considering these linkages, the planning team can begin to identify building clusters, and the infrastructure systems that support those clusters. For instance, building performance during a hazard and during recovery can be considered for individual buildings that provide a critical service and for clusters of housing or commercial facilities. Additionally, the service or function served by the cluster before the hazard event may change during recovery. For example, school facilities often are used as emergency housing for several weeks after an event. Temporary alternate uses of facilities should be taken into consideration as because building cluster performance goals are set during the next step in the process.

4. Step 3: Determine Goals and Objectives

4.1. Goals for Community Resilience

Community resilience should be based on long-term community growth and development goals. Each community should define its own long-term planning horizon, depending on its existing infrastructure, anticipated plans for improvements, and resources. For the built environment, renewal or replacement of existing buildings and infrastructure systems often takes place over 30 to 100 years, depending on the building or infrastructure system's use and the type of construction.

Having long-term community-level goals – such as minimizing disruptions to daily life, attracting new business, and improving recovery from hazard events – guides a diverse set of stakeholders as they develop resilience plans. Achieving the long-term goals of the community is made possible by developing performance goals for the built environment and the supported social functions, strategies for achieving those goals, and priorities for administrative and construction solutions. The desired, long-term performance goals are expressed in the Guide as *time to recovery of a function*. Time is a metric that is readily and broadly understood, and that can be evaluated.

There are two categories of performance when it comes to the built environment: 1) desired performance to be achieved over time through the resilience plan; and 2) anticipated performance if an event were to occur before the resilience plan was implemented.

To determine where shortfalls, or gaps, exist, the anticipated performance of the existing built environment needs to be estimated for the prevailing community hazards. Desired performance goals, anticipated performance of the existing built environment, and recovery phases, times, and costs for a hazard event provide a more complete basis for communities to assess expected gaps in performance, to prioritize improvements, and to allocate resources.

The Guide recommends that performance be evaluated at three levels – routine, design, and extreme – for each hazard. This approach helps communities understand performance across a reasonable range of hazard levels. Better understanding of how the built environment performs and recovers over a range of hazard levels further informs community decisions about priorities.

4.1.1. Establish Long-Term Community Goals

Long-term community goals guide the resilience planning, prioritization, resource allocations, and implementation process. The goals are high-level statements of outcomes that are desired to improve the community. Examples of these types of goal statements include the following:

- Improve resilience of an infrastructure system to improve community reliability and functions.
- Improve or add redundancy to a transportation route that is vulnerable to damage and minimize travel impacts on residents and supply impacts on businesses.
- Revitalize an existing area through improvements that make the community more resilient.

4.1.2. Establish Desired Performance Goals

Setting desired performance goals depends on determining a couple of important factors: (1) an acceptable level of damage for a particular hazard level (performance level) and (2) a corresponding time to restore full functionality. Performance levels address life safety, which are the focus of building and fire codes, as well as post-event functionality, which generally is not covered by those codes. Determining desired time to recover functionality (also shortened to *recovery time*) helps to prioritize repair and reconstruction efforts. Additionally, performance goals should consider the role of a facility or system on local, regional, and possibly national and international needs. For instance, if a production plant in a community is the national supplier for a particular product, the impact of damage to that plant extends well beyond the community.

The term *cluster* is used to denote groups of buildings or infrastructure systems serving a common function. However, a cluster does not necessarily mean that the buildings or infrastructure systems are geographically co-located. Examples are residential housing, schools, or healthcare facilities and supporting infrastructure. Such clusters serve community social institutions and should have similar performance goals.

Setting desired performance goals for safety and functionality of the built environment informs resilience plans for new construction as well as for existing buildings and infrastructure systems. New construction that meets the desired performance goals helps to improve a community's resilience over time. For existing construction, having clear performance goals helps identify clusters that may benefit from retrofits, relocation, or other measures to ensure that these clusters provide the needed social service.

Recovery phases. Recovery times for building clusters and infrastructure systems are organized around sequential recovery phases. The Guide uses the recovery phases as defined by the FEMA National Disaster Recovery Framework [FEMA 2011], as shown in Figure 4-1: short-term, intermediate, and long-term. The first phase usually focuses on rescue, stabilization, and preparing for recovery, and is expected to occur over a period of days. The second phase focuses on restoring the neighborhoods, workforce, and caring for the vulnerable populations and extends for weeks to months. The third phase relates to restoring the community's economy, social institutions and physical infrastructure, and may continue for years after the event. Activities during each recovery phase may overlap in planning and execution.

Figure 4-1: National Disaster Recovery Framework (NDRF) recovery continuum [FEMA 2011]

Performance levels for buildings. To ensure compatibility with codes and standards, common definitions of performance levels should be used for buildings and infrastructure systems. These range from *safe and operational* to *unsafe*. Table 4-1 provides definitions for building cluster performance levels that are used in the Guide. These were designated originally by SPUR [2009] to define the seismic performance of buildings.

Table 4-1: Performance level definitions for building clusters

Performance Level	Definition
A. Safe and operational	These facilities incur minor damage and continue to function without interruption. Essential facilities need this level of function.
B. Safe and usable during repair	These facilities experience moderate damage to their finishes, contents and support systems. They receive green tags from qualified inspectors and are safe to occupy after a hazard event. This performance is suitable for shelter-in-place residential buildings, neighborhood businesses and services, and other businesses or services deemed important to community recovery.
C. Safe and not usable	These facilities meet minimum safety goals, but remain closed until they are repaired. These facilities receive yellow tags from qualified inspectors. This performance may be suitable for some of the facilities that support the community's economy. Demand for business and market factors will determine when they need to be functional.
D. Unsafe – partial or complete collapse	These facilities are dangerous because the extent of damage may lead to casualties. These buildings receive red tags from qualified inspectors.

Functional categories. Categorizing community functions based on the support they lend to recovery is helpful when determining desired performance goals for the built environment. Table 4-2 gives an example of assigning building clusters by recovery phases. Infrastructure systems that support the clusters are not listed, but should be considered.

Four functional categories are suggested for inclusion in the three phases of recovery. Building clusters are assigned to one of those categories. The four categories include critical facilities and emergency housing (short-term), workforce housing and neighborhood restoration (intermediate term), and community restoration (long-term). Communities should consider human and social needs when assigning building clusters to the three recovery phases.

While three recovery phases are designated, there will be considerable overlap in their initiation and completion, as indicated in Figure 4-1. It is conceivable that all three recovery phases could start shortly after the hazard event.

Functionality levels for building clusters. Although individual buildings may be assigned desired performance levels that reflect their role in the community, the overall ability of a building cluster to serve its social institutions can be measured by how many or what percentage of buildings in the cluster are functioning. For purposes of planning, it is helpful to set goals for three levels of functionality based on the percentage of buildings in the cluster that are functional, as defined in Table 4-3. This process allows a community to define the shape of the recovery curves shown in Figure 4-1 for each recovery phase. When building clusters only have a few buildings, it may be appropriate to measure the percentage of service restored directly, rather than the number of buildings with restored functionality within a cluster.

In the post-event environment, 90 % functional can be considered full restoration. In many communities, approximately 10 % of the buildings are out of service for a variety of reasons at any given time [OSSPAC 2013]. The gradual, phased recovery levels in Figure 4-1 also show that not all buildings in a cluster are expected to recover at the same time. Chapter 12 in Volume II provides information on building cluster identification, and considerations for setting performance levels.

Table 4-2: Sample assignment of building clusters by functional category and recovery phases

Short-Term	**Critical Facilities**	• Disaster debris and recycling centers • Emergency operations centers	• Hospitals and essential healthcare facilities • Police and fire stations
Short-Term	**Emergency Housing**	• Animal shelters • Banking facilities (location known by community) • Food distribution centers • Faith and community-based organizations • Gas stations (location known by community)	• Nursing homes, transitional housing • Public shelters • Residential shelter-in-place • Shelter for emergency response and recovery workers
Intermediate	**Housing/Neighborhoods/Business**	• Buildings or space for social services (e.g., child services) and prosecution activities • Daycare centers • Essential city services facilities • Houses of worship • Local Businesses	• Local grocery stores (location known by community) • Medical provider offices • Neighborhood retail stores • Residential housing • Schools
Long-Term	**Community Recovery**	• Commercial and industrial businesses • Non-emergency city services	• Resilient landscape repair, redesign, reconstruction, repairs to domestic environment

Table 4-3: Functionality levels for building clusters

Functionality	Performance Level
30% functional	Minimum number needed to initiate the activities assigned to the cluster
60% functional	Minimum number needed to initiate usual operations
90% functional	Minimum number needed to declare cluster is operating at normal capacity

Supporting infrastructure systems. Building clusters require service from supporting infrastructure systems to be functional. In the short-term, temporary solutions, such as emergency generators or portable water supplies, may be used to restore service and functionality. Communities are encouraged to set functionality levels (Table 4-3) for the recovery of infrastructure systems so they support the building cluster recovery. The focus should be on system performance in terms of the percentage of capacity provided at the 30 %, 60 %, and 90 % milestones for the various building clusters. Consideration should be given to redundancies inherent in each infrastructure system and the consequence of the disruption.

New construction and retrofit. The procedure for setting performance levels for buildings, building clusters, and supporting infrastructure systems is directly applicable to new construction and retrofit projects. The design criteria established for those projects should be based on the same performance goal for the building cluster they support. To achieve long-term community resilience, all new construction should be designed to the community-designated performance level.

4.1.3. Define Community Hazards and Levels

With desired performance goals established, the next step is to determine the expected response of the existing buildings and infrastructure systems to a community's prevailing hazards, which may include natural, human-caused, or technological hazards. The community resilience plan is anchored to the design event – that is, the hazard level used to design buildings and other structures – but consideration of routine as well as extreme events may identify additional issues to be considered. The planning team is encouraged to evaluate multiple hazard levels to ensure comprehensive planning for a range of possible hazard conditions that may occur.

Prevailing hazards. Each community has its own prevalent hazards to consider when planning for long-term community resilience. The following is a partial list of hazards that communities may face:

- ***Wind –*** wind storms, hurricanes, tornadoes
- ***Earthquake –*** ground shaking, ground faults, landslides, liquefaction
- ***Inundation –*** river flood, flash flood, coastal flood/storm surge, tsunami
- ***Fire –*** urban/building, wildfire, and fire following another hazard event
- ***Snow or Rain –*** snow storms, ice storms, blizzards, drifts, ice dams, freezes or thaws, rain storms that overwhelm drainage systems
- ***Technological or Human-caused –*** blasts, vehicular (including rail) impacts, toxic environmental contamination as a result of industrial or other accidents as well as due to clean-up/disposal methods after a hazard event

Many of these hazards, such as wind, earthquake, and snow, have specified design criteria in current codes and standards for the built environment. However, some hazards do not yet have specified design criteria, such as tornadoes.

Each community should identify and plan for prevailing hazards that may have significant negative impact on the built environment. Communities may have already identified their prevailing hazards when developing a natural hazard mitigation plan, emergency operations plan, continuity of operations plan, or Threat and Hazard Identification and Risk Assessment (THIRA) Guide [CPG 201, FEMA 2013b]. Historical data may also be useful for understanding potential hazards and consequences, but should be interpreted and used carefully. Historical events are specific examples of the range of possible future events a community may face. Data on damage from historical events depend on a number of factors, including the density and condition of the built environment, the intensity of the hazard, and the community's readiness to respond and recover. Available sources of information for hazards include the following:

- The U.S. Geological Survey provides seismic design maps, historical data, and other related information and resources [USGS 2015].

- FEMA [FEMA 2015a] provides flood maps and the U.S. Army Corps of Engineers provides guidance for riverine and coastal flooding [USACE 2015].
- The National Oceanographic and Atmospheric Administration's [NOAA 2015] U.S. Climate Resilience Toolkit provides information on many natural hazards. In addition to the listed hazards, communities may also need to address weather and climate effects, such as sea level rise and drought that also can impact community resilience.
- The National Weather Service interactive flood map information [NWS 2015] provides historical data for inundation and hurricane hazards for each state.

Hazard levels. For each hazard identified, communities are encouraged to determine three hazard levels for planning:

- ***Routine* –** This hazard level is below the design level for the built environment and occurs more frequently. This event has a high probability of occurring (on the order of 50 % over a 50-year period, as indicated in Table 4-4). At this level, resilient buildings and infrastructure systems should remain functional and not experience any significant damage that would disrupt social functions in the community.
- ***Design* –** This is the hazard level used in codes and standards for buildings, bridges, and similar physical infrastructure systems. Design-level events tend to have a probability of occurring on the order of 10 % over a 50-year period for ordinary structures. The design hazard level for a specific building or infrastructure component may be greater than that for ordinary buildings, as required by its occupancy and risk category classifications in the adopted codes (see Chapter 12, Volume II for more information). To support community resilience, buildings and infrastructure systems should remain sufficiently functional to support the response and recovery of the community as defined by the performance levels identified in Table 4-1 and Table 4-3. Achievement of desired performance levels may require additional design criteria beyond those in codes and standards.
- ***Extreme*** – This hazard level exceeds the design level for the built environment. (Seismic ground motion hazards refer to the maximum considered event, which has a probabilistic basis that is supplemented with historical data). Extreme events have a small probability of occurrence, on the order of 2 % to 3 % over a 50-year period. The extreme hazard level should include those rare hazards that may plausibly impact a community, but may not be the greatest possible hazard a community can envision. They also may include anticipated long-term changes in hazards due to climate change. Critical facilities and infrastructure systems should remain partially functional at this level, with ability to restore functionality when needed to support the response and recovery of the community as defined by the performance levels. Other buildings and infrastructure systems should perform at a level that protects the occupants, though they may need to be rescued. Emergency response plans should be developed for scenarios based on this hazard level.
- Where hazard levels are not defined by code, the community may establish a scenario or hazard level based on available guidance or predicted frequency of occurrence. This case is indicated in Table 12-3 (Chapter 12, Volume II) by *locally determined*.

Table 4-4 shows hazard levels for buildings and other structures based on American Society of Civil Engineers (ASCE) Structural Engineering Institute (SEI) Standard 7-10 [ASCE/SEI 2010]. The defined hazards are reported in two ways: as an average interval of occurrence over time (mean recurrence interval, MRI) or as the probability the event level occurring in a 50-year time period. The probability of occurrence description helps convey the relative likelihood of hazard event occurrence for the same time period.

Table 4-4: Hazard levels for buildings and facilities

Hazard	Routine	Design	Extreme
Ground Snow	50 year MRI or 64% in 50 years	300 to 500 year MRI[1] or 15 to 10% in 50 years	TBD[4]
Rain	Locally determined[2]	Locally determined[2]	Locally determined[2]
Wind – Non-Hurricane	50 year MRI or 64% in 50 years	700 year MRI or 7% in 50 year	1,700 year MRI[3] or 3% in 50 years
Wind – Hurricane	50 to 100 year MRI or 64 to 39% in 50 years	700 year MRI or 7% in 50 years	1,700 year MRI[3] or 3% in 50 years
Wind – Tornado	Locally determined[3]	Locally determined[3]	Locally determined[3]
Earthquake[4]	50 year MRI or 64% in 50 years	500 year MRI or 10% in 50 years	2,500 year MRI or 2% in 50 years
Tsunami	Locally determined[3]	Locally determined[3]	Locally determined[3]
Flood	Locally determined	100 to 500 year MRI or 39 to 10% in 50 years	Locally determined
Fire – Wildfire	Locally determined[4]	Locally determined[4]	Locally determined[4]
Fire –Urban/Manmade	Locally determined[4]	Locally determined[4]	Locally determined[4]
Blast / Terrorism	Locally determined[5]	Locally determined[5]	Locally determined[5]

[1] For the northeast, 1.6 (the Load and Resistance Factor Design (LRFD) factor on snow load) times the 50-year ground snow load is equivalent to the 300 to 500 year snow load.

[2] Rain is designed by rainfall intensity of inches per hour or mm/h, as specified by the local code.

[3] Tornado and tsunami loads are not addressed in ASCE 7-10. Tornadoes are presently classified by the EF scale. See FEMA 361 [2015b] for tornado EF-scale wind speeds.

[4] Hazards to be determined in conjunction with design professionals based on deterministic scenarios.

[5] Hazards to be determined based on deterministic scenarios. Reference UFC 04-020-01 [DoD 2008] for examples of deterministic scenarios.

