AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards

Development of Guidelines for Implementing Performance Assessments of Water Systems Volume II: Commentary

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Table of Contents

List of Tables

List of Figures

List of Photographs (Need to add from original hard copy)

1 - Introduction

The Commentary contains supplementary information supporting the development and implementation of the Guideline for Assessing the Performance of Water Systems in Natural Hazard and Human Threat Events (Guideline). While not integral to the implementation of the Guideline, this information is useful for understanding the recommended methods, procedures, and practices and the data needed to screen out certain hazards system components from detailed investigations.

The Commentary is comprised of seven major sections:

- Recommended methods of analysis for performing hazard, component vulnerability, and system performance assessments; see Section 2.5 of the Guideline **(Section 2)**,
- A description of the methodology and data used to determine hazard level criteria for the Guideline; see Table 4-1 in Guideline **(Section 3)**,
- Supplemental guidance on assessing human threat hazards **(Section 4),**
- Guidance on assigning component vulnerability **(Section 5),**
- Supplemental guidance on system assessment **(Section 6),**
- References **(Section 7),**
- Acronyms for key terms used in the Guideline and Commentary **(Section 8)**,
- Terms and definitions **(Section 9)**,
- Hazard level tables for the U.S**. (Appendix A)**, and
- A bibliography of additional suggested references **(Appendix B)**.

Each of these sections is self-contained; no attempt has been made to integrate these discussions into a standalone report. The main purpose of the Commentary is to support the implementation of the Guideline.

The studies, examples, reports, maps, and references provided in the Commentary are believed to be state-of-the-practice, at the time of this writing. As with most guidance material, advances are expected to occur in technology and knowledge that will require this material to be reassessed for appropriateness. As such, this "living" document will require updating over time.

While the materials in the Commentary were developed with U.S. utilities in mind, much of the material is applicable worldwide (with the exception of the hazard maps in the Commentary and hazard tables in Appendix A), especially the methods of analysis that are introduced in Section 2.

1.1 Overview of the General Risk Management Decision Process

Figure 1-1 provides an overview of the generic decision process that is typically followed in determining what measures are necessary to achieve the desired level of system performance. The Guideline focuses on tasks associated with identifying hazards, assigning component vulnerability, and determining system response. A more general discussion of the entire process is provided in this section.

1.1.1 The Inquiry

The reason for conducting a performance assessment of a water system is to provide the information necessary to address a specific inquiry. Inquiries will invariably be generated by water system stakeholders, those individuals and groups that are impacted in some way by interruption in the normal operation of the water system. Typically, the most common stakeholders are those that pay and benefit from decisions related to water system performance. Basic stakeholders in the decision to reduce water utility system risks from natural hazards may involve:

- the water utility itself
- pertinent wholesalers or distributors associated with the water utility
- municipal governments to the extent that they subsidize or are subsidized by the water utility
- other water utilities associated with the primary water utility through mutual aid agreements
- local fire departments concerned to assure that fire flows are adequate
- various categories of customers (e.g., differentiated by service zones and/or by such customer types as industrial, institutional, commercial, and residential) and/or specific lists of customers (e.g., health-care facilities, emergency operating and public safety facilities, special manufacturers)
- insurers, bond-holders, bond rating agencies, and lending institutions
- federal and state agencies that may provide federal or state disaster assistance
- other federal, state, and local agencies that have additional expenses during disruptions to the water system
- other infrastructure systems (e.g., energy, wastewater, communications) that may be affected by disruption to the water system, and
- Federal, state and local agencies that regulate health effects (water quality) and/or that are involved with proactive antiterrorism programs (system performance).

In addition to various basic stakeholders, entire communities may be involved in various ways in disruption to a water system. For instance, the tourist industry may be harmed, out-migration may be increased, general contractors may have additional work, a surplus of general contracting labor may arise from the additional contracting labor needs in the affected region, and so on. Higher-order ripple effects of damages to potable water systems may be many and will generally require special expertise to address.

Because of the variety of sources for an inquiry, it is not possible to produce a comprehensive list of the types of inquiries. However, the following examples illustrate the types of more common inquiries. Although these examples are segregated in terms of “internal” inquiries and “external” inquiries, this differentiation is not important in implementing the approach described in the Guideline.

Internal Inquiries

- Upper management requesting information on general financial exposure
- Addressing risk management or insurance issues
- Defining the scope of capital improvement programs
- Evaluating performance goals (reliability)
- Assessing post-hazard service to emergency facilities (e.g., hospitals)
- Preparing exercises and training for event response
- Conducting an internal investigation following a disaster that causes unexpected damage or impacts

Outside Inquiries

- Inquiry by a regulatory body (system exposure)
- Inquiry by a regulatory body (hazard concern)
- Inquiry by a regulatory body (consequence concern)
- Inquiry by a regulatory body (operating concern)
- Inquiry by a regulatory body (integrity concern)
- Customer questions about the reliability of service
- Investor concerns, primarily for private gas utilities
- Changes in law or operating requirements (depends on the change)
- Inquiries by the press or the public
- Interaction with professional organizations
- In response to a bond-rating process
- External investigation following a disaster that causes unexpected damage or impacts

1.1.2 Defining the System

A water system consists of a variety of facilities and components, each with typical types of information that will be necessary in carrying out a performance assessment: These facilities and components can be segregated in terms of their primary function in the system:

- Conveyance
- Storage
- Pressurization
- Treatment
- Buildings
- Non-Building Components

It is often beneficial to perform walk-through surveys of the important facilities (headquarters, emergency operations center, maintenance yard, etc.), and visits typical pump stations, reservoirs, and potable water pressure reducing facilities. This first-hand observation is often necessary to establish the characteristics of key system components that may not be adequately described in plans or other design documentation and to ascertain the existing condition of the components.

An inventory list for the portion of the water system buildings and equipment being assessed is essential. Such a list provides a valuable vehicle for prioritizing site visits, design document review and other data gathering activities. The inventory of above-ground assets is particularly helpful to prioritize site visits, so that high-value and important items are examined and appropriately modeled. Where this list is lacking, it should be developed.

Ideally, the database should list replacement values for the buildings, other structures and equipment at all of the facilities. This can serve as a starting point, to construct the inventory database for the project, adding information about site conditions and the seismic vulnerability of the elements. The database can be expanded to include information on the agency's water reservoirs, transmission piping and distribution piping systems.

1.1.2.1 Conveyance

Water conveyance facilities include, but are not limited to:

- Above-ground piping structures such as pipe bridges, pipe supported by saddles or ring girders
- Pumping station and associated inlet and discharge lines
- Pen-stocks
- Aqueducts consisting of canals, tunnels, pipelines, conduits, and sometimes flumes (Photos 11 and 12)
- Intake piping (at lakes or rivers)
- Transmission piping
- Distribution piping
- Service and fire hydrant connections
- Valves and valve operators

The basic information on pipelines surveyed includes:

- section number
- location (with reference to various nodal points)—implying lengths of pipe
- pipe material(s)
- year installed (implying age)

- diameter
- pipe joint type
- lining and coating
- buried or above-ground (depth?)
- directionality of flows
- pressure-reducing valve locations
- elevations
- previous damages, leaks, and methods of repair
- maintenance history
- street rehabilitation schedule
- customer type (e.g., hospitals)

Information collected on the water delivery and distribution system may need to satisfy input requirements for hydraulic modeling as noted below and elaborated in American Water Works Association (AWWA) M32 on distribution network analysis for water utilities. As a general rule, in very large systems and for most decisions, pipelines representing the water system "backbone" typically are of a larger diameter (say NPS 12 to NPS 16 and even larger for the largest water systems) and may reflect the minimum size of pipelines considered in a natural hazards evaluation. For smaller systems, pipelines down to NPS 4 may be considered.

Larger systems may already have a hydraulic model in place. These models can be extremely important in assessing post-disaster response and recovery activities, and in modeling the consequences of natural disasters. Smaller system purveyors may not have a hydraulic model in place but may be required to create one to accurately assess potential risks caused by a disaster. The following is a list of typical hydraulic modeling data requirements. Some of this information can be obtained from supervisory control and data acquisition (SCADA) information, utility personnel, field recorders, fire flow data, static pressures from water storage tank elevations, or rule of thumb numbers based on accepted standards of practice.

- Pipe lengths and diameters
- Elevations at pipeline junction points
- Flow demands at pipeline junction points (e.g., maximum daily and hourly flows, maximum fire flows)
- Junction pressure data (e.g., pressure relief or sustaining valve station)
- Locations and capacities of supply pumps and booster pumps (including groundwater pumping wells (Photos 2 and 3)
- Locations and elevations of storage facilities

- Location and operational features of pressure regulating and control valves

1.1.2.2 Storage

Storage facilities can consist of storage reservoirs can include: steel and concrete storage tanks (elevated, surface, or buried), open or covered surface water reservoirs, and sumps. Information typically used to characterize storage facilities includes the following:

- construction date
- materials (e.g., steel, concrete)
- shape and dimensions
- applicable design standards (e.g., AWWA Code, year, seismic zone, wind velocity)
- maximum storage capacity
- type of roof
- minimum freeboard (height above maximum water level to top of tank wall)
- footing type (e.g., ring wall, mat, etc.)
- anchorage to footing (if any)
- type of inlet and outlet connections (e.g., flexible couplings)
- basic usage (e.g., potable versus emergency fire-flow protection)
- previous damages, if any, and methods of repair

1.1.2.3 Pressurization

Where static hydraulic head provides insufficient pressure, a variety of means are used to increase the pressure in the piping system, the most common facilities including booster pumping stations, hydro-pneumatic pumping stations, groundwater wells, pressure vessels, and surge tanks. The following information is useful for conducting a performance assessment:

- construction date
- as-constructed drawings
- applicable design standards (e.g., AWWA code and year)
- maximum and operating flow capacity and head (e.g., pump curves)
- type of mechanical and electrical equipment
- type of piping connections (e.g., connections to pump suction and discharge)
- basic usage (e.g., potable, emergency fire flow protection)
- type of well casing

- previous damage, if any, and repairs
- power supply backup
- hazardous materials on site

1.1.2.4 Treatment

- Water treatment facilities may be considered as major sub-systems, consisting potentially of a diversion structure, inlet control building, screen house, chemical building, mixing and sedimentation basins, filter basin, outlet building, wash-water tank, chlorine tank, clearwater tank, and pipe gallery. Information developed on each of these components will be similar to information gathered under building structures and other non-building components, above. Consideration of a major water treatment plant as a major sub-system is especially important if portions of the water treatment plant can continue to provide potable water even if portions of the treatment plant are damaged. Water treatment plants (Photo 1)

1.1.2.5 Buildings

Building structures may be located in water treatment, chlorination and fluoridation facilities, pumping stations and wells. In addition, there are a variety of utility buildings that may be important including administrative headquarters, buildings that house record-drawing vaults, computers and financial information; operations centers, maintenance facilities, and material storage buildings. Basic building structures that have significant occupancy tend to be covered under building codes. For buildings that are included in the water systems evaluation, the following information can be important:

- as-built drawings
- facility usage and function
- location
- base elevation (for specific flood-related hazards and for hydraulic evaluations)
- previous damage, if any, and causes
- previous damage repairs
- applicable design standards (e.g., building code and year)
- gravity load-carrying system
- lateral force-resisting system
- materials used in roof and floor diaphragms, structural columns and walls
- number of stories below ground
- number of stories above ground

1.1.2.6 Non-Building Components

Non-building components typically include electrical and mechanical equipment that is often housed within buildings:

- electrical equipment (e.g., motor control centers, electrical raceways)
- mechanical equipment (e.g., pumps, vessels, piping)
- instrumentation and control equipment (e.g., SCADA components)
- chlorination instrumentation and control equipment
- surveillance and security equipment (e.g., video monitors, lighting, automatic gates)

The following information requirements are often necessary in a performance assessment:

- function and use
- anchorage or bracing
- mass and center of gravity for components with significant overturning potential
- location (including story number in a building)
- base elevation (for such hazards as floods and for hydraulic evaluations)
- submergence-rating (if any)
- previous damage, if any, and repairs

Utility buildings, including administrative headquarters; an emergency and normal operating center, maintenance facilities, spare parts, equipment, and material storage (Photos 3, 14, 15 and 19)

1.1.2.7 Information Technologies

While not explicitly required in the Guideline, many water system owners and operators will wish to take advantage of available technologies to facilitate the presentation of the findings and recommendations from a performance assessment. Information technologies exist (and continue to evolve) for compiling and displaying water systems. While specific technologies are not recommended, some of the pros and cons of available technologies can be succinctly stated.