Table 4-5 reports the three levels of seismic hazard defined by SPUR for use in San Francisco's resilience planning. When there is incomplete information about hazards, scenarios can be used for planning or assessment purposes. Note that the *expected* hazard level, as defined by SPUR, is consistent with the *design* hazard level defined in the Guide. Scenarios are often developed for specific examples of hazard events that do not have a probabilistic basis (see Table 4-4) and should be used for more general resilience plans.

Table 4-5: SPUR [2009] seismic hazard level definitions

Routine	***Earthquakes that are likely to occur routinely.*** Routine earthquakes are defined as having a 70% probability of occurring in 50 years. In general, earthquakes of this size will have magnitudes equal to 5.0 – 5.5, should not cause any noticeable damage, and should only serve as a reminder of the inevitable. San Francisco's Department of Building Inspection (DBI) uses this earthquake level in their Administrative Bulletin AB 083 [San Francisco Building Code 2014] for purposes of defining the *service level* performance of tall buildings.
Expected	***An earthquake that can reasonably be expected to occur once during the useful life of a structure or system.*** It is defined as having a 10% probability of occurrence in 50 years. San Francisco's Community Action Plan for Seismic Safety (CAPSS) [ATC 2010] assumed that a magnitude 7.2 earthquake located on the peninsula segment of the San Andreas Fault would produce this level of shaking in most of the city.
Extreme (Maximum Considered Earthquake)	***The extreme earthquake that can reasonably be expected to occur on a nearby fault.*** It is defined as having a 2% probability of occurrence in 50 years. The CAPSS defined magnitude 7.9 earthquake located on the peninsula segment of the San Andreas Fault would produce this level of shaking in most of the city.

Hazard Impact. The concept of hazard impact is intended to capture the consequences of an event for a given hazard level. The same hazard level may result in varying consequences, depending on the disruption and damage to the built environment. Two measures are used to address the consequences of the event: the size of the *affected area* and the *level of disruption* to community functions. For example, a wildfire in wilderness areas, where there is little population, can burn many square miles of forest with little disruption. On the other hand, the 1991 Oakland Hills firestorm burned 1500 acres, 25 lives were lost, and 150 people were injured. The fire destroyed nearly 3400 structures and caused $1.5 billion in damage [USFA 1991]. The affected area was relatively small compared to other wildfires; but the disruption to the affected population and built environment was severe.

To assist communities in determining the anticipated performance of buildings and infrastructure systems (see Section 4.1.4), Table 4-6 defines categories for the size of the affected area and anticipated disruption level. Estimating the impact for a potential hazard event will help the community to determine anticipated performance levels and the extent of mutual aid that they may need.

Table 4-7 shows examples of hazard impacts of past events. Even though the DaVinci Fire (Los Angeles, 2014) became an uncontrolled (extreme) building fire that destroyed the apartment complex under construction [Rocha 2015], the impact on the community was localized. Similarly, the EF5 tornadoes (extreme) that struck Moore, OK [Kuligowski et al 2013] only affected a portion of the city and did not cause disruption to the entire community. In fact, unaffected Moore businesses were able to assist in the recovery. However, the same hazard event may cause varying levels of damage and disruption in communities. The Loma Prieta earthquake (California, 1989) caused regional damage and disruptions near Watsonville [Nakata et al 1999], but moderate community level damage and disruption to San Francisco. A hazard event may have sequential hazards, such as winds followed by storm surge during Hurricane Sandy in 2012 [FEMA 2013]. A number of New Jersey communities first lost power when *winds* came onshore (routine level, less than design wind speeds) and power distribution lines were damaged. When the *storm surge* subsequently came onshore (design event of 100- to 200-year flood elevation), a smaller set of communities were inundated, but many functions were severely disrupted in these areas.

Table 4-6: Affected area and anticipated community disruption level

	Category	Definition
Affected Area	Localized	Damage and lost functionality are contained within an isolated area of the community. While the Emergency Operations Center (EOC) may open, it is able to organize needed actions within a few days and allow the community to return to normal operations and manages recovery. Economic impacts are localized.
	Community	Significant damage and loss of functionality are contained within the community, such that assistance is required from neighboring areas that were not affected. The EOC opens, directs the response and turns recovery over to usual processes once the City governance structure takes over. Economic impacts extend to the region or state.
	Regional	Significant damage occurs beyond community boundaries. Area needing emergency response and recovery assistance covers multiple communities in a region, each activating their respective EOCs and seeking assistance in response and recovery from outside the region. Economic impacts may extend national and globally.
Anticipated Disruption Level	Minor	All required response and recovery assistance is handled within the normal operating procedures of the affected community agencies, departments, and local businesses with little to no disruption to the normal flow of living. Critical facilities and emergency housing are functional and community infrastructure systems are functional with local minor damage.
	Moderate	Community EOC activates and all response and recovery assistance is orchestrated locally, primarily using local resources. Critical facilities and emergency housing are functional and community infrastructure systems are partially functional.
	Severe	Response and recovery efforts are beyond the authority and capability of local communities that are affected and outside coordination is needed to meet the needs of the multiple jurisdictions affected. Professional services and physical resources are needed from outside of the region. Critical facilities and emergency housing may have moderate damage but can be occupied with repairs; community infrastructure systems are not functional for most needs.

Table 4-7: Examples of hazard impacts

Event	Community	Year	Level	Affected Area	Disruption Level
DaVinci Apartment Fire	Los Angeles	2014	Extreme	Localized	Minor
Moore OK Tornado	Moore	2013	Extreme	Localized	Moderate
Loma Prieta EQ	Watsonville	1989	Design	Regional	Severe
Loma Prieta EQ	San Francisco	1989	Design	Community	Moderate
Hurricane Sandy (wind event)	New Jersey	2012	Routine	Regional	Moderate
Hurricane Sandy (storm surge event)	New Jersey	2012	Design	Regional	Severe

4.1.4. Determine Anticipated Performance

The anticipated or likely performance of the designated clusters of existing buildings and infrastructure systems also needs to be estimated. Anticipated performance depends on (1) the likely level of damage that occurs during the hazard event (performance level) and (2) the corresponding recovery time to restore full functionality. The recovery time depends on the performance: a cluster may need limited repairs or perhaps replacement. This information, when compared with the performance goals previously set, defines the gaps that need to be addressed and informs pre-event planning for post-event response.

The majority of buildings and infrastructure systems in service today were designed to serve their intended functions on a daily basis under the normal environmental conditions. In addition, buildings and other structures are designed to provide occupant safety during a design-level hazard event, but they may not continue to be functional. Design and construction of buildings and physical infrastructure systems are performed by builders, architects, and engineers following their community codes and standards of practice.

Codes and standards are continually evolving due to changing technology, changing needs, and new information, which sometimes comes from observed performance deficiencies during past events. Much of the existing built environment may not meet the long-term performance goals set by communities. Temporary or interim solutions can address short-term needs while long-term, permanent solutions are set in place.

Assessment of the existing built environment should consider the performance expectations for adopted design codes. Since community resilience focuses on performance at the community level, selected building clusters and infrastructure systems are evaluated against the desired performance goals and functions based on social needs. Current engineering practice for predicting the performance of buildings and infrastructure systems under specific hazard events often is based on expert judgment or past experience of other communities. These techniques are constantly being developed and improved and Chapters 12 through 16 (Volume II) provide available guidance on how to estimate the performance of existing buildings and infrastructure systems.

Lack of personal experience with a damaging hazard event, and lack of understanding about the level of damage expected when a significant hazard event occurs, can lead to misconceptions about a community's vulnerability. Communities can gain better insights into their vulnerabilities based on national experience, not just local events, and can better address those vulnerabilities by adopting and enforcing land use guidelines and national model building codes. The cost of compliance for new construction is often minimal compared to the cost of recovery and reconstruction.

4.1.5. Summarize the Results

The planning team should document desired performance goals and anticipated performance for the built environment to improve communication among stakeholders and to support a comprehensive, high-level summary of the integrated performance of a community's buildings and infrastructure systems. To support the documentation, a tabular presentation of the many facets of a community resilience plan is provided in this Guide. It includes a detailed resilience table for each of the building clusters and infrastructure systems as well as summary resilience table that provides an integrated community-level overview. The detailed table includes a format for entering the desired performance goals for all clusters and subsystems defined for the community for each hazard level, as well as the anticipated performance levels for the hazard(s) under consideration. The summary tables combine all of this information together for buildings and infrastructure systems. Example tables are included in Chapters 12 to 16 (Volume II). The community resilience planning example (Chapter 9) for a fictitious community demonstrates how to use the six-step process and how to complete the resilience tables.

4.2. References

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5. Step 4: Plan Development

The planning team can next evaluate gaps between desired and anticipated performance of the built environment and identify solutions based on information about the community, its social dimensions, and the condition of the built environment. Solutions can be based on combinations of administrative and construction options, and multiple solutions may be proposed. Based on the long-term community goals and the most significant or serious gaps in performance, proposed solutions can be prioritized and selected. Strategies are then developed to identify opportunities and methods to implement the solutions as opportunities and funding become available.

5.1. Evaluate Gaps Between Desired and Anticipated Performance

The information in the compiled tables provides a record and a visual presentation of the recovery time gaps between the desired performance levels of the built environment and the anticipated performance. It should be relatively easy to identify those gaps, and to see differences between community expectations and the reality of current buildings and infrastructure systems.

5.2. Identify Potential Solutions to Address Gaps

With the gaps articulated, potential solutions for the built environment can be identified and evaluated. There may be multiple solutions or multiple stages to meet desired performance goals, including solutions to meet immediate needs as well as long-term, permanent solutions.

Both administrative and construction solutions should be considered. Each type can improve performance, reduce damage during hazard events, advance efforts to restore functions within desired timeframes, and improve overall community resilience.

Some administrative activities have low implementation costs and can yield significant long-term benefit. All communities, large and small, can identify and commit to implementing these kinds of solutions to support their needs.

Sometimes administrative and construction solutions can be combined. When a hazard event occurs, buildings and infrastructure systems are intended to provide protection to the occupants from serious injury or death. Communities can go a long way in achieving this goal by adopting and enforcing current building codes and regulations for new construction and the retrofit of existing buildings, where necessary, for public safety or to minimize community impacts.

Construction projects can add redundancies or robustness to buildings and infrastructure systems. For some hazards, such as flooding, the threat can be redirected. Mitigation projects completed prior to significant hazard events can support long-term resilience strategies, reduce demands during recovery, and speed the overall recovery process. Mitigation projects often are construction projects, but can also be administrative in nature. For instance, communities can adopt and enforce codes and standards with local amendments that strengthen resilience or develop mutual aid agreements that support streamlined recovery processes.

5.2.1. Potential Administrative Solutions

A community may begin to address performance gaps by considering administrative solutions. The following list of suggestions is not intended to be comprehensive, nor is it intended to be prescriptive. Each community is unique based on the characteristics and goals described above. Communities may have other administrative solutions that will support their resilience goals and strategies.

1. Organize and maintain a resilience office with designated leadership. Whether full- or part-time, this office is responsible for leading development, implementation, and evaluation of community resilience strategies, including integration with other community plans, public outreach, collaboration with private stakeholders, and updating the plan on a regular basis.
2. Align and integrate the resilience plan in a comprehensive approach with other community plans (e.g., General Plan, Emergency Operations Plan, Business Continuity Management Programs and Plans, Land Use Plans, Infrastructure and Transportation Plans, Housing Plans, Economic Development Plans, and plans related to the environment). This can be a lengthy collaborative process with the responsible agencies or partners, and may require community engagement – but this activity may be the difference between success and failure of a community resilience plan.
3. Align the resilience planning concepts with the FEMA Mitigation Plan [FEMA 2013] and prioritize mitigation grant requests with the resilience plan.
4. Utilize land use planning tools to manage the green infrastructure (natural capital) that supports community goals and to set design standards for construction in high hazard zones, such as flood plains, coastal areas, areas susceptible to liquefaction, etc.
5. Develop processes and guidelines for post-event assessments and repairs that will accelerate the evaluation process and the designation of buildings that can be used during repair.
6. Collaborate with adjacent communities to promote common understanding and opportunities for mutual aid during response and recovery phases. Develop mutual aid agreements as directed by the resilience plan.
7. Inform all stakeholders by publishing the performance gaps and resilience plans in transparent and publicly available methods, including announcements of results and progress.
8. Collaborate with managers of state- and federally-owned and leased properties to meet community resilience regulations or codes, if those community requirements are more stringent.
9. Develop and conduct education and awareness programs for all stakeholders in the community to enhance understanding, preparedness, and opportunities for improving community resilience.
10. Form a service provider council of public and private infrastructure owners and provide a quarterly forum for them to meet and discuss current activities and issues, dependencies, and future plans.

5.2.2. Potential Construction Solutions

Targeted construction projects aligned with a community's resilience goals and plans can greatly enhance community resilience. The following solutions are suggested for consideration when developing resilience plans for significant long-term impacts. Again, each community is unique based on the characteristics and goals described above, and each may have its own solutions. Furthermore, each community will need to consider the costs and benefits to the public and private sectors as part of the decision process.

Existing construction

1. Identify opportunities for natural resource protection and implementation solutions. This may include sediment and erosion control, stream corridor restoration, forest management, conservation easements, and wetland restoration and preservation.
2. Retrofit public buildings to initiate the resilience implementation process in the community. This, along with relocating or reconstructing public facilities, may immediately improve the community's ability to recover from a hazard event and may provide an incentive for private building owners to do the same.
3. Develop incentives and financial support to encourage critical buildings to be retrofitted or relocated to meet community codes and regulations, and to achieve desired performance and community resilience goals.
4. Implement or augment inspection programs to identify buildings and infrastructure systems that need improvements to adequately protect life safety for the prevalent hazards.
5. Consider the appropriateness of limited mandatory relocation or retrofitting programs for critical facilities through local ordinances. Identify and communicate viable funding opportunities.

New construction

1. Adopt and enforce the latest national model building codes, standards, and regulations for the built environment, and add requirements if needed to support specific community resilience goals.
2. Assure the effectiveness of the building department in enforcing current codes and standards during permit evaluation and construction inspections to ensure that the latest processes are being followed.
3. Enhance codes and standards with local ordinances to support resilience plans, stating performance goals in a transparent manner.

5.3. Prioritize Potential Solutions and Develop Implementation Strategy

Once the gaps are evaluated and prioritized relative to community goals, strategies can be developed to mitigate damage and improve recovery of functions across the community. Implementation strategies with short-term and long-term solutions should align community goals, address prioritized gaps and needs, and be integrated into all other community plans, such as land use planning or economic development. This process is compatible with the FEMA Mitigation Plan [FEMA 2013], which many communities are using. The Guide can incorporate mitigation planning into the community resilience process as part of the planning needed to restore community functionality.

Resilience strategies should identify opportunities to improve the built environment, or build-back better. After a disaster, there is significant pressure to restore the built environment quickly. Without pre-established strategies and solutions, communities often rebuild to pre-event conditions. With advance planning, reconstruction can promote community resilience. Immediately after a major hazard event, there is often community support for higher design standards, appropriate land use changes, requirements to repair and retrofit to higher resilience levels or the need to relocate facilities.

5.4. References

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6. Step 5: Plan Preparation, Review, and Approval

Plan Preparation. Community resilience goals, plans, and implementation strategies should be documented with supporting information from Planning Steps 1 through 4 (see Table 1-2, page 17).

Some basic guidance for plan preparation can be found in a publication by FEMA [2010]:

- Keep the language simple and clear by writing in plain English.
- Summarize important information with checklists and visual aids, such as maps and flowcharts.
- Avoid using jargon and minimize the use of acronyms.
- Provide enough detail to convey an easily understood plan that is actionable.

The planning team needs to determine an appropriate level of detail for the published plan. The adequacy, feasibility, and clarity of the plan should be key criteria for determining the level of detail. The team should include documents that help explain the proposed plan and recommended solutions, but avoid providing detailed documentation, such as analysis. Additional information can be made available to the public upon request.

Planners should estimate the resources needed to execute the plan, and should indicate its level of accuracy – including an explanation of the built-in assumptions. Some solutions may require further analysis before accurate estimates can be developed. Although it is not the team's responsibility to identify funding sources for implementation at early stages, the need for resources should be acknowledged. Possible funding mechanisms can be identified, including proposed redirection of funding from other planned projects.

Plan Review. The planning team should develop and implement an outreach strategy to be certain that the community at large is aware of and understands the plan, and to increase appreciation of and support for the approach. Outreach should be an integral part of the team's operation from its initial launch, and the outreach strategy should include various engagement efforts as planning proceeds.

At a minimum, when the plan nears readiness, the team leaders should consider doing the following:

- Have the draft plan reviewed by appropriate community government officials and other area governments, likely before it is released to the public. Involving these officials in planning and keeping them abreast of efforts along the way will improve the plan's accuracy and relevance and reduce the time required for final review.
- Make the draft plan available for public review in electronic and print formats in readily accessible locations. Posting on public websites is highly recommended. Accommodation may be required for special populations; for example, language issues may need to be addressed so that all interested members of the community are able to review the draft and participate in the public comment process. The plan should be available in alternate formats, upon request, to maintain compliance with the Americans with Disabilities Act.

A number of outreach options are available:

- Use various social media to announce the draft to the community.

- Hold one or more public meetings to present and discuss the draft plan with the community; encourage and prepare for media attendance at all public meetings. Conducting separate events for the news media are an additional consideration.
- Arrange one or more meetings with individual stakeholder groups whose cooperation will be vital for successful implementation of the plan. Some of these meetings may take place, before the public review process begins, to ensure the accuracy and relevance of the draft report.
- Ensure that employees of all government agencies with responsibilities under the plan are aware of and informed about the draft plan.
- Collect public comments and make them available to the community.

Community meetings, forums, and other forms of outreach can promote understanding about the community goals, social needs, existing buildings and infrastructure systems, prevailing hazards, and short- and long-term benefits of the proposed solutions and actions. For short- and long-term success, transparent public collaboration and support processes are a necessity.

Changes should be expected during this review process as the larger community weighs in on the community resilience plan. It is likely that compromises will need to be made to reflect stakeholders' varying points of views. Vigorous discussion is often a prerequisite for, and a good indicator of, a plan that reflects a diverse community. Healthy engagement at this level and during the plan's review may lead to a plan of action that garners broad support and the level of commitment necessary for long-term success in improving community resilience.

Plan Approval. Once the community plan for improving resilience is finalized with stakeholder and community input, the plan should be adopted formally by the community's governing body. Formal adoption by the community is needed to ensure that the plan will influence local government activities, to encourage and lay the foundation for collaborative agreements with private owners and stakeholders, and to provide a basis for implementation through local statutes or ordinances. Formal adoption also establishes the authority required for changes and modifications to the plan, and is the basis for budget-related actions that may be required in order to gain access to the necessary resources.

References

FEMA (2010) Developing and Maintaining Emergency Operations Plans, Comprehensive Preparedness Guide (CPG) 101, Version 2.0, Federal Emergency Management Agency, Washington, DC.

7. Step 6: Plan Implementation and Maintenance

Plan Implementation. Community resilience leaders and staff should develop and maintain a plan to track and document the implementation of adopted strategies and solutions. Implementation also requires continued active outreach and communication with the stakeholders involved in the plan's development and adoption – and with the broader community – through a variety of mechanisms.

With the planning portion of the six-step process complete – for now – the "heavy lifting" shifts from the planning team to the government offices and private sector organizations responsible for execution that will turn the plan into action.

The approved community resilience plan should be incorporated into these organizations' priorities and related policies, plans, and programs. To maintain momentum and continuity and to assure that the plan receives the persistent attention that it will need, it is critical that the governing body of the community designate a leader responsible for tracking, coordinating, and communicating resilience-related efforts. This can be the community resilience leader for the planning team, or the responsibility can shift to another office or official. This is an important decision, and one that should ensure that resilience does not become the province of an existing government function (e.g., public safety) to the exclusion of other functions. Nevertheless, the organizational structure selected is less important than the continuous and visible commitment to the community resilience plan, as demonstrated by the most senior leaders of the community.

If the six-step planning process has been followed, the plan will point to prioritized actions to be taken. Even so, some additional work may be needed to organize implementation strategies in terms of responsibilities, and to coordinate the flow and timing of actions so that there is a clear road map and schedule for those charged with implementation. In some cases, communities may decide to tackle the "easier" or less costly recommendations first, including administrative solutions. In other communities, leaders may decide to undertake at least one or more major actions in the built environment to ensure continued broad engagement and momentum. The resources available and the timing of budgets may help to determine which actions are taken first and those that will be scheduled for a later date.

The adopted community plan needs to be reviewed on a regular basis, consistent with the community's planning cycles. Progress can be tracked and publically posted. It is also important to report regularly on support garnered, challenges encountered, changing conditions, and benefits accrued over time.

The resilience plan, including the implementation strategy or specific solutions, may need to be modified depending on changes in the social, physical, characteristics of the community, unexpected events, or improved understanding of the built environment and impact of prevailing hazards.

Plan Maintenance. Ideally, the community resilience planning team will recommend a process for reviewing, evaluating, and revising the plan on a recurring basis. The resilience plan, including the implementation strategy or specific solutions, may need to be modified depending on changes in the social or physical characteristics of the community, unexpected events, or improved understanding of the built environment and the impact of prevailing hazards. These include the availability of innovative technological approaches to strengthen the performance of buildings and infrastructure. They also include lessons learned during implementation of the plan.

The initial part of plan maintenance is monitoring progress. A high priority on communicating progress and challenges is needed to achieve the following goals:

- Help the community to keep its focus on, and support for, implementing the plan, including the many stakeholders who participate in or benefit from its implementation.
- Ensure that the plan is adjusted for new information, insights, and circumstances.

The following key events are likely triggers for considering a review of the plan [FEMA 2010]:

- A major incident.
- A change in operational resources (e.g., policy, personnel, organizational structures, management processes, facilities, equipment).
- A formal update of planning guidance or standards.
- A change in elected officials.
- Major hazard-related exercises.
- A change in the jurisdiction’s demographics or hazard or threat profile.
- A change in the acceptability of various risks.
- The enactment of new or amended laws or ordinances.

References

FEMA (2010) Developing and Maintaining Emergency Operations Plans, Comprehensive Preparedness Guide (CPG) 101, Version 2.0, Federal Emergency Management Agency, Washington, DC.

8. Future Directions

8.1. Feedback on the Guide

NIST teamed with a broad cross-section of public and private sector stakeholders and experts to develop this Guide. A broad network of stakeholders has been engaged through workshops around the country, the solicitation of public comments, and direct interactions with community officials and others.

NIST encourages comments and feedback on the Guide. It will be especially valuable to have communities and those with responsibilities for, and expertise with, the built environment to offer reactions and recommendations for improvements. Based on responses to the Guide, NIST may revise it in the future. To facilitate this process, NIST would welcome answers to the following questions:

- Is this Guide useful in helping communities to better plan for disaster resilience? If so, in what ways is it useful? If not, how is it lacking?
- Is this Guide leading to improved resilience planning and execution at the community level?
- How can the Guide be better organized or presented?

Send comments to resilience@nist.gov.

8.2. Community Resilience Panel for Buildings and Infrastructure Systems

NIST is establishing a Community Resilience Panel for Buildings and Infrastructure Systems (Panel). The Panel is a forum to achieve broad stakeholder collaboration and consensus around goals and actions needed to achieve community resilience and to derive benefits from that improved resilience. The Panel will carry out its mission through a number of activities:

- Engaging and connecting community and cross-sector stakeholders by creating a process to encourage and support community resilience that focuses on buildings and infrastructure.
- Identifying policy and standards-related gaps and impediments to community resilience planning and execution.
- Raising awareness of sector dependencies and cascading effects of disasters.
- Identifying or developing consistent resilience definitions and metrics for use across sectors.
- Contributing to current and future resilience guidance documents (including the Guide).
- Reducing barriers to achieving community resilience.
- Developing and maintaining a Resilience Knowledge Base (RKB), a web-based repository for documents, data, tools, etc.

The Panel is engaging stakeholder interests that include, but are not limited to, community planning, disaster recovery, emergency management, business continuity, insurance/re-insurance, state and local government, standards and code development, and the design, construction, and maintenance of buildings and infrastructure systems (water and wastewater, energy, communications, transportation).

More information is available at www.CRPanel.org.

9. Community Resilience Planning Example – Riverbend, USA

This example uses a fictional community, called Riverbend, USA, to walk through the six-step process presented in the Guide. Riverbend is not intended to capture all possible aspects or complexities of community functions or the built environment. Rather, it is intended to help users of the Guide better understand aspects of the planning process, and assist them in applying the Guide in their own communities. The solutions used in Riverbend may or may not be appropriate for other communities. NIST encourages each community to determine its own path forward to improve community resilience.

9.1. Introduction

Riverbend is a community with a population of approximately 50,000. It is situated in a valley along the Central River that was settled by farmers and loggers over 160 years ago because of the area's fertile farmland and abundant timber resources. The Riverbend economy is driven by agriculture, manufacturing, finance, and real estate development. It is a typical middle-class city with a median household income close to the national average. Over the past few years, the logging and mining industries have experienced a downturn. Nevertheless, the city has been successful in transforming its economy by attracting employers to its other growing economic sectors.

Ms. Smith grew up in Riverbend and returned to live there after her community of Rockyside suffered the devastating impact of a flood. Ms. Smith was a former city council member in Rockyside, and was subsequently elected to the Riverbend City Council one year later.

Deeply affected by the flood she experienced in Rockyside, Ms. Smith advocated for development of a plan to make Riverbend more resilient. In making her case to the Mayor and other community leaders, she noted that Riverbend had hazard risks similar to Rockyside and warned a similar event could happen in Riverbend. Ms. Smith completed some research and believed the new NIST Guide contained a methodology flexible enough for her community, and that Rockyside might have fared better if it had developed and implemented resilience plans. After several lengthy discussions with other City Council members, the Mayor asked Ms. Smith to call and lead a City Hall meeting to engage the community. The goal of the meeting was to gauge and build support for developing a community resilience plan.

At the City Hall meeting, a majority of those who attended supported developing a plan to make Riverbend's buildings and infrastructure systems more resilient. Several community groups were concerned at first that there would be many difficult challenges in developing a plan, and were particularly worried about the cost to support such an initiative. However, after additional discussion about the importance of resilience in their community, residents saw the benefits of living and working in a more resilient community and Riverbend moved forward with developing a resilience plan. Many participants at the meeting wanted to be included in the process and offered help. As a result of the support at the meeting, Ms. Smith was appointed by the Mayor to lead the formation of a planning team and follow through with the methodology presented in the Guide. With approval of the City Council and support of the community, Ms. Smith began with Step 1.

9.2. Step 1: Form a Collaborative Planning Team (Chapter 2)

Achieving community resilience requires a broad base of support from stakeholders. As Riverbend would likely need assistance from neighboring communities, regions, and the state, Ms. Smith recognized that she needed to identify and engage public and private stakeholders within the community, as well as from Fallsborough, the city across the river. Ms. Smith established a large work group representing a broad cross section of Riverbend. She made sure to include those who could help define social needs. Her vision for the organization of the planning process included a planning team overseen by the city council, and seven task groups, as shown in Figure 9-1.

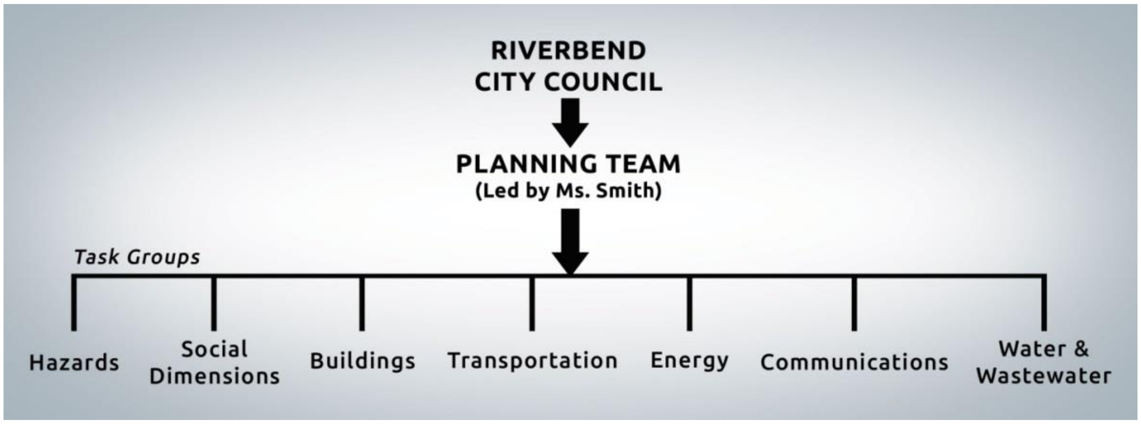

Figure 9-1: Riverbend, USA planning team and stakeholder task groups

The planning team was responsible for leading development of the resilience plan. The team reported to the City Council, which oversaw the process and would approve the final resilience plan. An important part of the planning team's responsibility was coordinating the task groups. A representative from each task group was included on the planning team to coordinate between the groups and to address dependencies among buildings and infrastructure systems. The responsibilities of the task groups were articulated as follows:

- ***Hazards Task Group –*** Identify potential hazards and appropriate scenarios so the buildings and infrastructure systems task groups can determine the anticipated performance of the built environment.
- ***Social Dimensions Task Group–*** Determine the social needs and priorities of the community and determine the time after a hazard event when these needs must be met. Table 9-2 lists the representatives of the social dimensions task group by social institution.
- ***Buildings Task Group–*** Identify and classify the buildings within Riverbend into one of the four building clusters described in the Guide (i.e., critical facilities, emergency housing, housing/neighborhoods, community recovery) based on how they meet the community's response and recovery needs.
- ***Transportation Task Group–*** Identify and characterize the transportation systems within the city boundary and the transportation network at the state and regional level, and how these systems meet response and recovery needs.

Table 9-1: Riverbend, USA government leaders and community stakeholders

City Council	Planning Team	Hazard Task Group
• Mayor • Four commissioners • Auditor	• Resilience lead (Ms. Smith) • City manager • City engineer • Public works representative • City planner • Riverbend Office of Emergency Management • Buildings department • Finance representative • Community outreach/ public information • Representative from each task group	• State geological survey • Riverbend Department of Community Development • University hazard specialist(s) • Flood plain manager • U.S. Army Corps of Engineers • Department of Environmental Protection
Social Dimensions Task Group	**Buildings Task Group**	**Transportation Task Group**
• See Table 9-2 for representatives by social institution.	• Building owners • Critical facility managers (hospitals, schools) • Privately owned building stock representative(s) • Local industry facility managers • General contractor • Real estate representatives • Engineers • Developers • Construction firms • Fire department • Land developers	• State and county Departments of Transportation • Engineer from Riverbend Department of Public Works • Railroad representatives • Emergency management representatives • Traffic engineer • Bridge engineer
Energy Task Group	**Communications Task Group**	**Water and Wastewater Task Group**
• Regional generation representatives • Distribution system provider (load serving entity) • Electric power engineer • Riverbend Office of Emergency Management • Liquid fuel distributor • State Public Utility Commission (PUC) • State Department of Energy	• State PUC • Telecommunication service providers • Riverbend Office of Emergency Management	• Riverbend Department of Public Works • Fallsborough water engineer • Emergency manager of regional fire and rescue • Environmental quality agency

Table 9-2: Social Dimensions Task Group by social institution

Family and Kinship	Economic	Government	Health
• Neighborhood representatives • Citizens groups	• City Chamber of Commerce • Retail managers • Gas station managers • Banking and finance sector • Local major industries	• Police and fire/EMS • City Department of Parks and Recreation • Senior living center • Aging and people with disabilities services • Courts	• Local health department • Hospitals • Urgent care/health offices • Behavioral health care providers
Education	**Community Service Organizations**	**Religious and Cultural**	**Media**
• Public schools • Private schools • Community college / higher education	• Shelter/food bank representatives • American Red Cross • Recreational/civic clubs or groups	• Local religious, cultural, or belief groups	• Local media outlets

- ***Energy Task Group–*** Identify and characterize infrastructure systems for electric power, natural gas, and liquid fuel systems, and for a hydroelectric dam, and their role in supporting response and recovery needs.
- ***Communications Task Group–*** Identify and characterize communication systems, including wireline, cellular, broadcast, and cable systems, and their role in supporting response and recovery needs. Additional responsibilities included coordinating with emergency response agencies to support emergency communication needs.
- ***Water and Wastewater Task Group–*** Identify and characterize water and wastewater infrastructure systems, and their role supporting response and recovery needs. Additional responsibilities included coordinating with the public health authority, environmental quality agency, firefighters, hospitals, and others to meet community needs.