Geographic Information Systems (GIS) and Computer-Aided Drafting (CAD) systems (e.g., ArcInfo, MapInfo, AutoCad) have become a key tool for water transmission and distribution system inventory, especially for larger agencies. These systems replace manual drawings, and there are significant costs involved in converting from manually-drafted drawings to an integrated electronic representation of piping systems, major plant structures and equipment. Design documents for new buildings and equipment are often maintained on CAD systems.

The evaluation of risks to water systems from natural hazards is greatly facilitated when water agency inventory data is well maintained using information technologies. GIS systems permit the overlay of piping systems with various geologic and topographic conditions, and so are very useful in natural hazard risk assessment. GIS representations of the water system facilitate hydraulic analysis in common software (e.g., WaterCad, H2ONet).

With the incorporation of available GIS databases from local and federal agencies, information can be quickly integrated. Figure 1-2 provides a composite map from a water system overlaid onto a USGS map. The utility map identifies major transmission lines and distribution piping larger than NPS 12[1]. From Figure 1-2, the water system map allows identification of information related to pipe diameters, location of pressure zones, and major features of the system. In addition if the drawing is to scale, lengths and elevations can be obtained. Even if not mapped, it is likely that operation and maintenance personnel would readily be able to identify location of control valves and other system components from such maps. In addition, GPS equipment can be used in conjunction with water system field surveys to provide data for mapping special features or to check key coordinates.

For purposes of illustrating the general inventory process, Figure 1-3 provides a hypothetical water system that contains virtually all of the major types of components of interest. The water system in Figure 1-3 contains two basic raw water sources, from a river and from runoff from snow-pack and mountain streams. Penstocks, canals, and aqueducts convey the raw water from the mountain streams to a water treatment plant. A tunnel could be included for some systems. Intake piping conveys the raw water from the river to a second water treatment plant. A third source of water is a groundwater well. The system contains booster pump stations and a distribution storage reservoir. Such a sub-system in a water system might be called a “pump-tank” sub-system. Treated water moves though transmission piping to distribution piping and finally into service connections and fire hydrants.

The water system in Figure 1-3 should not be regarded as being separate from other infrastructure systems: wastewater, electric power, communications, and roadways and highways. The interdependence of these systems is a key element to consider in the analysis of water system function following many of the natural hazards considered in these guidelines. Moreover, there may be many sources of contaminants found in such a system that may pose special water quality problems after natural disasters.

Basic components of interest (with photographic examples referenced in parenthesis) include:

- Steel and concrete reservoirs (Photos 4, 5, 6, 7 and 8)
- Open surface water reservoirs (Photos 9, 10, and 13)
- Canals (photos 11 and 12)
- Pressure vessels (e.g., surge tanks) (Photos 21, 30 and 31)

[1] The NPS designation refers to the nominal pipe size in inches and the corresponding pipe size in metric units. In this example, NPS 12 refers to a pipe with an outside diameter of 12.75 inches or 323.9 mm and corresponds to diamétre nominal (DN) 300 in standards prepared by the International Organization for Standardization (ISO).

- Valves and valve operators (Photo 27)
- Transmission piping (Photo 25)
- Above-ground piping structures: pipe bridges, pipe supported on saddles (Photo 29)
- Electric substation equipment: control equipment, electrical raceways (Photos 23 and 32)
- Mechanical equipment, pumps (Photos 2, 3, 17 and 18))
- (SCADA) Instrumentation, chlorination control, surveillance (Photos 7, 16, 19 and 20)
- Equipment for chemical storage and usage; chemical piping (Photo 21)

1.1.3 Define Assessment Metrics

In general, the primary system metrics for evaluating water system performance will relate to the amount of water delivered in terms of flow rate, service area, or stored volume. By and large, the appropriate metrics used in water systems subjected to natural hazards do not typically include health and safety as the extremely important considerations of warding off disease, injury, and deaths are accounted for in existing standards and procedures. Comprehensive assessment of total system performance for numerous hazards may often consider impacts on administration, social impacts, psychological impacts, political and legal concerns, and a host of other considerations that are not explicitly covered in this Guideline.

In most applications, system performance is gauged by welfare metrics. However, there may be circumstances in which the inquiry dictates alternate metrics. Alternate metrics can generally be characterized in terms of one of the following goals:

- Protect public and utility personnel safety,
- Maintain system reliability,
- Prevent monetary loss, and
- Prevent environmental damage.

Several different metrics can be used to quantify system performance relative to desired outcomes as illustrated in Table 1-1. Linking performance metrics to desired outcomes is important because it generally influences the choice of measurement methods for quantification. Some performance metrics might require specialized methods, while others may simply make use of field information or expert opinion.

The entries in the columns of Table 1-1 relate the direct measures of system performance to desired outcomes. For instance, “Casualties” and “Hazardous Materials Spillage” are shown as the performance metrics for the desired outcome of “Protect public and utility personnel safety.” In other words, to protect the safety of the public and the utility employees, casualties and hazardous material spillage must be avoided. There are also indirect consequences of an unfavorable outcome that are not indicated in Table 1-1. These indirect consequences can be significant, perhaps even greater than direct consequences. For example, the financial burden placed on an electric power utility to settle liability claims or to provide for environmental cleanup in the event of a hazardous materials spill would qualify as an indirect consequence and could be costly.

A system performance analysis should consider those principal components of a water system that are important in achieving various desired outcomes. Most major components should be included in a performance assessment directed at safety, system reliability, and prevention of monetary loss. Assessments directed at preventing environmental damage should focus mainly on components and systems related to the containment of hazardous materials, system control (shutdown and isolation) and emergency response (maintenance and equipment).

1.1.4 Define Target Performance

In general, the primary system performance targets for water systems will relate to required levels of water flow or service, consistent with the most common performance metric. The performance target may be stated in several ways, although the following general statements are most representative:

- Percent without service (in total or by customer sector) immediately following a hazard event
- Percent served (in total or by sector) within a specific time frame (e.g., number of days) following a hazard event
- Length of time for restoration to normal service following a hazard event

The definition of alternate performance targets will depend upon the metric of importance (e.g., direct damage to water system components, repair costs, loss of revenue from the sale of water) and the specifics of the inquiry.

1.1.5 Identify Significant Hazards

Geologic hazards, weather-related hazards and other natural hazards are characterized for the relevant portions of the water system (specifically earthquakes with associated liquefaction, tsunamis, and seiche, floods, windstorms including hurricane and tornado, and ground movements from landslide, frost heave, and settlement). Human threats considered in this guideline range from routine threats, such as vandalism, to extreme threats that include physical attack and sabotage that could include and biological, chemical, and radiological substances.

Published geologic mapping may be used, together with limited field reconnaissance. A geographic information system (GIS) representation of the water system can greatly improve the ability to correlate hazards with system components and facilities. GIS applications also allow portions of the system to be related to various geologic conditions, such as landslides, ground movements from freeze/thaw, or seismic hazards. Seismic hazards such as liquefaction and landslide may be examined, using published earthquake hazard zone maps to show how much of the system may be affected, and to assist in scoping further geologic investigations to assess the spatial variation of the hazard severity.

Like natural hazards, it would be desirable to quantify the human threat likelihood. There is little recurrence data to enable the evaluation team to use historical data. Further, the threat is constantly changing. Most notably, the threat of terrorism was different 10 years ago compared to what it is today, and compared to what it will be 10 years from now, with changes in world politics. The real value of quantifying the design basis threat would be to compare the human threat risk against the risk of natural hazards.

One approach is to assume that the human threat event will happen (probability equals 100%). This results in a relative risk assessment, and provides no guidance on the relative risk between natural hazards and the human threat. Another more realistic approach is to place bounds on the threat likelihood using available information and rational judgment. For example, how many terrorist attacks resulting in system loss of function would the evaluator expect within the next 50 years anywhere within the United States? Bounds on the answer to this question could be estimated considering the number of water utilities of comparable or larger size that constitutes a reasonable target, as well as the other infrastructure systems that may present comparable targets, such as wastewater and electric power.

1.1.6 Assess Vulnerability of System Components to Hazards

Of special importance in a water system evaluation is how damage is estimated in terms of the component functionality and also its restoration time. The general definition of component vulnerability may be in terms of damage (e.g., functionality, critical downtime, and/or repair cost) as a function of hazard intensity. The form of the definition may be deterministic or it may be probabilistic. Probabilistic models are often called fragility models. One may use very simple forms of such a vulnerability definition or more complex forms are available. However, the greater challenge is how to formulate credible definitions of vulnerability, especially in view of the variability in hazards and the limited data on which to base these models.

1.1.7 Assess System Performance to Component Damage

System performance after disasters can be interpreted in many ways. For instance, one can evaluate the numbers and durations of service zones lacking adequate pressure for fire flow and/or sanitary potable water. One can further identify those service zones that are more susceptible to water outages and/or shortages after natural disasters.

One can further translate these water outages and/or shortages into various economic terms. One such translation is in terms of prospective revenue losses to the water utility itself. These will be a function of rates and reduced water deliveries as these apply to different customers within the system as well as extra costs to respond to the system damages. Some of these revenue losses will be over and above the repair and labor costs that the water utility system itself incurs after governmental disaster assistance moneys, if any, are received.

Another such translation is to develop estimates of losses to the customers themselves. For instance, specific commercial, industrial, or institutional customers may have fairly well-defined water needs and may know fairly well the types of business or productivity losses that would arise from various water outages and/or shortages of various durations. In general, a business or economic survey would be needed to develop models of business and/or productivity losses arising from possible water outages and/or shortages.

Higher-order loss estimation, over and above primary losses and business interruption losses, is beyond the scope of this document. Nonetheless, macro-economic models exist that can estimate how much overall impact primary losses and business interruption losses can have on the local and regional economies. Such models generally need to take into account the infusion of outside capital (such as disaster assistance moneys), how productivity losses at one location can be compensated for by productivity gains at another location, how well business owners can shift their businesses in order to survive and possibly thrive in circumstances that have changed after the disaster, how some businesses such as utility construction firms may have increased business after disasters, and how various businesses are dependent on those that have suffered primary losses (e.g., how the tourist industry is dependent on local motels and hotels, that may have suffered losses owing to water outages and/or shortages).

1.1.8 Identify Modifications to Improve System Performance

The following discussion outlines some of the types of decisions for which a system performance assessment may be used. Decisions may be individual initiatives, such as the redesign of a water distribution reservoir. Alternatively, water utilities undertaking a more in-depth systems assessment may wish to consider defining practical alternatives and schedules to address a broad range of natural hazards and human threats. These alternatives may involve many diverse activities designed to reduce risks over time. For purposes of categorizing types of risk and decision alternatives, water utility decision-makers may consider:

1. *Engineering* M*easures*—Engineering measures include the design and construction of new facilities or the redesign and retrofit of existing facilities, geotechnical remediation, and use of temporary shoring. For instance, decision-makers may consider

    - levels of hazard-resistant design suitable for a major water utility component (e.g., water distribution reservoir)
    - elevation of equipment to avoid potential flood damage
    - submergence-rated equipment where elevation cannot be deployed
    - bracing or anchorage of equipment
    - addition of anchorage or flexible connections to water reservoirs subject to ground shaking hazards
    - installation of a floodwall to protect a major water system component
    - accelerated replacement of older more vulnerable pipelines
    - hardening Emergency Operations Centers and other buildings critical to water systems operations

2. *Land use Measures*—Land use measures include alternative siting or reduction of exposures in building structures that may be damaged. For instance, decision-makers may consider

    - alternative siting of a major water system component (e.g., away from a landslide prone region, or away from houses that could become inundated if damage occurs to the component, or outside a major flood plain)
    - reduction of exposure of critical equipment and personnel in a building that is more vulnerable to damage from natural hazards

3. *System Enhancement Measures*—System enhancement measures include providing additional system redundancy in order to assure that system goals are met. For instance, decision-makers may consider

    - the development of a major alternative water supply source or water treatment plan
    - the development of alternative sources of electric power and other energy sources
    - the development of backup communications systems
    - the installation of shutoff valves on gravity and pressure service lines in order
    - to isolate damaged portions of the system
    - the installation or upgrading of a SCADA system
    - the addition of loops of parallel pipelines to enhance transmission redundancy

4. *Emergency Response Measures*—Emergency response measures address the immediate response to events. Enhancements to emergency response capabilities may include

    - the development of a recovery plan, with drills and regular updates, may facilitate response and recovery after natural hazards
    - mutual aid agreements may assist along with cooperative activities with other key first-responder and short-term forecasting agencies.
    - spare parts, materials, personnel, and equipment may be developed in key locations to assure rapid response to restore the system

5. *Risk Transfer Measures*— Risk transfer measures relate to the use of insurance or other liability transfers (e.g., contractual liability transfers with manufacturers, suppliers, consultants) in order to limit the water utility's post-disaster liabilities and assure that adequate recovery funds exist, and

6. *Financial Reserving Measures* — Financial reserving measures relate to s retaining funds for emergency response and recovery contingencies.