The task groups largely worked in parallel, and at times jointly, with oversight from the planning team throughout the planning process. To promote team member participation, particularly for members outside the local community, face-to-face meetings were supplemented with virtual meeting capability (e.g., teleconference, webinar, and video conference).

9.3. Step 2: Understand the Situation (Chapter 3)

Once the planning team and task groups were created, the next step was to characterize both the social and built environments. The planning team assigned the social dimensions task group to characterize the social environment in a report. Similarly, the planning team asked each of the building and infrastructure system task groups to characterize their portion of the built environment. The hazards group was tasked to complete a report on the potential hazards that Riverbend might face. These reports were completed in parallel, using the guidance in the NIST Guide. The planning team, with representatives of each task group, then worked together to determine the links between the social and built environments. The following sections summarize the reports of the task groups, except for the hazards task group, which is addressed in Step 3.

9.3.1. Identify and Characterize the Social Dimensions (Section 3.1)

Riverbend is a typical middle-class city with an economy (Table 9-3) consisting of trade, government, manufacturing, education and health services, finance and business services, hospitality, and construction. One of the largest single employers is the National Aircraft Parts (NAP) factory. NAP manufactures aircraft parts for the region and employs over 3,000 people, many of whom live in Riverbend. NAP is also the sole supplier of several equipment components critical to the U.S. military. Approximately 40 % of the community's workforce is employed by small businesses. As the mining and logging industries have declined, Riverbend has successfully transformed its economy by attracting employers to its growing professional and business services, health services, and transportation sectors.

According to the 2010 United States Census, the median household income is slightly above the U.S. national average at $52,612 (see Table 9-4). Almost 20 % of the population, 25 years and older, have a four-year degree or higher. Statistics show the diversity in age of the city, with 40 % of the population under the age of 18, and 13 % of the population 65 years of age or older. Additionally, approximately 15 % of the population in Riverbend has a disability (includes those needing aid for mobility or access), as defined by the U.S. Census Bureau.

Table 9-3: Employment for Riverbend, USA

Industry	Percentage
Trade, transportation, and utilities	22
Government	18
Manufacturing	17
Education and health services	13
Professional and business services	8
Leisure and hospitality	8
Construction	5
Financial activities	4
Other services	3
Mining and logging	1
Information	1

The rate of emigration is low in Riverbend. A majority (59 %) of the housing units are owner occupied and the homeowner vacancy rate is low (2.6 %). Additionally, according to a demographic study conducted by the state university two years ago, the population of Riverbend is increasing and is expected to grow steadily over the next three decades.

Riverbend is governed by its City Council, which includes the Mayor, four Commissioners, and an auditor (see Table 9-1, page 60). The city's Office of Neighborhood Services provides a liaison between the city government and Riverbend's neighborhood associations. Riverbend has an active parks and recreation department that maintains widely-used bike paths, local parks, and walking/hiking trails. Additionally, there is a popular senior center and several golf courses located in the area.

The city is served by Central Regional Fire and Rescue, a special purpose district providing firefighting and emergency services. Because Riverbend is so close to the Central River, two of the four fire stations within Central Regional Fire and Rescue have water rescue capabilities. Additionally, there is a close relationship between the Central Regional Fire and Rescue and the Riverbend Department of Public Works. The police department has over 80 staff members – one third of whom are civilian – to provide services.

Riverbend's health system offers a variety of health services, including mental health services. The county department of health is located within the city limits. Additionally, Memorial Hospital provides a 76-bed facility, with over 130 health care providers on staff. There also are two urgent care facilities and a local non-profit healthcare provider in the city.

Riverbend is served by a public school district and a few private schools. There are a total of 23 K-12 public schools within the school district, serving approximately 9000 students. A two-year community college, which serves over 12,000 students, is located on the north edge of the downtown area.

Riverbend offers several programs to provide social support to those in need. Two food banks serve approximately 10,000 people each year from around the region. The city also has a homeless shelter that provides food, shelter, clothing, counseling and mental health referrals to over 100 homeless people each day.

Riverbend has local print and radio media. The city relies on nearby Fallsborough for local television news.

Table 9-4: Riverbend, USA population demographics

Demographic	Values
Household income under $35,000	32%
Household income over $100,000	13%
Median household income	$52,612
Households from different state within last 5 years	11%
Population (25 +) with four year degree or higher	18.4%
Population (25+) with graduate degree	6.1%
Ratio of Transfer Payments* to Earned Income	18%
Households receiving Food Stamp/SNAP benefits	15%
Unemployment rate	5.5%
Population below 18 years	40%
Population 65 years of age or above	13%
Population with disabilities	15%
Employed population, uninsured	82%
Unemployed population uninsured	63%
Gender (female)	51%

*Social security and public assistance

Overall, the residents of Riverbend have a good quality of life. A healthy percentage of residents are employed either inside or near the community. There is limited public transportation available, but most households have at least one vehicle, with 90 % relying on personal transportation (including carpool) to commute to and from work. Historically, the unemployment rate has been close to the national average. Riverbend has very active government and community groups. Many neighborhoods have citizen watch groups, and they have become involved in safety-related city government decisions.

Once the social dimensions task group characterized the social environment, they worked to identify the dependencies among and within Riverbend's social institutions. Following the Guide's methodology, the task group recognized that a disruption in the built environment that affects one social institution is likely to affect others. Using the templates provided in Chapter 10, Volume II of the Guide (Tables 10-3 and 10-4), the group identified ways in which the social institutions in Riverbend depend on each other, and identified each institution's internal dependencies. For example, the residents rely on businesses including National Aircraft Parts for employment, and services such as daycare.

The team also identified an important dependence for the city's services, particularly in the wake of a disaster. With severe disruption to services and damage to the built environment, there might be a diminished workforce available to perform those services. Immediately after the event, fire and police services, emergency medical services, and other emergency operations could be hindered. Longer-term, it could affect Riverbend's tax base, especially if people left the community.

Filling out the Guide's tables with information specific to Riverbend helped the task group better understand these dependencies—information they then shared with the rest of the planning team. This process helped identify the functions that are most critical during various phases of a hazard event and to identify potential vulnerabilities that may result from cascading failures in other infrastructure systems.

9.3.2. Characterize Built Environment (Section 3.2)

The buildings and infrastructure systems within and surrounding Riverbend were built over a long period of time. Roughly one-third of the downtown area lies within the 100-year flood plain. Most of the buildings and infrastructure in the downtown area were constructed soon after the city was founded, and are older than the rest of Riverbend. Following a downturn of the logging industry in the 1970s, the downtown area declined, and many residents moved into other neighborhoods. The city limits expanded, and the associated infrastructure to support this geographic growth absorbed much of Riverbend's resources. Downtown became characterized by lower-income residents and smaller businesses.

In the past 10 years, an improved economy has made downtown more attractive and there is significant reinvestment in the downtown building stock and urban renewal.

As discussed previously, each of the building and infrastructure system task groups was asked to develop a brief report on the status of their portion of the built environment. The following summarizes their key findings.

Buildings. The building stock in Riverbend ranges from unreinforced masonry buildings constructed over 100 years ago to mobile homes and single unit timber-framed houses built from 1950-1990. There also are modern steel mid-rise buildings, mainly for commercial or industrial purposes. A significant number of unreinforced masonry buildings remain downtown adjacent to the river. Table 9-5 summarizes buildings by occupancy class. The Riverbend task group also grouped buildings by age and state of maintenance to better understand their characteristics.

Transportation. Riverbend is bisected by an interstate freeway. It also includes state, county, and local roadways. Although there are other transportation systems in the region, including a regional airport and freight rail line, people rely on the roadway system for personal transport and goods are delivered by truck. The regional airport is located 48 km (30 miles) away from Riverbend, and has limited commercial airline service.

Only one bridge crosses the Central River. It is a 4-lane interstate bridge that is the primary crossing of the Central River in the region – completed in 1955 and widened in 1980. The next crossing of the Central River is 16 km (10 miles) north. The bridge also carries the water main from the Fallsborough Water Treatment Plant into Riverbend, an important dependency between the transportation and water systems. Therefore, failure of this bridge would significantly disrupt water service to the residents and businesses of Riverbend.

Table 9-5: Building occupancy class and building count

Occupancy Class	No. Buildings	Occupancy Class	No. Buildings
Residential		**Industrial**	
• Single family dwelling	11,131	• Heavy	65
• Mobile home	1,292	• Light	45
• Multifamily dwelling	3,073	• Food/drug/chemicals	13
• Temporary lodging	9	• Metals/minerals processing	4
• Institutional dormitory	30	• High technology	-
• Nursing home	5	• Construction	147
Commercial		• Agriculture	38
• Retail trade	175	• Religion/non-profit	77
• Wholesale trade	88	• Government	
• Personal and repair services	176	▪ General Service	27
• Professional/technical services	270	▪ Emergency response	9
• Banks	18	• Education	
• Hospital	3	▪ Grade schools	30
• Medical office/clinic	62	▪ College/university	10
• Entertainment/recreation	122		
• Theaters	5		
• Parking	-		

Within the downtown area, many people rely on transit bus service for mobility. Commuter bus service to Fallsborough provides transit access for workers. However, personal automobiles are the primary means of mobility for the majority of the population, and traffic during peak commute times is a frequent complaint for residents.

Energy. Riverbend Gas and Electric is an investor-owned utility that provides power and natural gas to Riverbend. It purchases power from a hydroelectric power plant located in Fallsborough that is maintained by the U.S. Army Corp of Engineers. There are no petroleum refineries in the city. Liquid fuel is transported to Riverbend via a liquid fuel pipeline from the neighboring major industrial center.

Electric power distribution is predominantly through overhead transmission lines with a single crossing of the Central River.

Communications. One national and one regional telecommunication company provide internet, cellular and wireline phone, and cable services to residents and businesses in Riverbend. Though these companies operate within a competitive environment, they have managed to co-exist and work together. The smaller, regional company has similar technology and shares infrastructure with the national company. In fact, the smaller regional service provider leases space from the national company's regional Central Office, located outside of Riverbend.

Water and wastewater. Riverbend does not have a water treatment plant. It gets its drinking water from Fallsborough, which is a wholesale provider selling treated water to a number of neighboring cities. Riverbend relies on County Environmental Services to treat sanitary sewage and storm water. The Riverbend Department of Public Works is responsible for designing, constructing, operating, and maintaining the city's water and wastewater infrastructure.

9.3.3. Link Social Dimensions and the Built Environment (Section 3.3)

Once the task groups characterized the social and built environments, representatives of the task groups worked with the planning team to link the social needs and institutions to the built environment. (Note: Chapter 10 in Volume II of the Guide provides examples of how to accomplish this goal). This is a key step in the process of addressing community resilience because the eight social institutions identified in the Guide (i.e., government, education, economics, health, family, media, religious/cultural groups, and community service organizations) rely on the built environment to function.

Following the approach in the Guide, the Riverbend planning team created one table for each infrastructure system (transportation, water and wastewater, energy, and communication) and for buildings. For each social institution, the table provides the following information:

1. Purpose of the infrastructure system or buildings
2. How that purpose is actualized
3. Direct and indirect consequences for individuals, groups, and the community when hazard events lead to degraded functionality

The Riverbend planning team found that identifying the direct and indirect consequences of a hazard event was particularly useful for developing priorities and community performance goals when planning for resilience (the next step in the process – see Section 9.4).

Table 9-6 shows a partially completed table that links the social institutions and transportation systems. Although the entire table was completed by the Riverbend planning team, the table presented here displays only their highest priorities. Table 9-6 shows that the transportation network of roads and the one interstate bridge are used to distribute goods for processing, as well as final goods for sale. The transportation network of roads and the interstate bridge allows consumers to access goods and services and provide a means for the workforce to go to and return from work. The regional airport (located outside of the community) is also included in the table, but it only provides limited commercial flights. The table also shows how the loss of any of these systems could disrupt the supply chain (i.e., the supply, manufacture, and distribution of goods and services) and increase the time commuters would spend on the road and their commuting costs. Indirect impacts are also listed in Table 9-6 to capture the potential for cascading effects. The team noted that supply chain disruptions could lead to short- and long-term business losses, rising prices, reduced competitiveness, and dwindling market share.

Table 9-7 shows how the Riverbend planning team characterized their social institutions' reliance on the buildings within their community. Table 9-7 only shows the highest priority links identified by the planning team. The table emphasizes the importance of the city's downtown area to the city's economy, as well as the importance of the local government to the day-to-day operation and overall safety of the city.

Table 9-6: Links between Riverbend's social institutions and transportation systems

Social Institution	Purpose of Transportation within each Social Institution	How Actualized within Built Environment	Possible Impacts if Transportation Systems Are Damaged	
			Direct	Indirect
Family	• Access to and from housing	• 1 Interstate road • 1 freight rail line • 1 bridge for vehicular traffic • Regional airport	• Displaced population (lack of access) • Inability to physically connect with others	• Demand for short-term/ nearby shelter
Economic	• Distribute goods for processing • Obtain labor and capital • Distribute intermediate goods • Distribute final goods for sale • Bring sellers (providers) and consumers together • Getting to and from work		• Loss of access to raw materials • Loss of employment • Increase in commuting time and costs • Consumers unable to obtain goods and services	• Loss of taxes, market share • Price increases
Government				
Health				
Education				
Community Service				
Religious				
Media				

Note: Only the highest Riverbend priorities are shown in this table. The entire table was completed by the planning team.

Table 9-7: Links between Riverbend's social institutions and buildings

Social Institution	Purpose of Buildings within each Social Institution	How Actualized within Built Environment	Possible Impacts if Buildings are Damaged	
			Direct	Indirect
Family				
Economic	• Point of sale • Location of employment, gathering points • Prepare materials for transport • Store materials • House equipment and machinery • Design and develop aircraft parts	• City's downtown: ▪ Stores ▪ Restaurants ▪ Bank ▪ Salon and barbershop ▪ Internet cafe ▪ Houses and apartments • National Aircraft Parts plant	• Loss of revenue • Loss of goods and services for sale • Loss of ability to manufacture goods • Loss of employment • Loss of income • Loss of housing • Loss of materials • Decrease in social capital	• Loss of taxes, market share • Price increases
Government	• Provide work and meeting space for leaders and staff • House public safety and emergency response capabilities	• Offices • Police stations • Fire and EMS stations • Emergency operations center (EOC) • Jail • Courthouse • Libraries	• Diminished emergency response • Disruption to government continuity • Loss of archived materials	• Increased casualties and economic damage
Health Care				
Education				
Community Service				
Religious				
Media				

Note: Only the highest Riverbend priorities are shown in this table. The entire table was completed by the planning team.

Table 9-7 shows that the buildings within the downtown district, from an economic standpoint, primarily support three things: 1) goods and services for consumers; 2) housing; and 3) jobs for the community. The downtown district consists of small-business retail, restaurants, banks, several salons and barbershops, and an internet café, as well as houses and apartments. The community benefits from a strong economy and sales tax. The downtown buildings also provide places for people to gather and socialize, increasing the social capital within the community. The loss of the buildings in the downtown area would result in loss of employment and income for workers, access to goods and services, revenue for the businesses, and housing for the community.

Table 9-7 also shows that the manufacturing plant facility, i.e., National Aircraft Parts (NAP), serves four functions: 1) store materials; 2) house equipment and machinery vital to manufacturing aircraft parts; 3) design and develop the parts; and 4) prepare materials for transport. The loss of this facility would result in the loss of income and employment for workers, loss of access to goods, loss of materials, and loss of revenue for the plant. Without the downtown area or the NAP, Riverbend also would experience secondary losses, such as a decrease in tax revenues.

Among other functions, Riverbend's government buildings provide office and meeting spaces for community leaders and staff and house public safety and emergency response capabilities (especially important during and after a hazard event). Government buildings consist of police stations, fire and emergency medical services (EMS) stations, an emergency operations center, mixed office spaces, a jail, a courthouse, and a library. The loss of any of these structures could disrupt continuity of government services. Damage to critical facilities could lead to diminished emergency response.

Although the transportation system and buildings were high priority concerns for Riverbend, the planning team recognized that dependencies were a key consideration. Buildings would not be functional without services from the supporting infrastructure systems: energy, transportation, water and wastewater, and communications. That led Riverbend planners to think about the dependencies between buildings and infrastructure systems, focusing on the continued functionality of critical downtown buildings that could have major impacts on public safety and the economy if they were damaged badly.

As they considered dependencies and social needs, the planning team worked with the task groups to identify the building clusters and supporting infrastructure systems. Table 9-8 shows the building clusters identified by the Riverbend planning team: Critical Facilities, Emergency Housing, Housing/Neighborhood/Business, and Community Recovery. That table also shows some specific buildings that were included in the building clusters. Since interruptions to the NAP factory's operations could be costly to the local and regional economies and impact the nation's military readiness, the planning team decided to categorize NAP as part of the Critical Facilities cluster.

Table 9-8: Riverbend, USA building clusters grouped by functional category and recovery phases

Building Clusters	
Critical Facilities (Short-Term)	**Housing/Neighborhoods/Business (Intermediate)**
1. Police and fire/EMS stations 2. Emergency operations centers 3. Memorial hospital and urgent care facilities, including pharmacies 4. Disaster debris and recycling centers 5. National Aircraft Parts (NAP) Factory	**1.** Waste management facilities **2.** Schools **3.** Medical provider offices **4.** Downtown district **5.** Local businesses outside of the downtown area **6.** Daycare centers **7.** Religious/cultural centers/facilities **8.** Fitness centers **9.** Buildings or space for social services (e.g., child services) and prosecution activities
Emergency Housing (Short-Term)	**Community Recovery (Long-Term)**
1. Residential shelter-in-place **2.** Food distribution centers **3.** Animal shelters **4.** Faith and community-based organizations **5.** Emergency shelter for emergency response and recovery workers **6.** Gas stations **7.** Banking facilities	**1.** Residential housing **2.** Commercial and industrial businesses, except National Aircraft Parts Factory **3.** Non-emergency city services **4.** Resilient landscape repair, redesign, reconstruction, and repairs to domestic environment

9.4. Step 3: Determine Goals and Objectives (Chapter 4)

After the planning team worked with the task groups to characterize the social and built environments of their community, they were ready to move forward in developing their community resilience plan.

9.4.1. Establish Long-Term Community Goals (Section 4.1.1)

The resilience plan is most effective if it supports long-term community growth and development goals. The planning team and task groups worked to identify long-term community goals based on existing community plans and input from community agencies and organizations. Three long-term goals and metrics were identified for Riverbend:

1. Minimal disruptions to daily life and commerce
   - Metric: Average commute time
2. Stable employment and new, diversified businesses to support economic growth
   - Metrics**:** Jobs added; tax base value
3. Improved ability of government services and critical facilities to function after hazard events
   - Metrics: Government services outages (number); disaster response drill performance; emergency response time

9.4.2. Establish Desired Performance Goals for the Built Environment (Section 4.1.2)

The planning team reviewed the links between the social and built environments to understand how building and infrastructure systems supported their social needs and institutions. Desired performance goals for buildings and infrastructure systems were determined independently from the type of hazard faced by the community. The desired performance goals were set to support community services before and after hazard events, including the sequence of services needed after an event.

The following high-level performance goals were set for each hazard level (routine, design, and extreme):

1. For routine events:
   - Meet community social needs within 1-3 days of the hazard event
   - Buildings and infrastructure systems should be fully functional within 3 days of the hazard event
2. For design events:
   - Meet critical social needs within 1 week and community social needs within 1-12 weeks
   - Complete reconstruction projects within two years of the event
3. For extreme events:
   - Preserve critical facilities, including key industry (e.g., NAP, see Table 9-8 for other critical facilities)
   - Meet critical social needs within 12 weeks
   - Complete reconstruction within 3- 4 years.

The planning team then worked with the building and infrastructure task groups to develop performance goals for building clusters and infrastructure systems to meet these high-level goals, using the tables in Chapters 12 to 16 (Volume II) of the Guide. Table 9-9 summarizes the tables presented in this example. However, only the design level event is discussed in detail for the sake of brevity.

The Riverbend planning team used the functionality levels for building clusters in Table 4-3 on page 40 (30 %, 60 %, and 90 %) to indicate the recovery sequencing expected to reach their desired performance goals:

- 30 % represents the fraction of buildings within a cluster or portion of infrastructure systems that need to be functional to initiate recovery activities
- 60 % represents the fraction needed for usual (i.e., daily) operations to resume at a reduced scale
- 90 % represents the fraction needed to declare the building cluster or infrastructure system at normal operating capacity.

(Note: The performance goals are tailored for a number of buildings or infrastructure system components, such as bridges. In Riverbend, the simple example of a single bridge focuses more directly on services provided, rather than the number of bridges able to provide service.)

Table 9-9: Summary of resilience tables for routine, design, and extreme events

Hazard	Routine Hazard	Design Hazard	Extreme Hazard
Building	Table 9-18, page 88	Table 9-11, page 76	Table 9-25, page 95
Transportation	Table 9-19, page 89	Table 9-12, page 77	Table 9-26, page 96
Energy	Table 9-20, page 90	Table 9-13, page 78	Table 9-27, page 97
Water	Table 9-21, page 91	Table 9-14, page 79	Table 9-28, page 98
Waste Water	Table 9-22, page 92	Table 9-15, page 80	Table 9-29, page 99
Communications	Table 9-23, page 93	Table 9-16, page 81	Table 9-30, page 100
Summary	Table 9-24, page 94	Table 9-17, page 82	Table 9-31, page 101

The following summaries briefly describe the key considerations taken into account by the planning team and task groups when they completed the performance goals tables for the design hazard event (Table 9-11 to Table 9-16 document the desired performance goals and anticipated performance for the design hazards):

Buildings (Chapter 12, Volume II). The planning team felt that critical facilities should experience little interruption or damage in a design hazard event (see Table 9-11) since these facilities were needed to support recovery and emergency services to the rest of the community. The NAP factory was also considered a critical facility due to its high level of employment and importance to the nation's defense needs. Therefore, it was important that this facility experience minimal interruption in a design hazard event. The Emergency Housing cluster would need to perform well so it could be used in the days and weeks following a design hazard event. The planning team made this decision because they felt that the performance goals for the Housing and Community Recovery building clusters could be made less stringent if emergency housing was available. They also decided it was unreasonable to set high performance goals for certain buildings (e.g., unreinforced masonry) due to inherent limitations of this construction type.

Transportation (Chapter 13, Volume II). The planning team found that many of the example transportation system components in the Guide performance goals table (see Chapter 13 in Volume II) did not apply to their community. Therefore, they only included the appropriate components in the performance goals table completed for Riverbend (see Table 9-12).

As previously discussed, the four-lane interstate bridge over the Central River is a major concern for the community because it is the only crossing that carries traffic and supports a water pipeline into Riverbend from Fallsborough. As seen in Table 9-12, after engaging with the State Department of Transportation, the planning team decided the bridge would be inspected for structural damage the day of the hazard event to ensure it was safe for emergency vehicles. If declared structurally sound, the bridge would be reopened with one lane in each direction (this meets the nominal 60 % functionality criterion), while the exterior two lanes would remain closed to permit a detailed inspection of damage to the fascia and soffit of the bridge. All lanes would then be open, hopefully by the day following the hazard event, making the bridge fully operational (meeting the nominal 90 % functionality criterion). Although the regional airport was not within the community, the planning team worked with representatives from the airport to understand the impact a design event could have on its functionality, so Riverbend would know how disruptions might affect their businesses.

Riverbend is served primarily by local roads. The team set goals for local roads to critical building clusters to be fully operational within 1 to 3 days, including debris removal, if necessary.

Energy (Chapter 14, Volume II). Similar to the transportation table, the planning team used the relevant rows in the energy performance goals table in Chapter 14. Riverbend's energy is generated solely by a hydroelectric power plant. Interruption to this facility would shut down the power system, which could in turn cause critical facilities within the city to become non-functional after their standby power is expended. As they collaborated, Riverbend planners were told by operators that the power plant was designed to continue functioning in a design event, and that was a reasonable goal.

For power infrastructure serving critical facilities, the team set a goal of being able to continue operations during or immediately after the hazard event and operate at full capacity the next day (see Table 9-13). In general, the restoration of the transmission and distribution infrastructure needed to be restored to building clusters within 1 to 3 days.

Communications (Chapter 15, Volume II). The planning team recognized that working with local service providers was essential to setting realistic performance goals for communications infrastructure. The regional and national telecommunications companies that served Riverbend work together in many ways. They share a regional Central Office and exchange nodes. The service providers told the community planners they thought it was reasonable to assume that these nodes would perform well in a design hazard event because of the recent construction and quality of the facilities.

The communication service providers worked with the resilience team planners to understand community priorities and desired performance goals. In terms of the 'last mile' (i.e., distribution system), the performance goal of little or no disruption to critical facilities such as hospitals, fire stations, and the emergency operations center (EOC) was set (see Table 9-16) to facilitate emergency services and recovery of function. The service providers understood the performance goals, but stated it would take 1 to 4 weeks (typically 1 week) to restore full functionality to communications infrastructure serving other building clusters. The community agreed that this was reasonable.

Water (Chapter 16, Volume II). With only one water main crossing the river from Fallsborough to Riverbend, water supply is a major concern. Critical facilities need a water supply within 1 to 3 days to remain fully functional. In addition to potable water, facilities also need an adequate water supply for fire sprinklers if they are occupied. The team concluded that housing and businesses could do without potable water for up to one week (indicated by the 90 % in Table 9-14). Temporary water supplies brought into the community would serve as a stopgap measure until then.

Wastewater (Chapter 16, Volume II). It was important that the wastewater infrastructure system not pollute the river with raw sewage, and that backups and overflows did not impact the community. The planning team set a goal of one week for the wastewater treatment plant to be operating with primary treatment and disinfection (indicated as 1 to 4 weeks in Table 9-15). However, they realized that meeting all regulatory requirements may take some time after a design event, and therefore set a goal of meeting those requirements in 6 months (shown as 4-36 months in Table 9-15). That would result in violations of those requirements, a consequence the team was prepared to accept.

9.4.3. Define Community Hazards and Hazard Levels (Section 4.1.3)

Identifying the community's prevailing hazards was the next step. Working in parallel with the other groups, the hazards task group reviewed existing hazard maps and historical events that had struck

Riverbend. Earthquakes and flooding were the main hazards that affected Riverbend (Table 9-10). Seismic hazards typically have a lower probability of occurrence (or longer mean recurrence interval, MRI) for the same 50-year period due to their sudden, unpredictable occurrence, and lack of warning time.

Table 9-10: Hazards considered by Riverbend, USA

Hazard	Routine	Design	Extreme
Earthquake	50 year MRI or 64% in 50 years	500 year MRI or 10% in 50 years	2,500 year MRI or 2% in 50 years
Flooding	50-year MRI or 64% in 50 years	100-year MRI or 39% in 50 years	500-year MRI or 10% in 50 years

Three levels were identified for each hazard: a routine event, a design event, and an extreme event. Section 4.1.3 defines the three hazard levels as follows:

- ***Routine –*** Hazard level is below the design level for the built environment and occurs more frequently. This event has a high probability of occurring (on the order of 40 % to 60 % over a 50-year period, as indicated in Table 4-4). At this level, resilient buildings and infrastructure systems should remain functional and not experience any significant damage that would disrupt social functions in the community.
- ***Design –*** This is the hazard level used in codes and standards for buildings, bridges, and similar physical infrastructure systems. Design-level events tend to have a probability of occurring on the order of 10 % over a 50-year period for ordinary structures (e.g., see risk category II, Section 12.2, Volume II). The design hazard level for a specific building or infrastructure component may be greater than that for ordinary buildings, as required by its classification in the adopted codes. Buildings and infrastructure systems should remain functional enough to support the response and recovery of the community as defined by the performance levels.
- ***Extreme*** – This exceeds the design level for the built environment. (Seismic hazards refer to the maximum considered event, which has a probabilistic basis that is supplemented with historical data.) Extreme events have a small probability of occurrence (on the order of 2 % to 3 % over a 50-year period). They also may include anticipated long-term changes in hazards due to climate change. This might not be the greatest hazard level that can be envisioned; rather it is one that the community believes is possible. Critical facilities and infrastructure systems should remain at least minimally functional at this level. Other buildings and infrastructure systems should perform at a level that protects the occupants, though they may need to be rescued. Emergency response plans should be developed for scenarios based on this hazard level.

Riverbend experienced a major flood event in 1861 (known locally as the Great Flood), shortly after the city's founding. Because there were few buildings and little infrastructure at the time, this event did not cause significant damage. There have been a number of lesser flood events through the years, and protective measures such as levees were constructed. While the levees limit the effects of flooding, parts of the downtown area are prone to flooding and, consequently, have declined over the years. The planning team also identified the wastewater treatment plant, National Aircraft Parts factory, and the bridge crossing the Central River as potentially vulnerable to flooding. Based on their review of flood hazard maps and available historical data for Riverbend, the hazards task group selected the flood events shown in Table 9-10 for resilience.

Since Riverbend had adopted modern codes for buildings and residential construction, the seismic hazard was determined from the seismic maps for the area. Therefore, the design event was based on an event with 10 % probability of occurrence in 50 years (the 500-year event) and the extreme event was based on a 2 % probability of occurrence in 50 years (the 2500-year event). The hazards group reported to the planning team that the 500-year event was appropriate to consider for most buildings. The task group also stated that buildings and infrastructure systems identified as critical to the community should be designed to support critical functions following an extreme event.

9.4.4. Determine Anticipated Performance (Section 4.1.4)

With the agreed upon social needs of the community and the corresponding desired performance goals for buildings and infrastructure systems, the task groups next completed an analysis of the anticipated performance of the built environment for the prevailing community hazards. This analysis answers the question of how the community's existing physical systems will perform relative to the desired performance goals.

The planning team had limited funds to carry out the analysis. The task groups analyzed the existing buildings and infrastructure systems using data from past flood and earthquake events in Riverbend, reviewed standards and codes to which the structures were built, and used expert judgment to assess anticipated performance. In subsequent resilience plan reviews, the team believed that the accuracy of these analyses would likely improve as better tools became available.

Riverbend estimated the anticipated performance of their building clusters based on each hazard type (i.e., earthquake and flood) and hazard level (i.e., routine, design, and extreme). Using the same tables for the desired performance goals (Table 9-9), the anticipated performance was recorded, and provided a visual summary of the current gap between the desired and anticipated performance. An X is placed in each row to indicate the anticipated performance of existing buildings and infrastructure systems at the 90 % recovery of function level, given the hazard type and level.

Based on the anticipated performance for the building clusters and infrastructure systems, the task groups estimated the anticipated affected area and disruption level in the community for the design earthquake event (see Table 4-6). The affected area is anticipated to be at the community scale, so that while the damage is mostly contained within Riverbend, assistance may be needed from nearby communities. The anticipated disruption level is moderate, meaning that critical facilities may be functional but non-critical systems may be only partially functional.

The planning team then completed the other anticipated performance goals for the design earthquake, as shown in Table 9-11 to Table 9-16. That process is described in the following sections.

Buildings (Chapter 12 in Volume II). Much of the building stock consists of older construction that used the existing design standards and building codes. The task group identified building types that would need to be retrofit for design flood (e.g., critical buildings with first floor or equipment below flood level) and earthquake events (e.g., unreinforced masonry). The anticipated current performance is shown in Table 9-11. Occupied building types would perform unsatisfactorily in earthquake events, needing to be reinforced or demolished.

Table 9-11: Riverbend, USA building performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Building Clusters	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
		Building Performance Category								
		A			B		C			D
Critical Facilities										
Emergency Operation Centers	R, S, MS	90%							X	
First Responder Facilities	R, S, MS	90%							X	
Memorial Hospital	R, S, MS	90%							X	
Non-ambulatory Occupants (prisons, nursing homes, etc.)	R, S, MS	90%							X	
National Aircraft Parts Factory (NAP)	R, S, C	90%							X	
Emergency Housing										
Temporary Emergency Shelters	R, S	30%	90%							X
Single and Multi-family Housing (Shelter in place)	R, S	60%			90%					X
Housing/Neighborhood										
Critical Retail	R, S, C		30%	60%	90%					X
Religious and Spiritual Centers	R, S			30%	60%	90%				X
Single and Multi-family Housing (Full Function)	R, S			30%		60%		90%		X
Schools	R, S			30%	60%	90%				X
Hotels & Motels	R, S, C			30%		60%	90%			X
Community Recovery										
Businesses – Manufacturing (except NAP)	R, S, C				30%	60%	90%			X
Businesses - Commodity Services	R, S, C				30%	60%		90%		X
Businesses - Service Professions	R, S, C				30%		60%		90%	X
Conference & Event Venues	R, S, C				30%		60%		90%	X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% 60% 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Transportation (Chapter 13 in Volume II). Riverbend's transportation system consisted mostly of local roads and a bridge. The transportation task group estimated that although some of the local roads would be damaged by a design earthquake, resulting in significant cracks in the roads, the transportation system would be mostly functional within 2 weeks (indicated as 1-4 weeks in Table 9-12). There could be limited damage to the bridge crossing the Central River, but it was expected to be repaired and operational within one month.