In decision-making, costs of decision alternatives (initial outlays) are always important. Low-cost risk reduction measures, such as using chains to anchor chlorine cylinders, often lie beneath the thresh-hold of consideration for a formal risk evaluation. Higher cost alternatives (e.g., retrofit of a steel distribution reservoir), however, need to be evaluated in order to compare system performance against costs and budgetary limitations.

The evaluation of decision alternatives may proceed through conceptual design, using qualitative assessments of cost effectiveness, and into preliminary design, so that costs (and performance) of each option can be adequately quantified. The evaluation of costs for decision alternatives may be done in-house, especially in larger water agencies, and especially at earlier stages of the evaluation process. Final evaluation of the benefits and costs for large projects often requires outside assistance, in the form of studies using engineering consultants and cost estimators.

Replacement and/or repair cost information for existing facilities will be needed if it is desirable to assess aggregate system dollar losses for various scenario events and/or for a representative suite of natural hazards scenarios. This will apply only if financial criteria are used in the decision process—beyond the consideration of initial outlays.

1.2 Multiple Levels of Analysis

The recommendations in the Guideline use multiple levels of analysis in a two-phase approach. This approach is intended to provide sufficient information to address a particular inquiry while reducing the likelihood for unnecessarily complex analyses. To prevent duplication of effort, the tasks identified for various levels of analysis build upon each other. That is, to implement a more advanced level of analysis typically requires completion of the tasks for all lower levels of analysis.

1.3 Risk and Uncertainty in the Decision Process

The goal of an evaluation of a water system subjected to natural hazards events is to gather and synthesize information that assists decision-making. That portion of a decision based upon the synthesized information from such an evaluation may be called a portion of the decision under risk. In a decision under risk, there is still an element of chance, but this is quantified through the risk evaluation process. For instance, in a deck of cards, the chance of picking a heart is one-in-four—as long as there are no jokers in the deck. Taking a chance of picking a heart can be a decision under risk—as long as one knows what the chances are of picking the heart. Through the synthesis of information in a water system evaluation, one can remove uncertainty.

In contrast, decisions under uncertainty—in their extreme form—do not have relevant information. Continuing the above example, one may be forbidden to know how many cards are in the deck and one may not know what proportion of the cards in the deck are hearts. In this case, one's wager on picking a heart would be a decision under uncertainty—or abject ignorance.

The ideal goal of the evaluation of a water system subjected to hazards is thus to produce a decision under risk, and not a decision under uncertainty. In a decision under risk, all key factors bearing on the decision would be fully and adequately quantified. A systems approach to water systems moves in this direction. Ignorance of the system at risk, hazards that may affect it, the vulnerability of its components, and the potential response of the system are removed.

Nonetheless, the state-of-the-art in this type of evaluation does not permit one to remove all uncertainties and unknowns. This is chiefly a result of the uneven quality of data and models used in such an evaluation. There are very few instances (e.g., very short-term forecasts of floods) in which ignorance is almost totally removed.

Considering hazard events alone, and not the uncertainties in estimating water facility and system response to them, one may be guided by earlier words from a working group of the American Nuclear Society (ANS):

> The ANS-2.12 Working Group wishes to clearly state that it is difficult to precisely establish the probability of occurrence of natural and external man-made hazards. The phenomena are complex and the probability of each is a function of parameters such as geographical location, time of year and nature of the hazards (ANS, 1978, foreword)

Table 1-1. Metrics to Measure System Performance Associated with Desired Outcomes

Desired Outcomes (Performance Targets)	**System Performance Metrics**					
	Capital Losses ($)	Revenue Losses ($)	Service Disruption (% service population)	Downtime (hours)	Casualties (deaths, injuries)	Hazardous Materials Spillage
Protect public and utility personnel safety					**X**	**X**
Maintain system reliability			**X**	**X**		
Prevent monetary loss	**X**	**X**	**X**	**X**		**X**
Prevent environmental damage						**X**

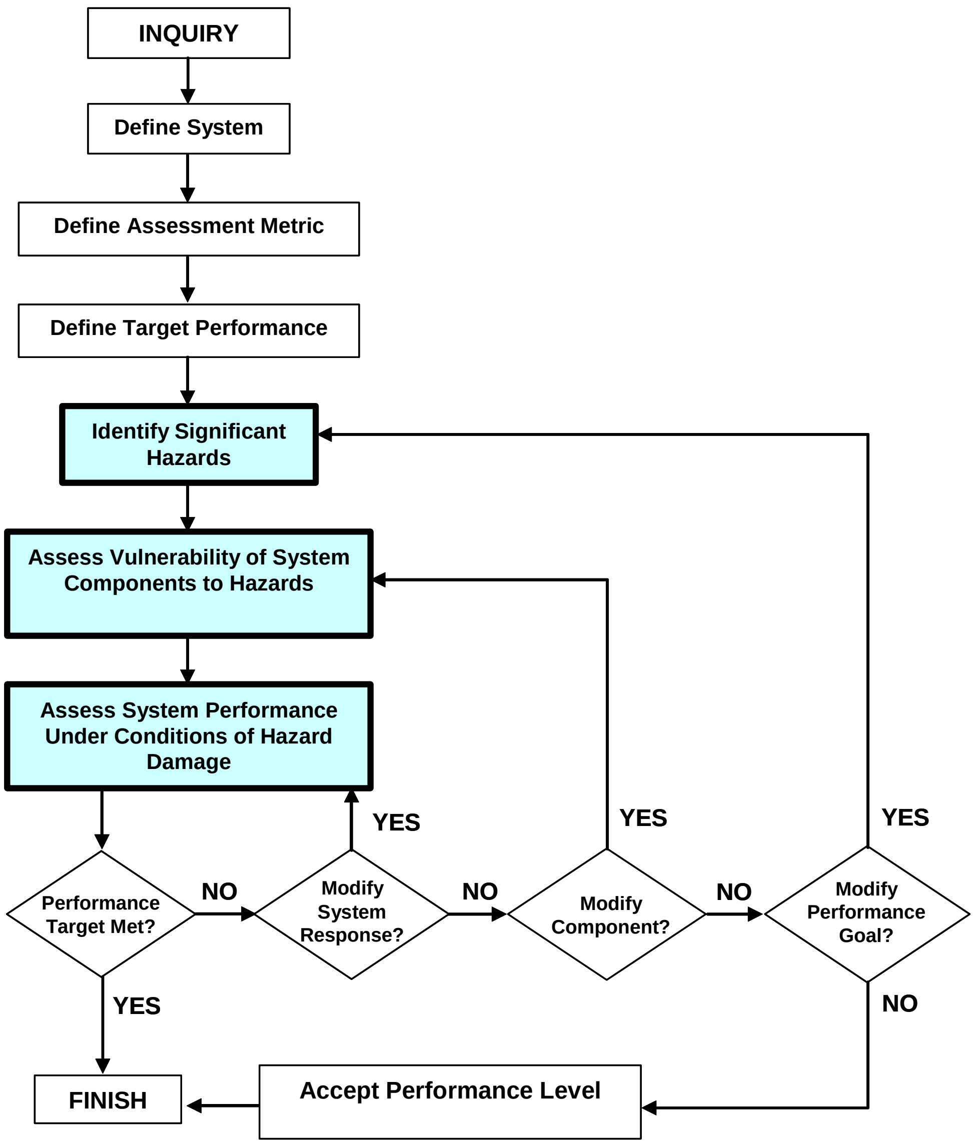

Figure 1-1. Decision-making Process for Assuring System Performance Goals Are Met

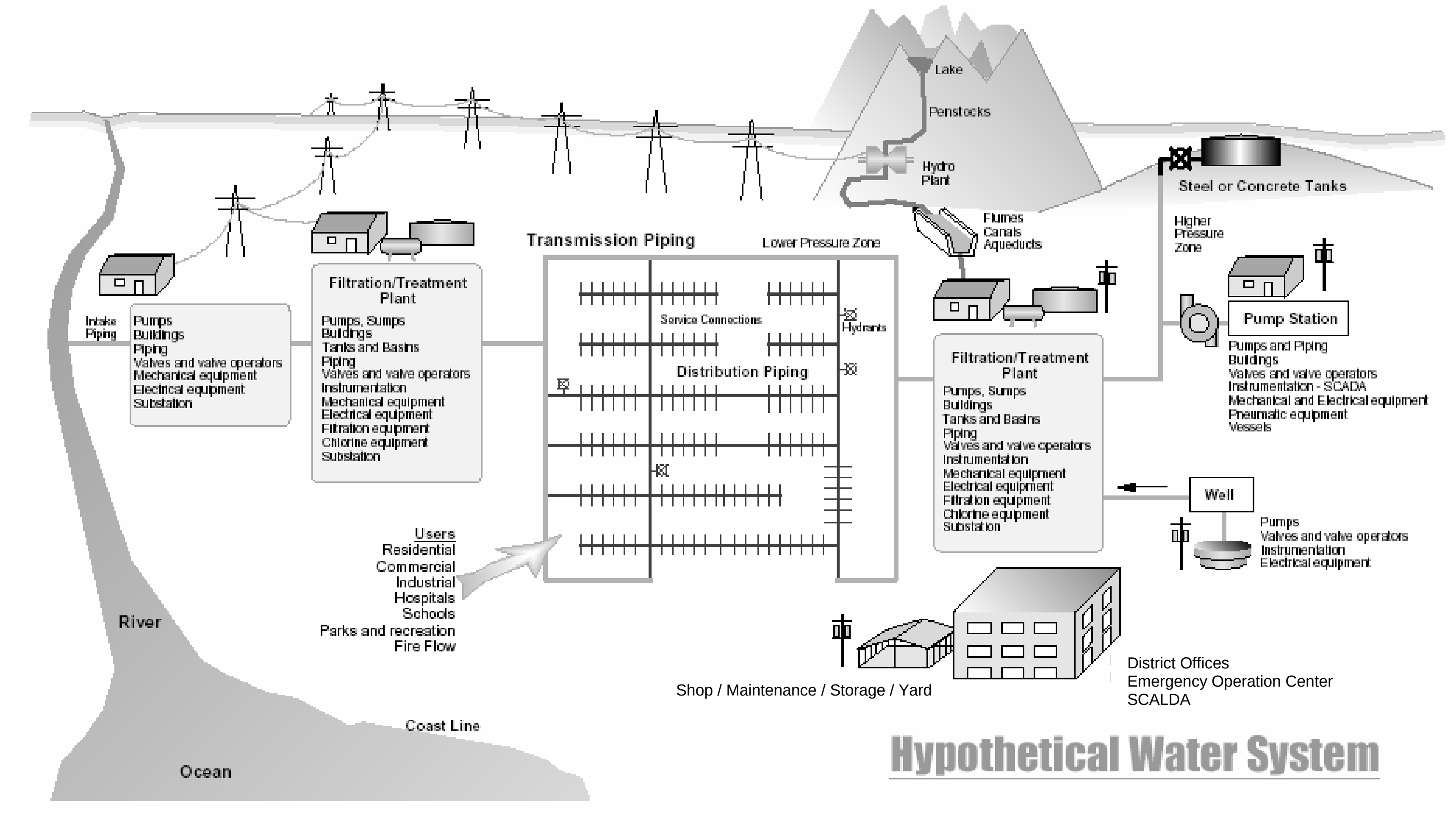

Figure 1-2: Hypothetical Demonstration System

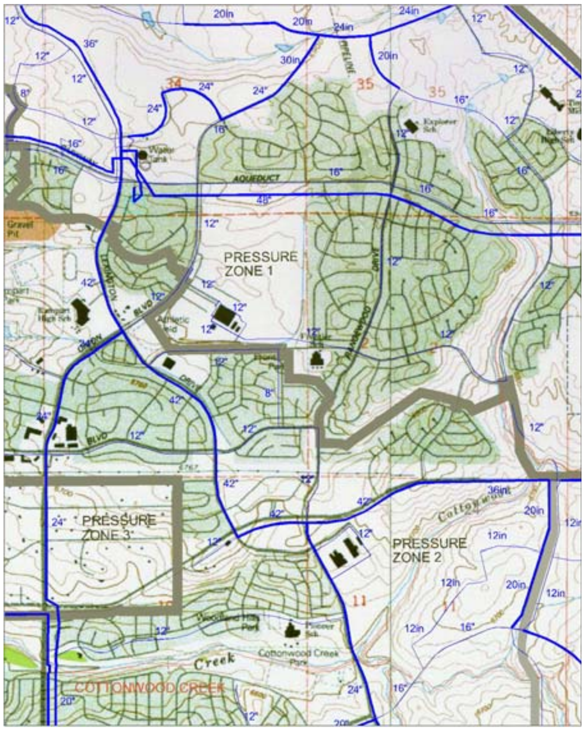

Figure 1-3: Composite Water System Map

Photos 1-6

Photos 7-12

Photos 13-18

Photos 19-24

Photos 25-30

Photos 31-32

2 - Transitioning to a Phase 2 Evaluation

When addressing an inquiry that requires consideration of a portion of the system with a large number of components or multiple hazards, it is likely that few components will be able to pass the Phase 1 screening. In such cases, several options can be considered for transitioning to a Phase 2 evaluation:

1. Simply skip the Phase 1 screening and go directly to a Phase 2 evaluation. This is expected to be the most commonly used alternative.
2. If multiple hazards are being considered, components or portions of the system for Phase 2 evaluation could be prioritized based upon vulnerability to the greatest number of hazards. For example, a pumping station that may be vulnerable to damage from earthquake, flood, and landslide might be given a higher priority than a building that is only vulnerable to earthquake.
3. If only a single hazard is being considered, components or portions of the system for Phase 2 evaluation could be prioritized based upon the users determination of importance in terms of the inquiry. For example, considering vulnerability to ground displacements, a tunnel might be given higher priority for Phase 2 evaluation than a pipeline based upon higher flow volume and the potential for longer downtime for the tunnel.

2.1 Recommendations for Phase 2 Analysis

This section describes methods to quantify hazard potential and severity, power equipment fragility or vulnerability, and system performance. Whereas, Tables 5-4 through 5-9 in the Guideline recommend tasks for each analysis level, the tables contained in this section (Tables 2-1 through 2-11) identify current procedures and practices that have been used to carry out these analyses in past projects. The tables include comments that discuss the advantages and disadvantages of each method, when each method may be most applicable, and pertinent resource documents describing the methodology. The tables include a determination of analysis level according to Levels 1, 2 or 3. This information is useful in achieving consistency of methods with respect to the level assignments provided in this guideline by offering methods of varying detail and sophistication.

The table for screening component vulnerability is based upon judgment and general knowledge of past damage in natural hazard events. As noted in the Guideline, the vulnerability screening table assumes that the components are of recent vintage. Users should carefully review the vulnerability screening table to confirm that the vulnerability rankings are consistent with their own knowledge of the components of their system and past experience with the response of their components in natural hazard events. If there are concerns regarding the validity of the component vulnerability screening table for a particular application, a prudent approach is to consider the components as failing the Phase 1 screening and proceed to a Phase 2 evaluation.

This section begins with a discussion of methods to assess natural hazards and human threats, proceeds to analysis methods for assessing equipment and building/equipment vulnerabilities, and ends with a presentation of methods for assessing system performance.

2.2 Selecting Phase 2 Analysis Level from Scoring Criteria

A use of a rating system is intended to provide an objective and transparent basis for determining the appropriate tasks necessary to answer the inquiry. While several suggestions are provided with respect to the details of the scoring methodology, it is expected that the definitions of factors contributing to the rating will be unique to specific water systems. One reason for this uniqueness lies in the variation in operational characteristics, service area, number and type of customers, and public policy issues among water systems. As an example, a large water system may give a low rating score if the impacts of a hazard impact fewer than 2,000 customers as this might represent less than 1% of their customer base. However, a small city system may give the same level of service interruption a high rating score because this might represent a much greater fraction of their customers.

The other reason for using a rating system is that is provides a means to prioritize efforts when dealing with multiple hazards, inquiries, or system components.

2.3 Determining Operational Importance Rating

The operational importance rating is a measure of the expected system response considering the hazard and component vulnerability. The two components of operational importance relate to the intrinsic importance to the functionality of the system, the system importance rating and the importance of the service provided by the system, the usage importance rating.

System importance will typically be scored according to the impact on the ability to deliver through the system. In evaluating the system importance of specific components, consideration should be given to the presence of alternate means to maintain water delivery, i.e., system redundancy. In the Guideline example, the SR for a pump station with a capacity greater than 10,000 gpm was assigned an SR of 5. However, if emergency wells are available that can provide 6,000 gpm, the SR for the pump station might be reduced to 3, considering this is the pumping capacity actually needed from the pump station.

Usage importance will typically be scored according to the end use of the water delivered through the system and the amount of time that activities that rely on water delivery might be interrupted. This is a result of the fact that most water systems do not employ separate networks for water to be used for drinking and sanitation and water to be used for fire fighting. Also, it is relatively uncommon for damage to water systems to result in direct injury to employees or the public.

In most cases, it will be necessary to establish scoring criteria based upon a combination of these measures. It is also possible that the type of customers served by the system may also be important in determining a usage score. For example, interruption of less than 50% of the total number of customers for less than 3 days might be assigned a rating of 3 while interruption of 50% of critical care hospital customers for less than three days might be assigned a score of 5.

Users can also develop more elaborate scoring methods by separately considering extent of service interruption, duration of service interruption, type of customers with service interruptions, loss of revenue from water sales, etc. However, considering that the scoring system is only intended to provide guidance in determining the level of effort necessary to obtain adequate information for risk management decisions, overly complex scoring methodologies are rarely justified.

Assignment of rating scores to recommended levels of analysis are intended to reflect the typical past practices in assessing water system performance. General inquiries should be addressed by very approximate assessment methods and should not impose substantial time or special information requirements in order to support a response to the inquiry. Similarly, there are very few instances where the highest level of analysis should be necessary.

One reason is for the limited need for advanced analysis methods is the lack of consistency in available analysis methods for quantifying hazards, vulnerability, and system response for various hazards. As a result, higher levels of assessment may often take on the characteristics of fundamental research projects as opposed to implementation of well-tested practices. For example, there is considerable data on the rate of water pipeline damage resulting from earthquake ground shaking that permit estimates of the quantity of pipeline damage in an aggregate sense. Such estimates are generally appropriate for Level 2 analyses. In contrast to this, there is limited data to allow a quantified estimate of damage at a specific pipeline location, such as might be necessary for a Level 3 analysis, based upon specific hazard parameters (e.g., ground acceleration, velocity or displacement, frequency content of the ground motion, ground motion incoherence) or pipeline design parameters (e.g., pipe diameter, depth of burial, soil strength, pipeline joint construction).

Another reason for the limited need for advanced analysis methods is related to the fact that most important function of water systems is related to public welfare with limited direct impacts on life-safety, environmental damage, or property damage. Therefore, the costs of implementing advanced analysis methods that are similar to the methods applied to systems with significant risks beyond public welfare should be difficult to justify.

2.4 Considerations for Modifying the Level of Analysis

As noted in the Guideline, experienced personnel can often determine the appropriate level of effort necessary to address inquiries without the Phase 2 scoring process. Similarly, users are encouraged to exercise judgment and specific knowledge of the underlying issues associated with a particular inquiry to modify the analysis level determined from the scoring process.

Such judgmental adjustments are appropriate for inquiries that are considered as preludes to more specific inquiries. In such cases, increasing the level of analysis for either the hazard or vulnerability assessment may be desirable to more fully address the reason for the inquiry.

Adjustments to the level of analysis are also appropriate based upon the characteristic of the system being assessed. For example, the lowest analysis level for system response is almost always appropriate for the assessment of linear water conveyance systems (e.g., pipeline conveying water from a surface water source to a treatment facility, wholesale water pipeline providing service to a limited number of community water systems).

2.5 Recommended Tasks for Performing Level 1 through Level 3 Analyses

- **Expert opinion** methods rely on the opinions of one or more individuals who can be considered experts by virtue of their knowledge of prior events on specific components and systems and are knowledgeable about the types of hazards being considered, the vulnerability of water system components and facilities to those hazards, and the response of the system to potential damage states associated with damage resulting from those vulnerabilities. The experts may be drawn internally from the water utility or may be individuals from the academic or consulting community that study particular types of hazards, or can be considered experts by virtue of their knowledge of prior events on specific components or systems. There are few or no calculations performed and minimal documentation is submitted to support any conclusions (e.g., a letter report). This approach is useful when limited data are available and when the cost of site-specific investigations can not be justified.

When applied to natural hazards, these methods are often supported with a review of available graphical data that permit the severity of a hazard to be identified for various locations within the system. Graphical data are usually presented using some type of Geographic Information System (GIS) or tool. The use of graphical data requires the existence of regional or national hazard maps and relies on one's judgment to assign vulnerability based upon hazard severity.

Other data that may be used to support expert opinion methods may be developed through interviews with company personnel to understand specific system characteristics and performance of the system under past hazardous events.

- **Statistical** methods applicable to hazard definition and assessing component or facility vulnerability. Both applications rely upon existing data sets that relate a specific outcome to a set of conditions.

  Statistical estimates of natural hazards are the most accurate and, in most cases, will provide a probabilistic assessment of the hazard. The most robust statistical estimates of natural hazards may require field investigations to obtain site-specific information (e.g, subsurface soil characteristics, topography, fault trenching investigations) that can be related to the likelihood and severity of a particular hazard using existing empirical or semi-empirical tools. Obtaining site-specific information can be costly and may require a substantial amount of time to complete. For this reason, statistical assessments of hazards based upon site-specific data are usually reserved for especially critical projects or assessments.

  Statistical assessment of vulnerability requires existing data sets that provide a means to correlate system component characteristics and damage levels with varying hazard intensity. Generally, these methods will normalize these incident/failure statistics according to some basic physical unit (e.g., number of incidents per kilometer of pipeline, number of incidents per 0.5 million gallons of storage). These methods are generally most useful in assessing the performance of a large number of components. This method is mostly applied in the case of earthquake studies, where some data sets on past performance have been compiled. For human threat assessments, the methods may involve the use of proprietary databases that may reside only within the company's data files.

  In particular cases, it may be advantageous to implement statistical methods using standard vulnerability models. A good example is HAZUS, a standardized loss estimation tool developed for the Federal Emergency Management Agency primarily to assess building structure performance for in earthquake, wind, and flood hazards. While HAZUS is less well developed for building service equipment than for building structures, other tools and software (often proprietary to various companies and consultants) are available that can provide improved assessment methods for specific categories of components and facilities of relevance to water systems.

- **Analytical** methods include detailed computation of component response parameters (e.g., stresses, strains, and deflections), often relying on structural analysis techniques (e.g., finite-element modeling or time-history analysis). These methods require detailed information on the building or components being evaluated in order to reliably predict or estimate the most critical weakness. Structural analysis of equipment for seismic loads may involve computing the severity of external loads (e.g. ground shaking, wind velocity, blast overpressure) at equipment mounting points for comparison with qualification specifications developed for the component or it's structural support system.
- **Simulation** methods are most applicable for quantifying specific system impacts or operational conditions. These methods typically use a computer network model that requires detailed characterization of the system and its operation. including detailed information on the performance of individual elements and detailed descriptions of the hazard severity throughout the entire system. Simulation methods are more applicable to situations where the response to a various levels of hazard damage is complicated by a large number of interconnected components (e.g., a metropolitan water distribution system, a large water treatment facility). This method can be limited using specific scenarios of interest or fully probabilistic (i.e., accounting for all quantifiable uncertainties, including the occurrence of the hazard). Implementation of probabilistic simulations is performed by analyzing multiple scenarios and relying upon Monte Carlo or Bayesian statistical techniques.
- **Penetration tests** are methods used to assess system response to human threat hazards that involve establishing a team of experts acting as adversaries that performs reconnaissance, scenario development, and implementation of a set of human threats (e.g., cyber, armed intrusion, sabotage) designed to exploit weaknesses they have discovered in the system. The activities of the adversarial group and the response of those individuals on the staff of the water utility responsible for thwarting the adversaries are typically monitored by a separate team with access to all communications of the adversarial group and the water utility related to the penetration test. These methods typically require establishing strict rules of engagement, particularly when the penetration test involves the simulated use of lethal force, chemical or biological agents, or actions that would otherwise have adverse impacts on safety or operation of the water system during the test.

2.5.1 Natural Hazard Determination

Many hazards can be addressed on a regional basis. For example, earthquake, windstorms, hurricane wind and storm surge, tornado, icing, and flooding hazards have all been mapped, largely for the entire contiguous U.S. Other hazards, such as settlement and some ground failure hazards caused by earthquake (liquefaction), are generally mapped for local areas; that is, no national maps are available to characterize the frequency or severity of these effects. Where available for local areas, these maps or databases are identified in the tables that follow.

Tables 2-1 through 2-5 list current procedures and practices for assessing earthquake hazards (ground motion, fault rupture, landslide, lurching, liquefaction, lateral spreading, settlement, tsunami and seiche), ground movement hazards/non-earthquake geohazards (gravity landslide, expansive soil, soil collapse, and frost heave), wind hazards (windstorm, tornado, and hurricane), icing, and flooding (riverine and storm surge), respectively.