Table 9-12: Riverbend, USA transportation infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Transportation Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Ingress (goods, services, disaster relief)										
Local Roads	R, S	60%	90%	X						
State Highways and Bridge	R, S	60%	90%		X					
Regional Airport	R, S		30%	60%	90%		X			
Egress (emergency egress, evacuation, etc.)										
Local Roads	R, S	60%	90%	X						
State Highways and Bridge	R, S	60%	90%		X					
Regional Airport	R, S		30%	60%	90%		X			
Community resilience										
Critical Facilities										
Hospitals	R, S	60%	90%	X						
Police and Fire Stations	R, S	60%	90%	X						
Emergency Operational Centers	R, S	60%	90%	X						
Emergency Housing										
Residences	R, S	30%	60%	90%	X					
Emergency Responder Housing	R, S	30%	60%	90%	X					
Public Shelters	R, S	90%		X						
Housing/Neighborhoods										
Essential City Service Facilities	R, S	30%	60%	90%	X					
Schools	R, S	30%	60%	90%	X					
Medical Provider Offices	R, S	30%	60%	90%	X					
Retail	R, S	30%	60%	90%	X					
Community Recovery										
Residences	R, S	30%	60%	90%	X					
Neighborhood retail	R, S	30%	60%	90%	X					
Offices and work places	R, S	30%	60%	90%	X					
Non-emergency City Services	R, S	30%	60%	90%	X					
All businesses	R, S		30%	60%	90%	X				

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 | 30% | 60% | 90% | Desired restoration times for percentage of elements within the cluster

3 | X | Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Energy (Chapter 14 in Volume II). The electric power system had performed well in past hazard events. The anticipated performance for the design earthquake event, indicated by the X's, are close to the desired performance goals. There was still room for improvement, however. Specifically, improving the resilience of the transmission and distribution system would help ensure the timely, sequential recovery of electric power service as desired in the community.

Table 9-13: Riverbend, USA energy infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Energy Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Power - Electric Utilities										
Community Owner or Operated Bulk Generation										
In Place Fueled Generation (Hydro, solar, wind, wave, compressed air)	R/C	90%	X							
Transmission and Distribution (including Substations)										
Critical Response Facilities and Support Systems										
Hospitals, Police and Fire Stations / Emergency Operations Centers	R, C	60%	90%	X						
Disaster debris / recycling centers/ related lifeline systems	R, C	60%	90%	X						
Emergency Housing and Support Systems										
Public Shelters / Nursing Homes / Food Distribution Centers	R, C		60%	90%	X					
Emergency shelter for response / recovery workforce/ Key Commercial and Finance	R, C		60%	90%	X					
Housing and Neighborhood infrastructure										
Essential city services / schools / Medical offices	R, C		60%	90%	X					
Houses of worship/meditation/ exercise	C		60%	90%	X					
Buildings/space for social services (e.g., child services) and prosecution activities	C		60%	90%	X					
Community Recovery Infrastructure										
Commercial and industrial businesses / Non-emergency city services	C			90%	X					
Residential housing restoration	R, S, MS, C			90%	X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 | 30% | 60% | 90% | Desired restoration times for percentage of elements within the cluster

3 | X | Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Water (Chapter 16 in Volume II). The main concern of the water and wastewater task group was that the bridge crossing the Central River was a potential point-of-failure for the water main pipe coming into Riverbend from Fallsborough. Based on past earthquake events in the region, experience, and expert judgment, the task group estimated that there would be some damage to the water main crossing the bridge in a design earthquake event, even the bridge was expected to perform well. Possible solutions included repairing or replacing the water main supports to the bridge or replacing that section of the pipe. A pipe failure could take weeks to months to repair, as indicated by the X's shown in Phase 3 of Table 9-14, so plans for a temporary water main that could be quickly put in place were also developed.

Table 9-14: Riverbend, USA water infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Water Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Source										
Raw or source water and terminal reservoirs	R, S			90%						
Raw water conveyance (pump stations, piping to WTP)	R, S				90%				X	
Potable water at supply (WTP, wells, impoundment)	R, S	30%		60%	90%			X		
Water for fire suppression at key supply points (to promote redundancy)	R, S	90%			X					
Transmission (including Booster Stations)										
Backbone transmission facilities (pipelines, pump stations, and tanks)	R, S	90%					X			
Control Systems										
SCADA or other control systems	R, S	30%		60%	90%		X			
Distribution										
Critical Facilities										
Wholesale Users (other communities, rural water districts)	R, S		60%	90%			X			
Hospitals, EOC, Police Station, Fire Stations	R, S		60%	90%			X			
Emergency Housing										
Emergency Shelters	R, S		60%	90%			X			
Housing/Neighborhoods										
Drinking water available at community distribution centers	R, S			60%	90%					
Water for fire suppression at fire hydrants	R, S				90%				X	
Community Recovery Infrastructure										
All other clusters	R, S			30%	90%				X	

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Wastewater (Chapter 16 in Volume II). The water and wastewater task group estimated that a design earthquake would cause significant damage to the wastewater treatment plant, and it could take months to years for repairs to be completed, as indicated in Table 9-15. Replacement of any heavy equipment alone could take over a year. The task group developed plans to support basic functionality with temporary measures to ensure primary wastewater treatment was provided, as needed, by the intermediate recovery phase.

Table 9-15: Riverbend, USA wastewater infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Wastewater Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Treatment Plants										
Treatment plants operating with primary treatment and disinfection	R, S			60%	90%				X	
Treatment plants operating to meet regulatory requirements	R, S				30%			60%	90%	X
Trunk Lines										
Backbone collection facilities (major trunkline, lift stations, siphons, relief mains, aerial crossings)	R, S			30%		60%	90%			X
Flow equalization basins	R, S			30%		60%	90%			X
Control Systems										
SCADA and other control systems	R, S				30%		60%	90%		X
Collection Lines										
Critical Facilities										
Hospitals, EOC, Police Station, Fire Stations	R, S			30%	90%				X	
Emergency Housing										
Emergency Shelters	R, S			30%	90%				X	
Housing/Neighborhoods										
Threats to public health and safety controlled by containing & routing raw sewage away from public	R, S		30%		60%	90%			X	
Community Recovery Infrastructure										
All other clusters	R, S				30%		60%		90%	X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Communications (Chapter 15 in Volume II). The communication task group stated that the performance goals in Table 9-16 were desirable, but they would need to work with local service providers to meet the long-term community development goals. It was noted that, based on performance for routine events, the communications infrastructure performed reasonably well, partly due to the redundancy in the network. Based on discussions with the service providers, the regional Central Office (outside of the community) was anticipated to be fully functional about 2 weeks after a design earthquake (indicated as 1-4 weeks in Table 9-16). Though it was anticipated that the 'last mile' of distribution for much of the city would not be fully functional until 8-12 weeks after a design earthquake, the task group also noted that the local service providers were already undertaking efforts that would result in performance being more in-line with the goals shown in the table.

Table 9-16: Riverbend, USA communications infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Communications Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Core Communications Buildings										
Communications Hub (e.g., Central Office, IXP, Data Centers, etc.)	R, S, C	90%			X					
Last Mile Distribution										
Critical Facilities										
Hospitals	R, S, C	90%			X					
Police and fire stations	R, S, C	90%			X					
Emergency Operation Center	R, S, C	90%			X					
Emergency Housing										
Residences	R, S, C			60%	90%		X			
Emergency responder housing	R, S, C			60%	90%		X			
Public Shelters	R, S, C			60%	90%		X			
Housing/Neighborhoods										
Essential city service facilities	R, S, C			30%	90%		X			
Schools	R, S, C			30%	90%		X			
Medical provider offices	R, S, C			30%	90%		X			
Retail	R, S, C			30%	90%			X		
Community Recovery Infrastructure										
Residences	R, S, C			30%	90%		X			
Neighborhood retail	R, S, C			30%	90%			X		
Offices and work places	R, S, C			30%	90%		X			
Non-emergency city services	R, S, C			30%	90%			X		
Businesses	R, S, C			30%	90%			X		

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% 60% 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

9.4.5. Summarize the Results (Section 4.1.5)

Develop Summary Resilience Tables. The planning team developed a summary resilience table (Table 9-17) of the desired and anticipated performance goals for the building clusters and infrastructure system. Those tables helped the planning team identify dependencies between infrastructure systems and buildings for each building cluster. These dependencies, along with the resilience gaps identified within the individual buildings and infrastructure systems, supported decisions about sequencing recovery of functions, and about which investments would best address their community resilience goals.

Table 9-17: Riverbend, USA summary resilience table of performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%							X	
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%				X	
Communication	90%			X					
Emergency Housing									
Buildings				90%					X
Transportation			90%	X					
Energy			90%	X					
Water			90%		X				
Wastewater				90%				X	
Communication				90%	X				
Housing/Neighborhoods									
Buildings						90%			X
Transportation			90%	X					
Energy			90%	X					
Water				90%				X	
Wastewater					90%			X	
Communication				90%			X		
Community Recovery									
Buildings								90%	X
Transportation				90%	X				
Energy			90%	X					
Water				90%				X	
Wastewater							90%	X	
Communication				90%			X		

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% 60% 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

9.4.6. Repeat Process for Each Hazard Type and Level

The process of determining desired performance goals and anticipated performance for building clusters and infrastructure systems was completed for each hazard type and level. The previous text in this section summarized the process used for the design earthquake event. Performance goal tables for the routine earthquake and extreme flood events are also included in this example, with the tables listed in Table 9-9 provided at the end of the example. The performance goals and anticipated performance are summarized as follows.

Routine Earthquake. The performance goal for the routine earthquake event was to experience little or no disruption to community functions, or the supporting building clusters and infrastructure systems. As shown in Table 9-18 to Table 9-23, the performance goals were mostly shifted to the left (i.e., shorter recovery time) as a result. The anticipated performance for the routine event was also estimated to be much better than for the design event, with little damage to buildings expected to occur. The summary resilience table for the routine earthquake event is shown in Table 9-24. Only a limited amount of disruption was anticipated, but this performance did not quite meet the desired performance goals.

Extreme Flood. The hazards task group found that much of the community would be vulnerable to an extreme flood event. Unlike the routine and design earthquake events, the desired performance goals were established with the expectation that many of the existing buildings and infrastructure systems were not designed for an extreme flood event, and that the community would be facing a significant recovery situation. However, future improved design and mitigation strategies were identified for critical infrastructure to achieve the desired performance goals. Table 9-25 to Table 9-30 show the desired performance goals and anticipated performance of the building clusters and infrastructure systems for the extreme flood event. Table 9-31 shows the summary resilience table. The performance goals and anticipated performance for the extreme flood event have longer recovery times than would be expected for a design event.

9.5. Step 4: Plan Development (Chapter 5 of the Guide)

Evaluate Gaps Between Desired and Anticipated Performance. Once the performance goal tables were filled out, the resilience gaps were identified (i.e., difference between the anticipated 90 % performance, X, and the desired 90 % performance goals). As can be seen in Table 9-17 (as well as Table 9-24 and Table 9-31), building clusters had some of the largest resilience gaps, and improving the performance of buildings in Riverbend was a priority. Water performance also showed a large performance gap in the summary table, and was also likely to be a priority.

Based on the three long-term community goals, the planning team worked with the task groups to identify solutions and investments would be most beneficial for Riverbend resilience. Identifying solutions to address the resilience gaps led to a long-term strategy that improved community resilience and met community goals.

Identify Solutions to Address Gaps. During the planning process, the team considered many projects that could be funded over a 50-year period to achieve the community goals. The team also identified short-term solutions that could be implemented because many of the larger investments required more resources than currently available and would be implemented over time. Administrative and construction solutions were developed by the tasks groups for consideration by the entire planning team.

Short-Term Administrative Solutions.

Communications – Charging Stations. The last mile of the communications infrastructure system was vulnerable to the earthquake and flood design event. The communications task group worked with service providers to develop potential solutions. Based upon their discussions, they recommended purchasing charging stations for cellular phones and deploying them after an event when external power is lost. These stations are commonly brought in by service providers after hazard events, but an adequate supply for businesses and residents was needed.

Long-Term Administrative Solutions.

Buildings Downtown. The part of the downtown area that is less prone to flooding has been well preserved and has flourished in recent years as restaurants and shops moved in. However, the portion of the downtown area that experiences frequent flooding has begun to languish, and small businesses in this part of town are struggling. The planning team determined whether the well-preserved part of downtown and its residents were subject to risks from more severe hazards events than recently experienced by Riverbend. The task groups found that the buildings in this area were vulnerable to a design flood and vulnerable to collapse in a design earthquake. Therefore, the task groups recommended the following actions:

- The city government should undertake buy-back programs for the downtown area. Houses and commercial properties in the 100-year flood zone and those in a state of disrepair would be purchased. These properties would be razed. To reduce negative impacts on residents, the city would financially assist residents and businesses with relocation to locations that would perform well during design flood and earthquake events. Hopefully, the relocated businesses would contribute to stabilizing employment and economic growth.
- Eventually, the land would be used to create a city-owned golf course. The golf course would provide jobs for management, food services, grounds keeping/maintenance. It would also provide a source of entertainment for residents and additional income to Riverbend, while allowing a spillway for floods.

Energy – Critical Facilities and Government Offices. The energy task group wanted to ensure government offices and critical facilities could continue operation during and immediately following a disruptive event or return to service quickly. They proposed that an energy assurance plan be developed to ensure police and fire stations, government offices, and critical facilities had sufficient power to allow them to operate emergency services until grid power could be restored. The energy task group would work with the regional electric utility to develop and implement cost-effective measures.

Short-Term Construction Solutions.

Water – Redundant Source. Pending a redundant water supply with the proposed new bridge (see long-term construction solutions), the water and wastewater task group advocated that the city restore three wells to provide a redundant water supply. These wells supplied Riverbend with water before the water main from Fallsborough was installed.

Long-Term Construction Solutions.

Buildings Downtown. The city should implement a seismic retrofit program to improve the performance of older, earthquake-vulnerable buildings. Some of these buildings pose a life safety risk during an earthquake. A plan would be developed that was affordable for building and business owners in the downtown district. Funding mechanisms considered included owner tax credits and city-financed loans. Building types that pose a life safety risk should be prioritized for improvement or moved to the buyback program.

Transportation – Highway Bridge. The single highway bridge over the Central River was identified as critical infrastructure for the community. Its failure would result in significant disruptions to commuters and trucks transporting goods since the nearest bridge was 10 miles away. The bridge also carried the water main from Fallsborough into Riverbend, so failure of the bridge would also sever the one source of water for Riverbend.

The bridge was vulnerable to design earthquake and extreme flood events. It had been maintained but had not been retrofitted to modern bridge design standard. Because the existing bridge was scheduled and budgeted for a deck replacement in 10 years, there was an opportunity to complete a seismic upgrade. However, the transportation task group completed a cost benefit analysis of completing a seismic upgrade, elevating the bridge deck, and mitigating against scour at the piers. The task group concluded that a bridge having an elevated surface was needed, and found that it was more practical and economical to construct a new bridge at a higher elevation. They recommended construction of a new bridge at a higher elevation rather than elevating the existing bridge.

The transportation task group recommended that they work with the State Department of Transportation to seek support for construction of a second bridge crossing. A second bridge would relieve congestion during high traffic periods when traffic volume exceeds the capacity of the bridge, increase redundancy of a critical transportation route and water system, and support regional growth.

Wastewater/Businesses – Flood Protection Levee. The wastewater treatment plant and the National Aircraft Parts (NAP) plant were both located in the flood plain. Because NAP was a large employer, it was important to the community that the factory remained in Riverbend. The planning team identified potential solutions to limit the vulnerability of these two facilities to flooding.