2.5.2 Human Threat Hazard Determination

Human threats encompass a wide range of possible hazards: biological, chemical, radiological, blast, cyber and physical attacks. Unlike threats from natural hazards, human threats are more difficult to quantify and there is usually very little statistical information upon which to draw. Furthermore, the available information may be proprietary or confidential for business and/or security reasons. Because of these challenges, assessment of human threats must be based on new and partially tested methods. In many cases, relying on experts (particularly those knowledgeable about these threats) is the only useful means of establishing threat characteristics and likelihoods.

Table 2-6 lists general methods used for assessing human threat potential. In addition to describing each method, the benefits (pros) and limitations (cons) of each method are identified.

2.5.3 Assessing Water System Component Damage from Natural Hazards

2.5.3.1 Assessment of Pipeline Vulnerabilities

In general, there is a wide range of methods for quantifying the damage or failure potential of water pipelines. Some of the key factors that will influence the performance of pipelines include: a) the type of hazard being analyzed (e.g., earthquake, flooding, etc.), b) the material properties of the pipeline, c) the age or condition of the pipeline, d) whether the pipeline is located in a dense urban area or a rural area, and e) the size and operating conditions of the pipeline (e.g., transmission versus distribution).

Table 2-7 lists methods that have been used to assess pipeline performance due to natural hazard loads. As in other previous tables, the advantages and disadvantages of using each method and resource documents are included.

2.5.3.2 Assessing the Vulnerability of Other Water System Components

There is broad experience with the performance of water system components in natural hazards events, although the data have not been extensively, rigorously and systematically collected and analyzed.

Table 2-8 lists methods that have been used to assess electric power equipment performance due to natural hazard loads. As in other previous tables, the advantages and disadvantages in using each method and resource documents are included.

2.5.3.3 Assessing Building and Service Equipment Vulnerabilities

In the context of transmission and/or distribution of electricity, buildings and service equipment apply mainly to structures or buildings that house substation equipment or help in the monitoring and control of power distribution. Other buildings that important to a performance assessment may those for offices, maintenance, and control centers. Services for these buildings can be varied and include such systems as HVAC, telecommunication, and data processing systems.

Table 2-9 lists methods by which to quantify the vulnerability of buildings and their associated equipment and when each method is most applicable. In addition, a list of resource documents that give additional examples of how these methods have been applied in practice is provided.

2.5.3.4 Assessing Water System Component Damage from Human Threats

The operating equipment in electric power systems may be vulnerable to human threats, which include: a) biological, b) chemical, c) radiological, d) blast, e) cyber and f) physical attacks. The types of equipment that are being considered include those associated with low voltage control, protection, and communication systems (e.g., SCADA).

Table 2-10 contains a preliminary list of current procedures and practices for quantifying the vulnerability of equipment due to human threats. In addition, the advantages and disadvantages of each method are identified.

2.5.4 System Performance Assessment

Methods for quantifying the performance of electric power systems are based on systems analysis techniques that can range from graphic methods to sophisticated simulation models. An important factor in deciding the right method is the level of understanding regarding how the results of the analysis will be used. For this reason, two additional parameters in defining methods for system performance assessment are helpful: desired outcome and key performance metrics. By including these two factors, it will become clearer which analyses are most appropriate for the assessment.

Table 2-11 describes the pros and cons and applicability of various methods of quantifying system performance. These methods are described in relation to the desired outcomes that are being sought. Citations are provided as a resource for understanding in detail the methodology being presented.

Six different performance metrics are used in this guideline and shown in Table 2-12. These metrics are used to measure the four identified desired outcomes (performance targets).

Table 2-12. Performance Targets and Performance Metrics

Desired Outcomes	System Performance Metrics
Protect Public and Utility Personnel Safety	• Casualties (deaths and injuries) • Hazardous Materials Spillage
Maintain System Reliability	• Service Disruption • Downtime
Prevent Monetary Loss	• Capital Loss • Revenue Loss • Service Disruption • Downtime • Hazardous Materials Spillage
Prevent Environmental Damage	• Hazardous Materials Spillage

2.6 Factoring Cost and Schedule

The response to any inquiry will need to consider the amount of labor effort (water utility staff, consultants, outside experts) devoted to responding to the inquiry, which may be defined by the inquiry, and the costs associated with obtaining the information necessary to adequately address the issues raised by the inquiry. In nearly all cases, the cost and labor effort are directly correlated. General guidance on the amount of labor effort associated with varying levels of analysis is provided in Figure 2-1 is only intended to represent a very approximate estimate of the level of effort that might be required. However, Figure 2-1 is intended to be sufficient for high-level budgetary and scheduling purposes.

Figure 2-1 can also be useful in justifying alternate levels of analysis that might otherwise be considered appropriate for a particular inquiry. For example, Figure 2-1 can be used to modify the effort to respond to an inquiry that might otherwise require an H3-V2-S2 analysis to an H1-V1-S1 analysis if (1) a response is required within a time frame on the order of one week or (2) if the available budget to respond to the inquiry will not support the costs associated with more than 15 days of labor.

Adjustments to the level of effort and time necessary to perform the tasks associated with a more advanced level of analysis may also be appropriate considering the quality of available information. For example, assessment of the system wide impact of a repeat of a hazard event will require minimal effort to establish the hazard and vulnerability because these issues are defined by the inquiry.

2.7 Dealing with Multiple Hazards

Ideally, water system performance assessments that seek to answer inquiries that relate to multiple natural hazards and human threat events should be undertaken in a balanced fashion in which proper consideration is give to the variation in the likelihood of hazard occurrence, system component vulnerability, and system response. This approach is generally feasible for natural hazards for which design values are commonly specified in probabilistic terms (e.g., 100-year flood elevations, 50-year ice thickness, 500-year earthquake ground shaking.) Implementing such a consistent approach can be considerably more difficult for other natural hazards that are localized in nature (e.g., earthquake surface faulting, river scour, static slope stability) or depend upon initiating events or conditions (e.g., slope movement triggered by unusually high rainfall, leaking water lines, earthquake ground shaking, or excavation activity, subsidence from underground mining operations, hurricane related storm surge).

If all natural hazard events are defined with an equal probability of occurrence, the scoring methodology of the Guideline can be used to prioritize the hazards in terms of importance to system response. The selection of the probability of occurrence should consider the basis for the inquiry driving the assessment. For example, if the inquiry is related to questions regarding the maximum extend of potential water service interruptions, preference would be given to selecting a lower probability of occurrence associated with more substantial hazard events (e.g., annual probability of exceedance of 0.2% or less). On the other hand, if the inquiry was related to whether or not sufficient capital reserves were available to respond to likely natural hazard events preference would be given to selecting a higher probability of occurrence (e.g., annual probability of exceedance of 2% or greater).

A consistent, risk-based approach to hazard prioritization is difficult if the inquiry relates to human threats, especially human threats associated with terrorist acts. As of 2005, there are no accepted methods for estimating the likelihood of hazards and vulnerabilities related to terrorist acts. Unlike most natural disasters which can be analyzed and probabilities of occurrence developed based on historical data and engineering principals, terrorism by its very nature and definition defies a reasonable level of predictability. While the relevance of the probability of attack in analyzing risk is generally accepted, quantifying this probability is the subject of much debate. With respect to the goal of a consistent risk-based analysis approach it is generally contended that:

1. The probability of a terrorist attack cannot be measured.
2. The likely mode and location of a potential terrorist attach can not be defined.
3. The measure of effectiveness for deterrence of a terrorist attack cannot be gauged.

For this reason, vulnerability assessments such as those required for certain water systems by EPA typically consider a terrorist attack as a certainty (100% probability of occurrence). Thus, the typical practice for addressing terrorist attacks focuses on identifying vulnerabilities and steps that can be taken to reduce those vulnerabilities.

Clearly, an alternate approach is necessary if the outcome of the performance assessment is to determine the most effective and balanced allocations of budgetary resources to improve water system performance. One approach to assigning a probability of a terrorist attack on a water system is based on qualitative assumptions regarding the number of water systems exposed and the number of attacks that might occur in a finite time frame. For instance, a user might estimate that there are 500 water systems in the United States similar to the users system. If it is further assumed that a significant attack (an attack in which the system overall is significantly disabled) will be conducted at one of these systems every five years, the average annual probability for an attack on any given facility is 0.04%. Alternatively, if it is estimated that there are 2000 similar systems in the United States, the average annual probability, based upon the same assumption of one significant attack in five years is 0.01%. The upper estimate of annual probability for a terrorist attack is roughly equivalent to typical probabilities for significant natural hazards (e.g., earthquake annual probability of 0.04% is the basis United States building codes). The lower estimate of annual probability for a terrorist attack is roughly comparable to the likelihood of the most extreme natural hazards (e.g., design earthquake ground motions for the proposed Yucca Mountain nuclear waste repository is being based upon an annual exceedance probability on the order of 0.01%).

Table 2-1. Procedures and Practices for Quantifying Earthquake Hazards

EARTHQUAKE HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Ground Motion	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar seismic characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Relevant ground-motion data obtained from credible publications or websites, such as those produced by the U.S. Geological Survey, state geological surveys (e.g., California), earthquake engineering centers or organizations (e.g., Southern California Earthquake Center-SCEC), or universities.	Data can be obtained quickly and are usually accurate.	Studies are usually regional and may overlook local faults, seismic sources, or ground conditions that may be important. Many of the regional studies estimate ground motions for assumed local geology (e.g., bedrock), which may not be appropriate for site(s) of interest.	When cost or time considerations prohibit site-specific studies.	USGS 1997b; Frankel et al. 2000; USGS 2002; and the USGS website, http://eqhazmaps.usgs.gov/, provide rock-site ground-motion seismic hazard data for the U.S.
	Level 3 **Statistical (Site-Specific)**	Ground-motion hazard computed for site or sites using established probabilistic seismic hazard analysis (PSHA) methods.	Method is most accurate and robust. Current information on regional seismic sources and local geology can be easily incorporated.	Implementation of method is more expensive and time consuming than other two approaches.	When cost and time considerations are not excessively restrictive. Method is more appropriate for large systems affecting major population centers in seismic areas or for systems that would have adverse consequences, if incapacitated.	Cornell 1968 provides basic methodology.

EARTHQUAKE HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Fault Rupture	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar seismic characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Maps of potentially active faults can be obtained for some western states (e.g., CA, OR, WA, NV, UT, AZ) from primarily the state geological surveys, but publications describing the fault-rupture displacement hazard are more difficult to find, are unavailable, or do not exist.	Fault maps are relatively easy to obtain and at reasonable cost.	Data or information on fault displacements is difficult if not impossible to obtain from the literature.	When location of active fault is of primarily interest or when cost and time constraints prohibit site-specific study.	Not applicable. Fault maps, if available, can usually be obtained from the appropriate state agency.
	Level 3 **Statistical (Site-Specific)**	Office-based studies and sometimes field investigation are required to estimate fault-rupture hazard.	Approach is only available method in most cases to accurately estimate fault-rupture hazard.	Approach can be time consuming and expensive.	When key components are located in known or suspected active fault zones and estimates of the rupture hazard are required for reliability assessments.	Formal methodology described in Youngs et al. 2003; McCalpin 1996; Nyman et al. 2003.

EARTHQUAKE HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Ground Failure (landslide, lurching, liquefaction, lateral spreading, settlement)	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar seismic characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Maps of potential liquefaction and landslide areas are available for some locations, but landslide-prone areas are not confined to seismic regions.	Maps are easy to obtain.	Information on the permanent ground displacement hazard, which is of primary importance, typically is not available or does not exist. Maps of potential hazard exist for relatively few locations. Conservatism is often built into such maps.	When location of ground-failure hazard is of primary interest or when cost and time constraints prohibit site-specific study.	Available liquefaction maps are listed in Power and Holzer 1996; California Geological Survey (www.consrv.ca.gov/cgs) Information on available landslide maps for California, for example, can be found on website http://www.consrv.ca.gov/cgs/rghm/landslides/ls_index.htm. Various websites contain information for obtaining maps for liquefaction and landslide hazards; these websites can be accessed through key word searches.
	Level 3 **Statistical (Site-Specific)**	Methods have been developed to estimate (1) probability of liquefaction or landslide at given locations and (2) annual probability of permanent ground displacement due to liquefaction or landslides.	Only available procedure when published information is not available.	Methods are generally difficult to apply and few professionals have developed and implemented methods. Methods can be expensive and time consuming.	When data are necessary for reliability assessments.	Methods for computing probability of liquefaction can be found in National Research Council 1985, p. 174–89 and O'Rourk et al., 1999. Method for probabilistic treatment of landslides with application can be found in USGS Open-File Report 98-113 (USGS 1998).

EARTHQUAKE HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Inundation (Tsunami & Seiche)	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar seismic characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Maps of tsunami hazard can be obtained for the West Coast of the continental U.S. and Hawaii, where the hazard is greatest.	Tsunami hazard maps are relatively easy to obtain.	Maps may not reflect local conditions at a particular coastal site. Seiche hazard maps typically do not exist.	When cost or time considerations prohibit site-specific study.	See National Tsunami Hazard Mitigation Program website. www.pmel.noaa.gov/tsunami-hazard/
	Level 3 **Statistical (Site-Specific)**	Office-based studies are required to estimate tsunami or seiche hazard.	Studies would provide more accurate information.	Studies would be too time consuming unless a sufficient amount of previous work had been done to serve as a starting point.	When key components are located in high tsunami/seiche hazard areas.	Synolakis 2003

Table 2-2. Procedures and Practices for Quantifying Ground-Movement Hazards (non-earthquake induced)

GROUND-MOVEMENT HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
• **Gravity Landslide** • **Expansive Soil** • **Soil Collapse** • **Frost heave**	**Level 1** **Expert Opinion**	Estimates based on previous work of expert.	Estimates likely to be better than those obtained directly from available regional studies.	Approach may not provide accurate assessment of hazard if expert does not have adequate local database.	When data or publications on hazard in location of interest are not available or too time consuming to compile or interpret.	Not applicable
	Level 2 **Statistical (Published Data)**	Relevant data/information obtained from credible publications or websites.	Data/information can be obtained quickly.	If available, data/information is usually for broad regions at small scales and thus not very useful for specific local areas. None of the information is cast in a probabilistic framework suitable for risk analysis.	When adequate information is available.	Many publications are available and can be obtained by using library reference or web searches. However, few are likely to have information for a particular location. The USGS, NOAA, and state geological survey websites can be quick sources of information.
	Level 3 **Statistical (Site-Specific)**	Qualified professional firm performs evaluations and analysis.	Approach better addresses local hazards if expert opinions and published data/information are not available or feasible.	Can be expensive and time consuming and would only provide a qualitative description of likelihood of hazard (e.g., low, moderate, high) and perhaps its possible extent of movement.	When key components are located in vicinity of hazard that is considered potentially severe and when other approaches are inadequate.	Many publications are available on the identification and evaluation of the hazard, but none presents method to quantify hazard probabilistically for risk assessment.

Table 2-3. Procedures and Practices for Quantifying Wind Hazards

WIND HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
• **Windstorm** • **Tornado** • **Hurricane**	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar wind characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Data obtained from national wind maps published in building codes and from literature.	Data can be obtained quickly and are usually accurate.	Information is usually regional and would likely overlook local conditions that could affect wind velocity.	When cost or time considerations prohibit site-specific studies.	Wind velocity maps can be found in ASCE 7-05, for example.
	Level 3 **Statistical (Site-Specific)**	Wind hazard computed using probabilistic wind hazard analysis (PWHA) similar to PSHA method for ground motion.	Method is most accurate and robust and can include local data affecting wind velocities.	Implementation of method is more expensive and time consuming than other two approaches.	When cost and time considerations are not excessively restrictive. Method is more appropriate for large systems affecting major population centers in wind hazard areas or for systems that would have adverse consequences, if incapacitated.	Site-specific model can be constructed from information in Section 3.4.

Table 2-4. Procedures and Practices for Quantifying Icing Hazards

ICING HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Ice Accumulation on Structures, Equipment, etc.	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar icing characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Data obtained from publications, maps.	Data can be obtained quickly and are usually accurate.	Information is regional and may overlook local conditions.	When cost or time considerations prohibit site-specific studies.	ALA, 2004
	Level 3 **Statistical (Site-Specific)**	Probabilistic model based on meteorological data and local conditions.	Method is most accurate and can account for local conditions.	Implementation of method is more expensive and time consuming than other two approaches.	When cost and time considerations are not excessively restrictive. Method is more appropriate for large systems affecting major population centers in icing hazard areas or for systems that would have adverse consequences, if incapacitated.	Site-specific model can be developed from sufficient historical ice storm data.

Table 2-5. Procedures and Practices for Quantifying Flood Hazard

FLOOD HAZARD	PROCEDURES AND PRACTICES	DESCRIPTION OF METHOD USED TO QUANTIFY LIKELIHOOD OF HAZARD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
• **Riverine** • **Headwater** **(Flood from dam or tank failure is not a natural hazard, but should be considered)**	**Level 1** **Expert Opinion**	Estimates based on previous work of expert in region of interest or in regions of similar flood characteristics. Expert performs few or no calculations and submits minimal documentation, such as a letter report.	Estimates can be quite accurate depending on qualifications and relevant experience of expert.	Approach is generally more time consuming and expensive than approaches using published information.	When published data are not available and site-specific approaches are too expensive.	Not applicable
	Level 2 **Statistical (Published Data)**	Hazard maps and data available from FEMA, USGS, NOAA, USACOE.	Data can be obtained quickly and are usually accurate.	Local conditions affecting hazard may be overlooked.	When cost or time considerations prohibit site-specific studies.	FEMA 1996
	Level 3 **Statistical (Site-Specific)**	Flood hazard computed using established probabilistic methods incorporating regional and local data.	Method is most accurate.	Implementation of method is more expensive and time consuming than other two approaches.	When cost and time considerations are not excessively restrictive. Method is more appropriate for large systems affecting major population centers in flood hazard areas or for systems that would have adverse consequences, if incapacitated.	

Table 2-6. Procedures and Practices for Quantifying Human Threats

PROCEDURES & PRACTICES	DESCRIPTION OF THE METHOD	PROS	CONS
Level 1 **Expert Opinion**	Estimates based on the judgment of informed individuals (i.e., Director of Security, Chief Information Officer, law enforcement or military intelligence officers who have access to current human threat information), individuals from the academic or consulting community who study particular types of human threats or other individuals who can be considered experts by virtue of their knowledge of prior events on specific components/systems.	Can be an inexpensive and quick approach although improved confidence in the evaluation of the likelihood of one or more human threats. Confidence comes from the ability to identify an adversary, intent, capability, history, and quantifiable threat levels. This method can be accurate enough to base specific mitigation measures on.	If performed under time and cost constraints, this approach is limited by assumptions based upon prior specific human threats. Individuals with knowledge about one type of threat may not be aware of the potential for other threats. Improved confidence may be moderately time consuming owing to the need to locate and obtain a qualified opinion of the threat to particular components/systems. This method provides a qualitative rather than a quantitative estimate. As a result, the estimate is generally not very precise.
Level 2 **Statistical**	Probabilistic analysis of specific types of human threats to identify their potential or likelihood.	Provides a mathematically robust evaluation of verifiable, existing data that can be used in a statistical evaluation of risk. Sources may include open file reports or local, state or federal agencies or their information centers.	This evaluation may be very precise in describing the hazard, but potentially can be inaccurate because of the historical data of particular types of human threats on specific components; systems may not be available or may not be credible. Historical data are often proprietary and not available in open file reports or available from governmental agencies.

Table 2-7. Procedures and Practices for Assessing Pipeline Performance

METHOD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Level 1 **Expert Opinion**	Can usually provide a realistic assessment of vulnerability, even with limited specific information on the pipeline. This method can effectively point to areas that require more detailed analysis. Usually inexpensive when compared to other analytical solutions.	Opinions from equally qualified experts can often vary significantly. Quantitative estimates of vulnerability are usually not possible using this method alone. Demands a high level of expertise on the part of the expert.	This method is best used when it is not clear what actions should be taken to quantify vulnerability. Can also be effective in helping to resolve internal questions or issues.	
Level 2 **Statistical**	Assessment of performance is based on actuarial experience. Data can also be used to quantify accuracy limits of estimates. Can usually be applied with very little internal or outside resources.	Usually this method is good for measuring the performance of generic groups of pipes. Difficult to incorporate any special or unique features that may be present. Lack of data prevents this method from being effective.	This method is best employed when assessing the performance of a large group of pipes (e.g., large network). Can be effectively used to rank vulnerabilities. Usually employed in network or systems analysis studies.	ALA, 2001b
Level 3 **Analytical**	These methods provide the most precision and accuracy. Implementing these methods will allow a detailed assessment of the potential for specific failure modes. Can be used to assure that design criteria are effectively met.	The method requires more detailed information to implement. May also require in-situ data that may be costly to collect.	This method is appropriate for developing or ensuring specific design specifications. Particularly important in assessing the performance of large and critical pipelines.	ASCE 1984; Nyman et al. 2003, ALA, 2001a; Honegger and Nyman, 2004

Table 2-8. Procedures and Practices for Quantifying Equipment Vulnerability in Natural Hazard Events (continued)

Table 2-8. Procedures and Practices for Quantifying Equipment Component Vulnerability in Natural Hazard Events

METHOD	DESCRIPTION OF THE METHOD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Level 1 **Expert Opinon**	Use of judgment based on direct knowledge Senior or most knowledgeable staff, first estimate performance individually and then compare and discuss in a group and arrive at a consensus.	This approach provides data that is based or anchored to experience. This method can be very inexpensive.	User can be led to believe that the final answer is more accurate than it really is. Accuracy is based on the data being applicable. Confidence in the answers can be very low to high depending on the amount and nature of data.	Use when some experience data exists but not enough to have well-behaved statistics. Results based on this data should only be used to determine whether potential for significant risk from hazard exists, plan for post disaster response, or identify relatively vulnerable points in system.	
Level 2 **Statistical**	Probabilistic analysis of components based on experience data derived from previous hazard loading or various similar loading sources on similar components.	Provides a mathematically robust evaluation of existing data that can be used in a statistical evaluation of risk. This approach is only a little more expensive than using estimates or informed estimates if the data exist.	This evaluation may be very precise in describing the hazard, but can be inaccurate in assessing performance because the historical data may not be available or may not be applicable.	Can be used for determining accurate return on investment for proposed system upgrades.	Sources may include open file reports from local, state, and federal agencies or their information centers.
Level 3 **Analytical**	Mathematical evaluation that involves modeling component to obtain deflections, strains, and in some cases, stress at key locations of component with various mountings to various motions. *For example:* Based on calculations, when a certain component is subjected to a defined level of shaking, enough members yield such that a mechanism is created. The amount of potential energy in the system will drive the mechanism such that displacement constraints are exceeded and by definition the component fails.	This method is very flexible in that any condition that is desired can be modeled and studied. This method can be relatively expensive, even for one component.	Modeling certain failure modes of electrical components requires an understanding of the failure process.	Can be used for raising confidence of any fragility model derived from estimates or informed estimates.	

Table 2-9. Procedures and Practices for Quantifying the Vulnerability of Buildings and Service Equipment (continued)

Table 2-9. Procedures and Practices for Quantifying the Vulnerability of Buildings and Service Equipment

METHOD	DESCRIPTION OF METHOD	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Level 1 **Expert Opinon**	Screening method that relies on one's judgment in combination with natural hazard depictions using GIS tools or published digital data and maps. May includes walkdown to identify typical weaknesses and required loss reduction measures for each significant hazard. Criticality, costs, and benefits of each risk reduction measure are qualitatively rated.	Rapid and efficient. Defines significant concerns for each hazard. When considered in combination with hazard severity and frequency, this method can be used to identify buildings and equipment requiring further study using more formal, quantitative methods.	Quality of assessment may be highly variable. Results vary according to the framework and personnel used to do the survey. This is a simple approach, but demands high level of experience and judgment to be effective.	This is appropriate as a first step in any analysis, at any level. For larger utilities, this may be performed in-house, to define a further scope of work to be executed by others. Especially useful for flood, where elevation of building compared to flood levels determines risk. Implementation with walkdown is appropriate for large or for critical buildings, such as emergency operations centers, engineering offices, and for facilities required for post-event repair and recovery.	ASCE Standard 7-05 (2005); International Building Code 2003 (ICC 2003) Scawthorn 1986; ASCE/SEI 31-03 (2003b); FEMA 356 (2000). FEMA 386-7 (2002a). FEMA 426 (2003b)
Level 2 **Statistical**	Desktop study using HAZUS or other scenario-based risk assessment software, with multi-hazard capability.	Rapid and efficient. Provides preliminary, order-of-magnitude estimates of economic loss and downtime for the defined (usually maximal) scenarios. May serve as a basis for eliminating some hazards or part of the system from further evaluation.	Crude and approximate. Limited to arbitrarily defined scenarios. Few "system" models are provided, so business interruption loss estimates are crude. Does not provide loss reduction measures or quantify their benefits. May require several consultants with different software packages, which can produce inconsistent results.	HAZUS is only applicable to earthquake, wind, and flood. Such software provides only a subset of the total financial losses and downtime for building and a few common equipment types.	FEMA 2003a; Wong et al. 2002
Level 3 **Analytical**	Methods based on the use of structural analysis techniques (e.g., finite-element modeling) or time-history analysis. Requires detailed information on the building and its components. Can identify critical weaknesses in a building or equipment component.	Improved accuracy. Allows rational, systematic assessment of many aspects of building and equipment vulnerability, the determination of damage states for various scenarios, and the effectiveness, in terms of reductions in overstress or displacement under various retrofit options.	Requires quantitative evaluation of hazard scenarios. Costly and time consuming. Results vary with methods and software chosen, expertise of user, etc. Often difficult to assign dollar losses to buildings or components for a given damage state.	Appropriate for large or critical buildings and equipment, such as emergency operations centers, utility engineering offices, and for facilities required for post-event repair and recovery. May be appropriate for intermediate-sized buildings and equipment important to operations, especially where previous screening studies have identified potential high risks.	Scawthorn (1986); ASCE/SEI 31-03 (ASCE, 2003b); FEMA 356 (2000) ASCE 7-05 (2005) FEMA 386-7 (2002a); FEMA 426 (2003b)