They recommended that the city partner with the state to pursue a mitigation grant to build a flood control levee to protect both facilities. The levee design should consider the seismic performance of the levees and potential for subsequent flooding before levees could be repaired and functional again.

Prioritize Solutions and Develop Implementation Strategy. The planning team worked with the task groups to prioritize the proposed solutions to develop an implementation strategy over 50 years. The proposed strategy and schedule, which considered the relative benefits of each solution, were outlined as follows:

1. Purchase charging stations that could be deployed following a hazard event and made available for community events. This will occur within 6 months of resilience plan approval.
2. Initiate the buy-back program within two years, and plan for it to be completed over 25-30 years. If additional resources become available, the program could be accelerated.
3. Develop the golf course over the same time period. Revenues from the golf course would support other resilience solutions.
4. Apply for a FEMA Pre-Disaster Mitigation (PDM) program grant with the state.
5. Restore three city wells to provide a redundant water supply. The project (inspect, test, and retain the appropriate permits and approvals) is anticipated to take 3-5 years.
6. Develop and implement an energy assurance plan in 5-10 years. The plan could be completed more quickly, but it is not the highest priority because the energy system performed well in past flood and earthquake events in the region.
7. Engage with the State DOT to advocate for a new bridge to be completed within 5-10 years.

8. Develop plans to replace the existing bridge after the second bridge is completed.
9. Develop incentives and financial mechanisms for business owners in the downtown area to implement seismic retrofits, and work with them to do so. This program should be initiated in the next 3 years and completed within 20 years.

9.6. Step 5: Plan Preparation, Review, and Approval (Chapter 6)

The draft resilience plan was prepared and submitted to the Riverbend City Council. The plan contained the community resilience goals and the prioritized implementation strategy, as well as the following supporting information:

- Summary report characterizing the social dimensions of Riverbend
- Summary report characterizing the built environment of Riverbend
- Tables and associated text that describe the linkages between the built and social environments
- A list of the long-term community goals and associated metrics
- Summary report defining Riverbend's hazards types and levels
- Performance tables and associated text explaining the desired performance goals for the built environment and the anticipated performance of the built environment
- Summary resilience tables and associated text, including identification of the dependencies among buildings and infrastructure systems and the gaps between desired and anticipated performance
- The administrative and construction solutions developed by Riverbend to address gaps in performance
- Proposed prioritization and scheduling of implementation of the resilience strategies

Once the plan was developed, the planning team publicized its release and formally opened a 60-day public comment period to collect input from additional stakeholders. To engage the community, the team organized two community City Hall meetings, two weeks apart during the first month of the plan's release. Local media were encouraged to cover the proposed plan; Ms. Smith and several members of the planning team met with reporters.

Additionally, the planning team disseminated the draft plan to all task groups, encouraging them to distribute the plan throughout their organizations, departments, and agencies for review. After the public comment period, the planning team finalized Riverbend's resilience plan and submitted it to the City Council for approval. The community was widely informed of the plan's approval once it was signed by the Mayor.

9.7. Step 6: Plan Implementation and Maintenance (Chapter 7)

Once the plan was approved, Riverbend began the implementation process, starting with the short-term solutions. City staff began contacting vendors about bulk purchasing of charging stations for cellular phones. They were able to purchase these charging stations at a bulk rate within 4 months of the resilience plan approval (2 months faster than anticipated).

Riverbend also began engaging in some long-term solutions. For example, within the first 6 months, Riverbend worked with the state to apply for a FEMA Pre-Disaster Mitigation (PDM) program grant. The deadline for the first funding cycle had passed by the time Riverbend's plan was finalized. However, they were successful in attaining funding for construction of the flood control levee during year two of the implementation.

Throughout the implementation of their resilience plan, the city's leaders tracked progress and posted it on the city's website. Riverbend decided to review their resilience plan on an annual basis and to assess whether the implementation strategy or any solutions required modification.

9.8. Looking Forward

The development, approval, and implementation of the Riverbend resilience plan had several immediate benefits. The community became more informed and engaged in civic affairs, and they began to share the vision for their community, as evidenced by increased participation in organizations and meetings. Communication between stakeholders developed into regular exchanges that provided daily benefits to their businesses and operations, as well as the community. All the community plans were aligned with the resilience goals over the next planning cycle, ensuring consistency in efforts and allocation of resources.

The value of the resilience goals and implementation of the solutions was understood by the community as a long-term work in progress. The resilience leadership kept the stakeholders informed of progress and setbacks. The transparency led to strong, continued support in the community.

9.9. Supplemental Information: Routine Earthquake Performance Goals Tables

Table 9-18: Riverbend, USA buildings performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Building Clusters	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
		Building Performance Category								
		A			B		C			D
Critical Facilities										
Emergency Operation Centers	R, S, MS	90%	X							
First Responder Facilities	R, S, MS	90%	X							
Acute Care Hospitals	R, S, MS	90%	X							
Non-ambulatory Occupants (prisons, nursing homes, etc.)	R, S, MS	90%	X							
National Aircraft Parts Factory (NAP)	R, S, C	90%	X							
Emergency Housing										
Temporary Emergency Shelters	R, S	90%		X						
Single / Multi-family Housing (Shelter in place)	R, S	90%		X						
Housing/Neighborhoods										
Critical Retail	R, S, C	90%		X						
Religious and Spiritual Centers	R, S	90%		X						
Single and Multi-family Housing (Full Function)	R, S	90%		X						
Schools	R, S	90%		X						
Hotels & Motels	R, S, C	90%		X						
Community Recovery										
Businesses – Manufacturing (except NAP)	R, S, C	60%	90%	X						
Businesses - Commodity Services	R, S, C	60%	90%	X						
Businesses - Service Professions	R, S, C	60%	90%	X						
Conference & Event Venues	R, S, C	60%	90%	X						

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 | 30% | 60% | 90% | Desired restoration times for percentage of elements within the cluster

3 | X | Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-19: Riverbend, USA transportation infrastructure performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Transportation Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Ingress (goods, services, disaster relief)										
Local Roads	R, S	90%	X							
State Highways and Bridge	R, S	90%	X							
Regional Airport	R, S	60%	90%	X						
Egress (emergency egress, evacuation, etc)										
Local Roads	R, S	90%	X							
State Highways and Bridge	R, S	90%	X							
Regional Airport	R, S	60%	90%	X						
Community resilience										
Critical Facilities										
Hospitals	R, S	90%	X							
Police and Fire Stations	R, S	90%	X							
Emergency Operational Centers	R, S	90%	X							
Emergency Housing										
Residences	R, S	90%	X							
Emergency Responder Housing	R, S	90%	X							
Public Shelters	R, S	90%	X							
Housing/Neighborhoods										
Essential City Service Facilities	R, S	60%	90%	X						
Schools	R, S	60%	90%	X						
Medical Provider Offices	R, S	60%	90%	X						
Retail	R, S	60%	90%	X						
Community Recovery										
Residences	R, S	60%	90%	X						
Neighborhood retail	R, S	60%	90%	X						
Offices and work places	R, S	60%	90%	X						
Non-emergency City Services	R, S	60%	90%	X						
All businesses	R, S	30%	60%	90%	X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-20: Riverbend, USA energy infrastructure performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Energy Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Power - Electric Utilities										
Community Owner or Operated Bulk Generation										
In Place Fueled Generation (Hydro, solar, wind, wave, compressed air)	R, S, MS	90%								
Transmission and Distribution (including Substations)										
Critical Response Facilities and Support Systems										
Hospitals, Police and Fire Stations / Emergency Operations Centers	R, C	90%	X							
Disaster debris / recycling centers/ Related lifeline systems	R, C	90%	X							
Emergency Housing and Support Systems										
Public Shelters / Nursing Homes / Food Distribution Centers	R, C	90%	X							
Emergency shelter for response / recovery workforce/ Key Commercial and Finance	R, C	90%	X							
Housing and Neighborhood infrastructure										
Essential city services facilities / schools / Medical offices	R, C		90%	X						
Houses of worship/meditation/ exercise	C		90%	X						
Buildings/space for social services (e.g., child services) and prosecution activities	C		90%	X						
Community Recovery Infrastructure										
Commercial and industrial businesses / Non-emergency city services	C		90%	X						
Residential housing restoration	R, S, MS, C		90%	X						

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-21: Riverbend, USA water infrastructure performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Water Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Source										
Raw or source water and terminal reservoirs	R, S	90%		X						
Raw water conveyance (pump stations and piping to WTP)	R, S	90%		X						
Potable water at supply (WTP, wells, impoundment)	R, S	90%		X						
Water for fire suppression at key supply points (to promote redundancy)	R, S	90%		X						
Transmission (including Booster Stations)										
Backbone transmission facilities (pipelines, pump stations, and tanks)	R, S	90%		X						
Control Systems										
SCADA or other control systems	R, S	90%		X						
Distribution										
Critical Facilities										
Wholesale Users (other communities, rural water districts)	R, S	90%		X						
Hospitals, EOC, Police Station, Fire Stations	R, S	90%		X						
Emergency Housing										
Emergency Shelters	R, S	90%		X						
Housing/Neighborhoods										
Drinking water available at community distribution centers	R, S		90%		X					
Water for fire suppression at fire hydrants	R, S		90%		X					
Community Recovery Infrastructure										
All other clusters	R, S			90%	X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-22: Riverbend, USA wastewater infrastructure performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Wastewater Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Treatment Plants										
Treatment plants operating with primary treatment and disinfection	R, S			90%	X					
Treatment plants operating to meet regulatory requirements	R, S			90%	X					
Trunk Lines										
Backbone collection facilities (major trunkline, lift stations, siphons, relief mains, aerial crossings)	R, S		60%	90%	X					
Flow equalization basins	R, S		60%	90%	X					
Control Systems										
SCADA and other control systems	R, S	90%		X						
Collection Lines										
Critical Facilities										
Hospitals, EOC, Police Station, Fire Stations	R, S		90%	X						
Emergency Housing										
Emergency Shelters	R, S		90%	X						
Housing/Neighborhoods										
Threats to public health and safety controlled by containing & routing raw sewage away from public	R, S		60%	90%	X					
Community Recovery Infrastructure										
All other clusters	R, S		60%	90%	X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-23: Riverbend, USA communications performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Communications Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Core Communications Buildings										
Communications Hub (e.g., Central Office, IXP, Data Centers)	R, S, C	90%		X						
Last Mile										
Critical Facilities										
Hospitals	R, S, C	90%		X						
Police and fire stations	R, S, C	90%		X						
Emergency operation center	R, S, C	90%		X						
Emergency Housing										
Residences	R, S, C	90%			X					
Emergency responder housing	R, S, C	90%			X					
Public shelters	R, S, C	90%			X					
Housing/Neighborhoods										
Essential city service facilities	R, S, C	60%	90%		X					
Schools	R, S, C	60%	90%		X					
Medical provider offices	R, S, C	60%	90%		X					
Retail	R, S, C	60%	90%		X					
Community Recovery Infrastructure										
Residences	R, S, C	60%	90%		X					
Neighborhood retail	R, S, C	60%	90%		X					
Offices and work places	R, S, C	60%	90%		X					
Non-emergency city services	R, S, C	60%	90%		X					
Businesses	R, S, C	60%	90%		X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-24: Riverbend, USA summary resilience table of performance goals for routine earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Routine
Affected Area	Localized
Disruption Level	Usual

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%	X							
Transportation	90%	X							
Energy	90%	X							
Water	90%		X						
Wastewater		90%	X						
Communication	90%		X						
Emergency Housing									
Buildings	90%		X						
Transportation	90%	X							
Energy	90%	X							
Water	90%		X						
Wastewater		90%	X						
Communication	90%			X					
Housing/Neighborhoods									
Buildings	90%		X						
Transportation		90%	X						
Energy		90%	X						
Water		90%		X					
Wastewater			90%	X					
Communication		90%		X					
Community Recovery									
Buildings		90%	X						
Transportation			90%	X					
Energy		90%	X						
Water			90%	X					
Wastewater			90%	X					
Communication		90%		X					

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 | 30% | 60% | 90% | Desired restoration times for percentage of elements within the cluster

3 | X | Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

9.10. Supplemental Information: Extreme Flood Performance Goals Tables

Table 9-25: Riverbend, USA building performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Building Clusters	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
		Building Performance Category								
		A			B		C			D
Critical Facilities										
Emergency Operation Centers	R, S, MS	90%								X
First Responder Facilities	R, S, MS	90%								X
Acute Care Hospitals	R, S, MS	30%		60%		90%				X
Non-ambulatory Occupants (prisons, nursing homes, etc.)	R, S, MS	30%			60%		90%			X
Anything Aircrafts Part Factory (NAP)	R, S, C	30%			60%		90%			X
Emergency Housing										
Temporary Emergency Shelters	R, S	30%		60%	90%					X
Single and Multi-family Housing (Shelter in place)	R, S	30%			60%		90%			X
Housing/Neighborhoods										
Critical Retail	R, S, C			30%	60%	90%				X
Religious and Spiritual Centers	R, S			30%		60%	90%			X
Single and Multi-family Housing (Full Function)	R, S				30%		60%	90%		X
Schools	R, S				30%	60%	90%			X
Hotels & Motels	R, S, C				30%		60%	90%		X
Community Recovery										
Businesses – Manufacturing (except NAP)	R, S, C				30%		60%		90%	X
Businesses - Commodity Services	R, S, C				30%		60%		90%	X
Businesses - Service Professions	R, S, C					30%		60%	90%	X
Conference & Event Venues	R, S, C					30%		60%	90%	X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-26: Riverbend, USA transportation infrastructure performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Transportation Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Ingress (goods, services, disaster relief)										
Local Roads	R, S			30%	60%	90%	X			
State Highways and Bridge	R, S			30%	60%	90%	X			
Regional Airport	R, S			30%	60%	90%	X			
Egress (emergency egress, evacuation, etc)										
Local Roads	R, S			30%	60%	90%	X			
State Highways and Bridge	R, S			30%	60%	90%	X			
Regional Airport	R, S			30%	60%	90%	X			
Community resilience										
Critical Facilities										
Hospitals	R, S	30%	60%	90%		X				
Police and Fire Stations	R, S	30%	60%	90%		X				
Emergency Operational Centers	R, S	30%	60%	90%		X				
Emergency Housing										
Residences	R, S			30%	60%	90%	X			
Emergency Responder Housing	R, S	30%	60%	90%	X					
Public Shelters	R, S	30%	60%	90%	X					
Housing/Neighborhoods										
Essential City Service Facilities	R, S			30%	60%	90%	X			
Schools	R, S			30%	60%	90%	X			
Medical Provider Offices	R, S			30%	60%	90%	X			
Retail	R, S			30%	60%	90%	X			
Community Recovery										
Residences	R, S			30%	60%	90%	X			
Neighborhood retail	R, S			30%	60%	90%	X			
Offices and work places	R, S			30%	60%	90%	X			
Non-emergency City Services	R, S			30%	60%	90%	X			
All businesses	R, S			30%	60%	90%	X			

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-27: Riverbend, USA energy infrastructure performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Energy Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Power - Electric Utilities										
Community Owner or Operated Bulk Generation										
In Place Fueled Generation (Hydro, solar, wind, wave, compressed air)	R/C		90%	X						
Transmission and Distribution (including Substations)										
Critical Response Facilities and Support Systems										
Hospitals, Police and Fire Stations / Emergency Operations Centers	R, C			60%	90%	X				
Disaster debris / recycling centers/ Related lifeline systems	R, C			60%	90%	X				
Emergency Housing and Support Systems										
Public Shelters / Nursing Homes / Food Distribution Centers	R, C			60%	90%	X				
Emergency shelter for response / recovery workforce/ Key Commercial and Finance	R, C			60%	90%	X				
Housing and Neighborhood infrastructure										
Essential city services facilities / schools / Medical offices	R, C			60%	90%	X				
Houses of worship/meditation/ exercise	C			60%	90%	X				
Buildings/space for social services (e.g., child services) and prosecution activities	C			60%	90%	X				
Community Recovery Infrastructure										
Commercial and industrial businesses / Non-emergency city services	C			60%	90%	X				
Residential housing restoration	R, S, MS, C			60%	90%	X				