Table 2-9. Procedures and Practices for Quantifying the Vulnerability of Buildings and Service Equipment (continued)

Table 2-10. Procedures and Practices for Quantifying Component Performance Against Human Threats

METHOD	DESCRIPTION OF THE METHOD	PROS	CONS
Level 1 **Expert Opinion**	Estimates based on judgment or the determination of individuals (i.e., Director of Security, Chief Information Officer, law enforcement, military intelligence officers) or other individuals who can be considered experts by virtue of their knowledge of prior events on specific components and systems and are knowledgeable about network architecture, system components, barrier systems, access-control systems, SCADA, computer security systems, business procedures and databases, and communication systems.	Can be an inexpensive and quick approach because the individuals performing the assessment rely only on personal expertise and knowledge. Can provide confidence in the evaluation of vulnerability of components or systems. Confidence comes from the thorough identification of all critical system components and their various vulnerabilities. This method can be accurate enough to base specific mitigation measures.	This approach is limited by the individual's prior knowledge of the component and system vulnerabilities. Individuals with knowledge about one type of component or system may not be aware of other types. This method may be moderately time consuming to survey each site and conduct interviews of staff who operate the components and systems. This method provides a qualitative rather than a quantitative estimate. As a result, the estimate is generally not very precise.
Level 2 **Penetration Tests**	Active scanning and penetration tools are used to identify vulnerabilities. Often involves the establishment of rules of engagement, a white cell for continuous communication with the utility, and an undercover red cell that performs the reconnaissance, scenario development, and exploitation.	Provides a quantitative evaluation of a facility or computer system's vulnerability. The evaluation includes the amount of effort required to exploit the vulnerability and perform the penetration. Penetration tests can be conducted on a regular basis to determine the effectiveness of mitigation measures.	Generally limited to a particular set of components and systems within the utility to avoid disruption of normal services provided by the utility. If a large number of facilities or computer systems are tested, this method can be expensive and very time consuming.
Level 3 **Simulation**	Possible failure or disruption modes are simulated using commercially available software (Ponist 2003; Sandia National Laboratory, 2002) or internal tools or methodologies.	Sophisticated software tools can provide the most robust estimates of impacts. In general, very useful in developing "what-if" scenarios for planning.	Effort can be significantly greater and may require the use of software with significant data needs or requirements. May require special training in order to implement in-house.

Table 2-11. Procedures and Practices for Quantifying System Performance (continued)

Table 2-11. Procedures and Practices for Quantifying System Performance

PROCEDURES AND PRACTICES	PROS	CONS	WHEN APPLICABLE	RESOURCE DOCUMENTS
Level 1 **Expert Opinion**	Simple screening method or scoping study approach and can provide helpful visual displays for decision makers. Easily understood by public safety agencies and operations and maintenance personnel.	Cannot provide reliable (neither accurate nor precise) measure of of the metric of interest. Does not consider the network features of a system Requires more effort to apply.	For scoping a study, convincing top-level management to undertake a detailed study or providing illustrations of results of a more detailed evaluation.	
Level 2 **Statistical**	Provides rough mean estimates considering specific conditions of the components at each site. Can provide a general assessment of impact of a hazardous condition on system performance.	Cannot provide precise estimates of the metric of interest. Can only provide macro information on outages originating within a highly networked system (e.g., a distribution system).	When the primary concern is with an estimate of average performance or when the critical facilities, the system as a whole, the area of interest, or the hazard in question can be treated as being fairly localized.	Seligson et al. 1996
Level 3 **Simulation (Limited or Full Probabilistic)**	The limited method permits quality assurance with respect to detail. The full probabilistic method provides an analysis of outage areas based on network connectivity, projected failure modes, and simulation of many events accounting for uncertainties. Both the limited and full methods permit consideration of a broader range of hazard intensity.	Limited simulations cannot provide robust statistics. Effort is significantly greater than statistical methods, especially for full probabilistic.	When it is desirable to develop a system-wide distribution of variation in system performance.	Limited: Rose 1999; Chang et al. 1995 Full Probabilistic: Moghdaderi-Zadeh 1991; McGuire 1990; Taylor et al. 2001; Perkins and Taylor 2003

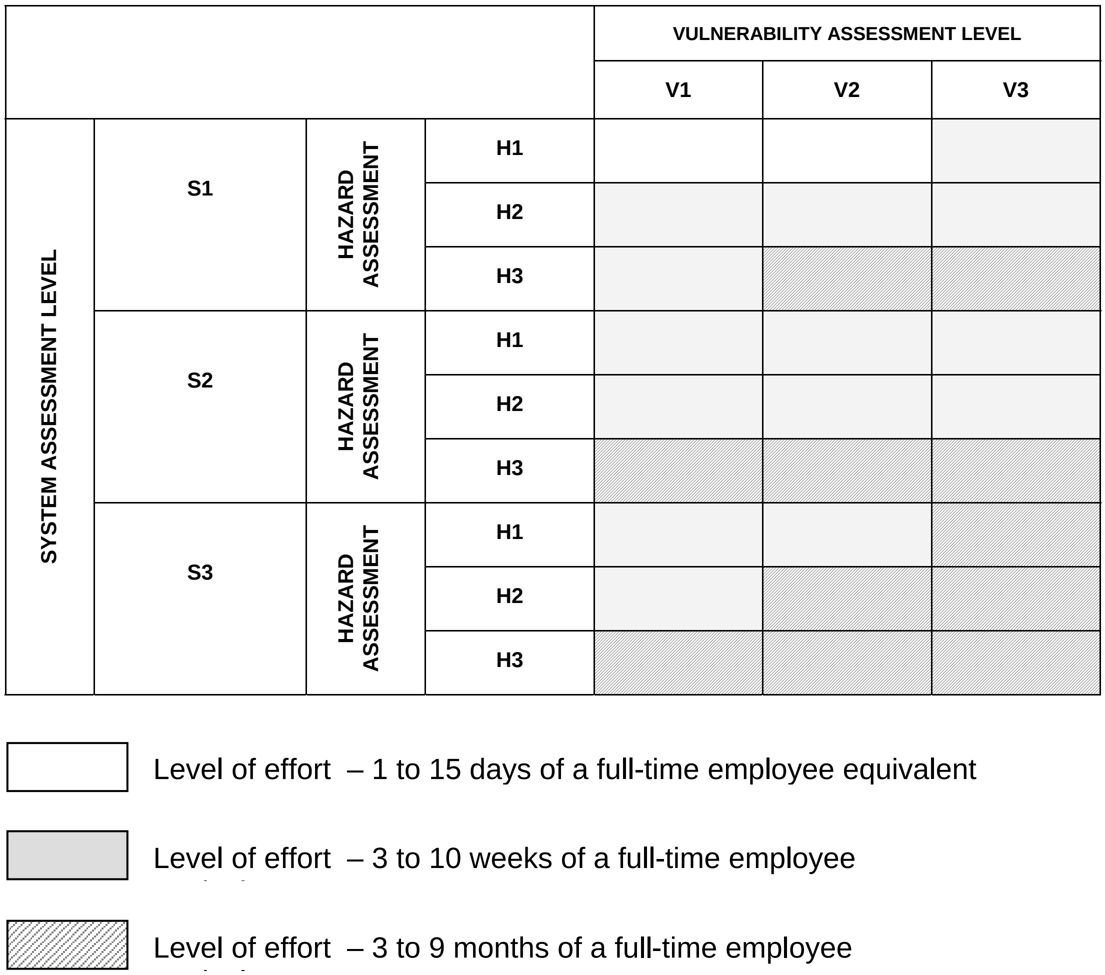

Figure 2-1. Range of Effort Needed to Perform Hazard, Vulnerability, and System Assessments at Different Levels

3 - Hazard Level Criteria

This guideline uses national hazard map data to help screen out sites or areas that are obviously not affected by certain natural hazards. It also provides a summary of the criteria that were used to judge whether areas were in low, moderate, or high hazard zones. The definitions and assumptions used to create the criteria are presented below. In addition, detailed tables showing these hazard levels by state and by county are contained in Appendix B of this commentary. These tables are ordered alphabetically by state and by county to make their use easy and practical.

The user should also note that natural hazard maps at other geographic scales and hazard probabilities can be used with the approach in the Guideline. For example, the U.S. Geological Survey provides probabilistic ground motion maps for 2, 5, and 10 percent probabilities of exceedance in 50 years. Naturally, the ground motion values on these maps increase with decreasing probability of exceedance. Water utilities may elect to base Phase 1 screening or the determination of analysis levels on different probabilities of exceedance. The methodology provided in this guideline should accommodate the various maps with their associated probabilities of exceedance, but due consideration should be given to the choice of appropriate separation points for low, moderate, and high hazard levels.

For the evaluation of selected natural hazards that are not extensively geographically distributed (e.g., a small landslide, a site with potential soil collapse, a localized flood zone), one can construct intensity scenarios for the site of interest. Intensity here represents the natural hazard effects at a single site. The term “site” is represented by some localized region (e.g., a zip code, a township section, a clearly identified lot). For such geographically concentrated natural hazards, there is generally no difference between identifying the hazard to be considered and evaluating the hazard intensity at a particular site.

However, for hazards that are extensively distributed geographically (e.g., hurricanes, earthquakes, great floods), the natural hazard identified must be treated separately from its local site intensity modification effects. Geographically large water utility systems require that initiating events be modeled first, followed by the modification of intensity (however physically measured) for the various sites within the water utility system. Hence, to comprehensively cover the topic of modeling natural hazards for water system risks, modeling efforts must consider both (1) how to model sources of natural hazards and then, as needed, (2) their attenuation or other intensity modification influences.

The Guideline focuses on publicly available information and models, and not the many proprietary models and computer programs covering natural hazards. The public literature provides examples of four types of modeling methodologies ranging from fairly complete and rigorous to indicative of a hazard problem only. The modeling methods are variously described as: (A) relatively complete probabilistic modeling capability is available in data form in the literature, (B) only a partial probabilistic modeling capability is available in data form in the literature, (C) an approximate probabilistic modeling capability is available using data in the literature and (D) the data in the literature is only indicative of a possible problem with no associated probabilities. Each hazard is also described as either independently occurring (I) one from the other or dependently occurring as the result of an associated hazard (D).

Tables 3-1 through 3-3 list the available computer programs, probabilistic hazard maps, indicative hazard maps, historic hazard data and hazard conditioning data that are readily available and can be used in modeling. Example reference sources available on the Internet and in the literature are also listed. The hazard and conditioning data can be used to develop coarse probabilistic models. Supplemental references for various hazards are provided in Appendix B. Table 3-4 presents an overview of the judged current ability of available information and data to be used to model hazards probabilistically without a great deal of theoretical algorithm development.

3.1 Earthquake

The Guideline uses the same earthquake hazard levels adopted by the authors of FEMA 154 (FEMA 2002b, ATC 2002); see Figure 3-1. This is a well-accepted, standard document for screening a building for potential seismic risk. It defines hazard levels with respect to two ground motion parameters specified in the IBC 2003, which in turn references maps published by NEHRP (National Earthquake Hazards Reduction Program) and the U.S. Geological Survey (USGS 1996a, 1996b, 1997b; Building Seismic Safety Council 2004; and Frankel et al. 2000). The ground motion parameters are the design 5%-damped elastic spectral acceleration for a single-degree-of-freedom system with a period of 0.2 sec, referred to as S_S, and a similar measure for single-degree-of-freedom system with a period of 1.0 sec, referred to as S_1. Both parameters are accelerations and are measured in units of distance per unit time squared or, more conveniently, in multiples of gravity *(g)*. To simplify the application of these parameters for this guideline, the S_s parameter was transformed into peak ground acceleration (PGA) by dividing them by 2.5. A site with high earthquake hazard is defined as one with a PGA greater than 0.5g. A site with moderate hazard is defined as one that has either a PGA greater than or equal to 0.15g or less than or equal to 0.5g. A site with low hazard is defined as one that has a PGA less than 0.15g. These separation points are judged to be reasonable in representing ground motions high enough to cause severe damage to water facilities (high), moderate damage to facilities (moderate), and little or no damage to facilities (low).