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-28: Riverbend, USA water infrastructure performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Water Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Source										
Raw or source water and terminal reservoirs	R, S, MS	30%		60%	90%			X		
Raw water conveyance (pump stations and piping to WTP)	R, S, MS				60%	90%			X	
Potable water at supply (WTP, wells, impoundment)	R, S, MS			30%	60%	90%			X	
Water for fire suppression at key supply points (to promote redundancy)	R, S, MS			90%	X					
Transmission (including Booster Stations)										
Backbone transmission facilities (pipelines, pump stations, and tanks)	R, S, MS	30%				60%		90%	X	
Control Systems										
SCADA or other control systems	R, S, MS				30%	60%	90%	X		
Distribution										
Critical Facilities										
Wholesale Users (other communities, rural water districts)	R, S, MS					60%		90%	X	
Hospitals, EOC, Police Station, Fire Stations	R, S, MS				60%	90%		X		
Emergency Housing										
Emergency Shelters	R, S, MS				60%	90%		X		
Housing/Neighborhoods										
Drinking water available at community distribution centers	R, S, MS			30%	60%	90%		X		
Water for fire suppression at fire hydrants	R, S, MS				60%	90%			X	
Community Recovery Infrastructure										
All other clusters	R, S, MS						60%	90%		X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% 60% 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-29: Riverbend, USA wastewater infrastructure performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Wastewater Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Treatment Plants										
Treatment plants operating with primary treatment and disinfection	R, S, MS				30%	60%		90%	X	
Treatment plants operating to meet regulatory requirements	R, S, MS								90%	X
Trunk Lines										
Backbone collection facilities (major trunkline, lift stations, siphons, relief mains, aerial crossings)	R, S, MS					30%	60%		90%	X
Flow equalization basins	R, S, MS					30%	60%		90%	X
Control Systems										
SCADA and other control systems	R, S, MS						60%		90%	X
Collection Lines										
Critical Facilities										
Hospitals, EOC, Police Station, Fire Stations	R, S, MS				30%	90%			X	
Emergency Housing										
Emergency Shelters	R, S, MS				30%	90%			X	
Housing/Neighborhoods										
Threats to public health and safety controlled by containing & routing raw sewage away from public	R, S, MS				30%	60%	90%		X	
Community Recovery Infrastructure										
All other clusters	R, S, MS						60%		90%	X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-30: Riverbend, USA communications infrastructure performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Communications Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Core Communications Buildings										
Communications Hub (e.g., Central Office, IXP, Data Centers)	R, S, MS, C	90%			X					
Last Mile										
Critical Facilities										
Hospitals	R, S, MS, C	90%			X					
Police and fire stations	R, S, MS, C	90%			X					
Emergency operation center	R, S, MS, C	90%			X					
Emergency Housing										
Residences	R, S, MS, C			30%	90%			X		
Emergency responder housing	R, S, MS, C			30%	90%			X		
Public shelters	R, S, MS, C			30%	90%			X		
Housing/Neighborhoods										
Essential city service facilities	R, S, MS, C			30%	60%	90%		X		
Schools	R, S, MS, C			30%	60%	90%		X		
Medical provider offices	R, S, MS, C			30%	60%	90%		X		
Retail	R, S, MS, C			30%	60%	90%		X		
Community Recovery Infrastructure										
Residences	R, S, MS, C			30%	60%	90%			X	
Neighborhood retail	R, S, MS, C			30%	60%	90%			X	
Offices and work places	R, S, MS, C			30%	60%	90%			X	
Non-emergency city services	R, S, MS, C			30%	60%	90%			X	
Businesses	R, S, MS, C			30%	60%	90%			X	

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

Table 9-31: Riverbend, USA summary resilience table of performance goals for extreme flood

Disturbance [1]	
Hazard Type	Flood
Hazard Level	Extreme
Affected Area	Regional
Disruption Level	Severe

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings						90%			X
Transportation			90%		X				
Energy				90%	X				
Water							90%	X	
Wastewater					90%			X	
Communication	90%			X					
Emergency Housing									
Buildings						90%			X
Transportation				90%		X			
Energy				90%	X				
Water					90%		X		
Wastewater					90%			X	
Communication				90%			X		
Housing/Neighborhoods									
Buildings							90%		X
Transportation				90%		X			
Energy				90%	X				
Water					90%			X	
Wastewater						90%		X	
Communication					90%		X		
Community Recovery									
Buildings								90%	X
Transportation				90%		X			
Energy				90%	X				
Water							90%		X
Wastewater								90%	X
Communication					90%			X	

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

Glossary

List of Terms

Term	Definition
Buildings	Individual structures, including its equipment and contents, that house people and support social institutions.
Built Capital	Buildings and infrastructure systems, including transportation, energy, water, wastewater, and communication and information systems.
Built Environment	All buildings and infrastructure systems. Also referred to as built capital.
Business Continuity	• The capability of an organization or business to continue delivery of products or services at acceptable predefined levels following a disruptive incident. [ISO 22301, 2012]. • An ongoing process to ensure that the necessary steps are taken to identify the impacts of potential losses and maintain viable recovery strategies, recovery plans, and continuity of services [NFPA 1600, 2013].
Clusters	A set of buildings and supporting infrastructure systems, not necessarily geographically co-located, that serve a common function such as housing, healthcare, retail, etc.
Communication and Information Systems	Equipment and systems that facilitate communication services, including Internet, cellular and phone services.
Community	• In the NPG, the term 'community' refers to groups with common goals, values, or purposes (e.g., local businesses, neighborhood groups). • In this Guide, the term 'community' refers to a place designated by geographical boundaries that functions under the jurisdiction of a governance structure, such as a town, city, or county. It is within these places that people live, work, play, and build their futures.
Community Resilience	• "The ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies" [PPD-8, 2011]. • "The ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents" [PPD-21, 2013].
Community Social Institutions	A complex, organized pattern of beliefs and behavior that meets basic individual, household, and community needs, including family/kinship, government, economy, health, education, community service organizations, religious and cultural groups (and other belief systems), and the media.
Critical Facilities	Buildings that are intended to remain operational during hazard events and support functions and services needed during the short-term phase of recovery. These facilities are sometimes referred to as essential buildings.

Term	Definition
Critical Infrastructure	"Systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters" [PPD-21, 2013].
Dependency	The reliance of physical and/or social systems on other physical and/or social systems to function or provide services.
Disaster	A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources [National Science and Technology Council, 2005].
Disruption	The consequences of a hazard event that results in loss of services or functions in a community.
Emergency Responders	Official and volunteer workers during the short-term phase of recovery, also referred to as the response phase.
Energy Systems	Electric power, liquid fuel, and natural gas generation, transmission, and distribution.
Financial Capital	Financial savings, income, investments, and available credit.
Function	The role or purpose of a particular institution (e.g., education, finance, healthcare) within a community.
Functionality	Capability of serving the intended function, where the built environment provides an operational level that allows a social institution to provide services.
General Plan	A document designed to guide the future actions of a community, with long-range goals and objectives for the local government, including land development, expenditure of public funds, tax policy (tax incentives), cooperative efforts, and other issues of interest (such as farmland preservation, or the rehabilitation of older neighborhoods areas). Also referred to as a comprehensive plan, master plan, or land use plan [Extension, 2015].
Governance Structures	The governing body of a community.
Hazard	A potential threat or an incident, natural or human-caused, that warrants action to protect life, property, the environment, and public health or safety, and to minimize disruptions of government, social, or economic activities [PPD-21 2013].
Hazard Event	The occurrence of a hazard.
Hazard Impact	The quantification of the community consequences of a hazard through affected area and level of disruption measures.
Hazard Level	The quantification of the size, magnitude, or intensity of a hazard, such as wind speed, seismic ground acceleration, flood elevation, etc.

Term	Definition
Human Caused Disaster	A hazard event caused by human error or a deliberate action including a terrorist activity.
Implementation Strategies	A planned set of actions that taken together will help meet a goal. To achieve community resilience, a set of solutions may include land use planning, codes and standards for new construction, and specific retrofit requirements.
Infrastructure System	Physical networks, systems, and structures that make up transportation, energy, communications, water and wastewater, and other systems that support the functionality of community social institutions.
Life Safety	Life safety in the built environment refers to buildings and other structures designed to protect and evacuate populations in emergencies and during hazard events.
Mitigation	Activities and actions taken to reduce loss of life and property by lessening the impact of hazard events.
Performance Goals	Metrics or specific objectives that define successful performance. For the built environment, performance goals include objectives related to desirable features, such as occupant protection or time for repairs and return to function.
Redundancy	The use of multiple critical components in a system to increase reliability of system performance and function, particularly when one of the multiple components is damaged.
Retrofitting	Improving the expected performance of existing buildings and infrastructure systems through remedial repairs and measures that often improve system resistance or strength.
Robustness	The ability of a structure or system to continue operating or functioning under a variety of demands or conditions.
Shelter-in-place	Safely remaining in a building, e.g., a residence, during or after a hazard event.
Social Capital	Broadly the term refers to “social networks, the reciprocities that arise from them, and the value of these for achieving mutual goals” [Schuller, Baron, and Field 2000].
Stakeholders	All parties that have an interest or concern in an operation, enterprise, or undertaking.
Technological Hazard	A human-caused event due to an accident or human error.
Transportation Systems	Buildings, structures, and networks that move people and goods, including roads, bridges, rail systems, airports, coastal or riverine ports, and trucking hubs.
Vulnerable populations	Groups of individuals within a community whose needs may go unmet before or after a disaster event, including the elderly, people living in poverty, racial and ethnic minority groups, people with disabilities, and those suffering from chronic illness. Additional social vulnerabilities can include renters, students, single-parent families, small business owners, culturally diverse groups, and historic neighborhoods.

Term	Definition
Wastewater Systems	Systems that collect wastewater, move it through a system of pipelines and pump stations to treatment plants and discharge into a receiving water.
Water Systems	Systems that are supplied by either surface or ground water, treat and store the water, and move it to the end user through a system of pipelines.
Whole Community	The National Preparedness Goal defines 'whole community' for preparedness efforts to strengthen the security and resiliency of the United States and includes individuals, communities, the private and nonprofit sectors, faith-based organizations, and Federal, state, and local governments.
Workforce	People who provide labor to one or more of the community social, business, industry, and economic institutions.

List of Acronyms

Acronym	Definition
100RC	100 Resilient Cities
AAR	After Action Report
AASHTO	American Association of State Highway and Transportation Officials
AC	Advisory Circular
ACI	American Concrete Institute
AEP	Airport Emergency Plan
AES	Automatic Extinguishing System
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
ALA	American Lifelines Association
ANSI	American National Standards Institute
APA	American Planning Association
APPA	American Public Power Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ATC	Applied Technology Council
AWWA	American Water Works Association
BART	Bay Area Rapid Transit
BPS	Bulk Power System
BRIC	Baseline Resilience Indicators for Communities
BSI	British Standards Institute
CAIDI	Customer Average Interruption Duration Index

Acronym	Definition
CAIFI	Customer Average Interruption Duration Index
CaLEAP	California Energy Assurance Planning
CAMV	Covered Aerial Medium Voltage
CARRI	Community and Regional Resilience Institute
CART	Communities Advancing Resilience Toolkit
CATV	Cable Television
CCSF	City and County of San Francisco
CEI	Critical Energy Infrastructure
CIP	Capital Improvement Plan
CHP	Combined Heat and Power
CSA	Community Service Area
COLTs	Cell on Light Trucks
CPG	Comprehensive Preparedness Guide
CRF	Community Resilience Framework
CRI	Coastal Community Resilience Index
CRS	Community Rating System
CSO	Community Service Organization
CSRIC	Communications Security, Reliability, and Interoperability Council
DLC RT	Digital Loop Carrier Remote Terminal
DLR	Dynamic Line Rating
DOB	Department of Buildings
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DOGAMI	Oregon Department of Geology and Mineral Industries

Acronym	Definition
DOT	Department of Transportation
DR	Demand Response
DSM	Demand Side Management
EA	Environmental Assessment
EAS	Emergency Alert System
EBMUD	East Bay Municipal Utility District
EE	Energy Efficiency
EF	Enhanced Fujita (scale)
EIA	Energy Information Administration
EIM	Energy Imbalance Markets
EIS	Environmental Impact Statement
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EOP	Executive Office of the President
EPCRA	Emergency Planning and Community Right-to-Know Act
EPA	Environmental Protection Agency
EPFAT	Emergency Power Facility Assessment Tool
EPRI	Electric Power Research Institute
ERO	Electric Reliability Organization
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration

Acronym	Definition
FTA	Federal Transit Administration
GDP	Gross Domestic Product
GETS	Government Emergency Telecommunications Service
GIS	Geographic Information System
GTAA	Greater Toronto Airports Authority
HAZMAT	Hazardous Materials
HVAC	Heating, Ventilation, and Air Conditioning
IA	Iowa
IBC	International Building Code
IBHS	Institute for Business and Home Safety
ICC	International Code Council
ICLEI	Local Governments for Sustainability
IEBC	International Existing Building Code
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility
IPAWS	Integrated Public Alert and Warning System
IPP	Independent Power Producer
IRC	International Residential Code
ISO	International Organization for Standardization
ISP	Internet Service Provider
ITS	Intelligent Transportation Systems
IWUIC	International Wildland-Urban Interface Code
IXP	Internet Exchange Points
LADWP	Los Angeles Department of Water and Power
LAWA	Los Angeles World Airports

Acronym	Definition
LRFD	Load Factor and Resistance Design
MAP-21	Moving Ahead for Progress in the 21 Century Act
MARAD	United States Maritime Administration
MCEER	Multidisciplinary Center for Earthquake Engineering Reduction
MSC	Mobile Switching Center
MPO	Metropolitan Planning Organization
MRE	Manual for Railway Engineering
NAPSR	National Association of Pipeline Safety Representatives
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NCHRP	National Cooperative Highway Research Program
NDRF	National Disaster Recovery Framework
NEBS	Network Equipment Building Standards
NEC	National Electric Code
NEPA	National Environmental Protection Act
NERC	North American Electric Reliability Corporation
NESC	National Electric Safety Code
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NGO	Nongovernment Organization
NHSRC	National Homeland Security Research Center
NIBS	National Institute of Building Sciences
NIPP	National Infrastructure Protection Plan
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration

Acronym	Definition
NPG	National Preparedness Goal
NRC	Nuclear Regulatory Commission
NRECA	National Rural Electric Cooperative Association
NWS	National Weather Service
NYCC	New York Panel on Climate Change
NYCDEP	New York City Department of Environmental Protection
NYSERDA	New York State Energy Research and Development Authority
OCDI	Overseas Coastal Area Development Institute of Japan
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
PANYNJ	Port Authority of New York and New Jersey
PARRE	Program for Risk and Resiliency Evaluation
PDM	Pre-Disaster Mitigation
PEP	Private Entry Point
PHMSA	Pipeline and Hazardous Materials SafetyAdministration
PIANC	World Association for Waterborne Transport Infrastructure
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PMU	Phasor Measurement Unit
POTS	Plain Old Telephone Service
PPD-8	Presidential Policy Directive 8
PPD-21	Presidential Policy Directive 21
PSAP	Public-Safety Answering Point
PSEG	Public Service Enterprise Group
PV	Photovoltaic
ROW	Right of Way
RPS	Renewable Portfolio Standards

Acronym	Definition
RUS	Rural Utilities Service
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control Data Acquisition
SDWA	Safe Drinking Water Act
SEI	Structural Engineering Institute
SFPUC	San Francisco Public Utilities Commission
SGIP	Smart Grid Interoperability Panel
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SLR	Sea Level Rise
SPUR	San Francisco Planning and Urban Research Association
SSO	Standards Setting Organizations
THIRA	Threat and Hazard Identification and Risk Assessment
TIA	Telecommunications Industry Association
TRB	Transportation Research Board
TSP	Telecommunications Service Priority
TVA	Tennessee Valley Authority
UFC	United Facilities Criteria
UN	United Nations
UNIDSR	United Nations International Strategy for Disaster Reduction
UPS	Uninterruptible Power Supply
URI	Utility Resilience Index
US	United States
USA	United States of America

Acronym	Definition
USACE	United States Army Corps of Engineers
USGC	United States Coast Guard
VOAD	Voluntary Organizations Active in Disaster
VSAT	Vulnerability Self-Assessment Tool
WARN	Water/Wastewater Agency Response Network
WEA	Wireless Emergency Alerts
WHEAT	Water Health and Economic Analysis Tool
WPS	Wireless Priority Service
WWTP	Wastewater Treatment Plant

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