High: PGA $>$ 0.5 g
Moderate: 0.15 g $\leq$ PGA $\leq$ 0.5 g
Low: PGA $<$ 0.15 g

3.1.1 Earthquake—General

An earthquake causes sudden trembling of the Earth as the result of abrupt release of slowly accumulating strain along a fault. The theory of plate tectonics can explain the majority of earthquakes. In this theory, re-introduced in 1967, the “solid” Earth is broken into several major plates. These 50- to 60-mile-thick (80- to 97- km) rigid plates or segments of the Earth’s crust and upper mantle move or float slowly and continuously over the interior of the Earth, meeting in some areas and separating in others. Speeds of relative motion between adjacent plates range from a fraction of an inch to about 5 inches (12.5 cm) per year. These intraplate earthquakes constitute perhaps 90% of the world’s earthquakes; another 10% of the world’s earthquakes are intraplate.

Hazards associated with earthquakes include the phenomena of surface faulting and attendant ground shaking as well as earthquake-induced landslides, liquefaction, lurching, tsunamis, and seiches.

Table 3-5 provides general references for modeling earthquakes probabilistically. Here, it must be repeated that most probabilistic modeling of earthquakes (as for other natural hazards) is focused on sites rather than on geographically distributed systems. Hence, for probabilistic modeling, it is necessary to disaggregate information and models used elsewhere in order to model initiating events (earthquake scenarios) randomly. This is true of such maps, for instance, as those found in Figure 3-2, a probabilistic ground motion map for the United States. The disaggregated information used to develop this map is much more pertinent to the probabilistic evaluation of water utilities—except for those that are very small in areal extent.

Non-probabilistic or deterministic modeling is also common, and there are many sources listed that provide pre-specified earthquake scenarios, scenarios not randomly selected. These can be used for intermediate or operations evaluations of water systems to the extent that other pertinent hazard elements (especially estimates of ground failures) are reasonable.

3.1.2 Earthquake-Fault Rupture

Faulting or the differential movement of the two sides of a fracture at the Earth's surface is of three general types: strike-slip, normal, and reverse (see Figure 3-3). Combinations of the strike-slip type and the other two types of faulting can be found. Although displacements of these kinds can result from landslides and other shallow, earth failure processes, surface faulting, as the term is used here, applies to differential movements caused by deep-seated tectonic or volcanic forces in the Earth, the slow movement of sedimentary deposits toward the Gulf of Mexico, and faulting associated with salt domes.

Figure 3-4 provides a map of young surface faulting zones in the conterminous United States. The USGS has published on the Internet a listing of all the faults that are considered active and can break ground. Data given are:

- State
- Name of fault
- Slip rate (mm/yr)
- Fault end points (lat/long)
- Fault length (km)
- Fault dip (degrees)
- Fault width (km)
- Characteristic magnitude (M- moment magnitude)
- Rate at which the characteristic magnitude might be expected (number/year N)

- Gutenberg/Richter A-value for use in the equation log N=A-bM
- b-value in the above equation

For evaluating prospective permanent ground displacements within a specific region of faults, such references as Wells and Coppersmith (1994) may provide estimates of maximum displacement given the magnitude of an event. Randomization must occur along the fault segment in order to determine the extent of the fault rupture zone. And finally, a distribution must be used to simulate how the displacements at various points compare with the maximum displacement.

Table 3-6 is the template for this hazard. With the USGS data, this method of probabilistic modeling is rated an “A”.

3.1.3 Earthquake-Ground Shaking

Considerable efforts have been undertaken by government, academicians, and consultants to evaluate earthquake hazards from strong ground motions. Particular reference is made to efforts by the USGS to develop probabilistic strong ground motion maps. These maps define strong ground shaking at various return intervals (e.g., 50 year life with a 10%, 5% and 2% chance of occurrence) for the entire United States. These efforts may be called probabilistic seismic (site) hazard evaluations (PSHA’s). As noted throughout this document, evaluating water systems risks requires the use of individual scenarios, since they are not located at a single site. As a consequence, with rare exceptions, the results of PSHA’s are not useful in the actual evaluation of water system risks—unless water utility systems are small in spatial extent. However, the models developed by geoscientists and engineers in constructing probabilistic seismic hazard maps can be desegregated and then recombined to produce bases for earthquake hazard evaluations.

Modeling specific earthquake occurrences may start with historic events. These are some problems, however:

1. There is considerable uncertainty in the locations of previous earthquakes.

2. Estimates of earthquake magnitudes becomes more uncertain as the earthquake occurrences date farther back in time, before the advent of and continuing development of seismograph stations and even before the advent of large numbers of historic records of the earthquakes.

3. Considering the problem of pre-instrumental earthquakes, the time-span of recorded earthquake occurrences is very short in the United States as contrasted to the time-span of the geologic processes that produce them.

For this reason, over the past twenty-five years, investigators have been developing pertinent paleoseismic data from fault trenching and liquefaction-displacement studies in order to provide scientific perspectives on these geologic processes and rates of occurrences of earthquakes in diverse regions throughout the United States. Current investigators thus typically use models that combine scientific (paleoseismic) perspectives along with the historic record. The USGS data developed for faults mentioned in Table 3-6 are an example.

To date, the development of earthquake scenarios that represent the full range of possible locations and magnitudes has been rare in the published literature, although widespread among proprietary models—especially those used in catastrophe insurance and reinsurance modeling.

Various methods have evolved for generating a representative set of earthquakes. At a beginning level, one may merely use USGS and other catalogs of previous earthquake occurrences, and replicate those. More sophisticated levels assume a weighting for these events plus a consideration of paleoseismic information. Sample methods that combine historic methods with paleoseismic methods are found in Toro and Silva (d.u.), Anderson et al. (2002). A method that disaggregates basic models used by USGS and recombines them to develop a representative suite of scenarios is found in Taylor et al. (2001). Table 3-7 provides a template for earthquake-shaking.

3.1.4 Earthquake-Landslide

Section A3.2.1 describes the factors involved with a landslide. The sudden impact or trigger caused by an earthquake adds load over that which gravity provides. There are two references that address the likelihood of landsliding in two, very different ways. These are discussed below as probabilistic analysis procedures.

The first procedure is developed in Keeney et al. 1978. The authors conclude that an analysis of earthquake induced slides is greatly complicated by uncertainties about earthquake occurrence and about the interpretation of slope stability analyses. Due to these uncertainties, a probabilistic analysis is the most useful way of investigating the problem and presenting the results. The report illustrates a probabilistic model which incorporates both statistical analyses of earthquake occurrence and subjective probability assessments of sliding potential developed by a group of landslide experts. The subjective probability assessments provide a systematic procedure to quantify and communicate an engineer's professional knowledge. The concept of subjective probability can be useful in any situation where an engineer must integrate his knowledge about a site, results of various field tests, and his experience.

The second is Jibson et al, 1998, and parallels that of Keefer et al., 1978. The authors model the dynamic performance of slopes using the permanent-displacement analysis developed by Newmark. Using Newmark's method to model the dynamic behavior of landslides on natural slopes yields reasonable and useful results. Newmark's method models a landslide as a rigid block that slides on an inclined plane. The block has a known critical (or yield) acceleration, ac, which is simply the threshold base acceleration required to overcome shear resistance and initiate sliding. The analysis calculates the cumulative permanent displacement of the block relative to its base as it is subjected to the effects of an earthquake acceleration-time history.

In the analysis, an acceleration-time history is selected, and the critical acceleration of the slope to be modeled is superimposed. Accelerations below this level cause no permanent displacement of the block. Those portions of the record that exceed the critical acceleration are integrated once to obtain the velocity profile of the block; a second integration is performed to obtain the cumulative displacement history of the block. The user then judges the significance of the displacement. Newmark's method is based on a fairly simple model of rigid-body displacement, and thus it does not precisely predict measured landslide displacements in the field. Rather, Newmark displacement is a useful index of how a slope is likely to perform during seismic shaking.

Newmark showed that the critical acceleration of a potential landslide block is a simple function of the static factor of safety and the landslide geometry, expressed as:

$a_c = (FS\text{-}1)g \sin a$ ....(3)

in which

a_c	=	the critical acceleration in terms of
g	=	the acceleration of Earth's gravity
FS	=	the static factor of safety against sliding
a	=	the angle from the horizontal that the center of mass of the potential landslide block first moves

This can generally be approximated as the slope angle. Thus, conducting a Newmark analysis requires knowing the static factor of safety and the slope angle and selecting an earthquake strong-motion record at the site in question.

Given the set of earthquakes described in A3.5.3 and using either of the two methods generally described a likelihood of landslide occurrence can be computed. This area is fraught with uncertainties, however. It is difficult enough to estimate the likelihood of shaking let alone the likelihood of landslide given the ground shaking.

Because the latter Jibson et al. method correlated fairly well with the Northridge earthquake landslide incidence (a known event) their method is rated a "B" to "D". Table 3-8 presents the template for earthquake-landslide.

3.1.5 Earthquake-Lurching and Liquefaction

Lurching includes lateral spread, flow failures and loss of bearing strength during an earthquake. It is sometimes hard to distinguish landslide from lurching or liquefaction since land failure is the common result of each. Lateral spreads involve the movement of large blocks of soil as a result of liquefaction in a subsurface layer. Movement takes place in response to the ground shaking generated by an earthquake. Lateral spreads generally develop on gentle slopes, most commonly on those between 0.3 and 3 degrees. Horizontal movements of lateral spreads commonly are as much as 10 to 15 feet (3.0 to 4.6 m), but, where slopes are particularly favorable and the duration of ground shaking is long, lateral movement may be as much as 100 feet to 150 feet (30 m to 46 m). Lateral spreads usually break up internally, forming numerous fissures and scarps in the surficial earth materials.

Considerable efforts have been undertaken in the last decade to provide materials for evaluation of liquefaction hazards on a regional basis (See especially references to Bartlett and Youd, Youd, and J.P. Bardet et al.). To date, these efforts have primarily provided methods that can be applied for components which can be associated with existing boring log data. Modeling sites and locales for which boring log data are not clearly available or for which reasonable assumptions cannot be made on potential critical values of input parameters significantly increases the uncertainties involved.

For sites for which boring log data are available, displacements owing to liquefaction are a function of

(a) earthquake magnitude (moment magnitude),

(b) peak ground acceleration and/or the closest distance from the earthquake source to the site,

(c) slope and length of free-face,

(d) the thickness of saturated cohesionless soils with boring log blow counts $(N1)_{60}$ less than 15 derived from boring log data for each layer evaluated,

(e) the average fines content (percent finer than 75 μm) derived from all sub-layers, and

(f) the average D_{50} grain size in the thickness of saturated cohensionless soils, derived from sub-layers.

This data-intensive approach has recently been simplified. The development of data on average fines content and average D50 grain size within the thickness of the saturated cohesionless soils, derived from all sub-layers is not required.

This method does not meet the need to evaluate sites for which boring log data are absent. In particular, for sites for which boring log data are absent, scenario estimates can be made of the moment magnitude, the peak ground acceleration, and the closest distance from the earthquake source to the site. Information on slope and length of free-face as well as on the thickness of saturated cohesionless soils with blow counts less than 15 would need to be surmised or else alternative methods would need to be used.

Where sufficient boring log data is available, finite different codes such as Itasca's FLAC *(Fast Lagrangian Analysis of Continua)* can provide a means to compute permanent ground displacement. It should be noted, however, that the calculated displacements are subject to significant uncertainties—in excess of those found by systematic variation of input parameters. Furthermore, the numerical precision that can be obtained with sophisticated software, such as FLAC, is not generally indicative of the accuracy of the methods when considering the quality of the input data and the lack of any rigorous correlation with actual earthquake case histories.

Simplified methods where little data are available do not provide estimates of the extent (in measured quantities such as centimeters) of permanent ground displacement. Likewise, liquefaction susceptibility maps that have been developed largely for landuse planning purposes have not been defined either in a uniform fashion for all regions of the United States nor for use in developing unbiased risk statistics. For landuse planning purposes, for instance, the region labeled "High" liquefaction susceptibility may include many regions that contain predominantly low liquefaction susceptibility sites whereas a region labeled "Moderate" liquefaction susceptibility may include some site that has a high liquefaction susceptibility. The terms "high," "medium," and "low" may have different, undisclosed meanings according to the investigators and the region of the country that has been evaluated.

Thus, evaluation of liquefaction severities in specific earthquake scenarios has improved considerably in the past decade for sites which may be associated with boring log data. However, for other sites, makeshift methods must currently be employed, with clearly specified assumptions with many uncertainties involved. Hence, for sites with boring log data, the methods are currently rated an "A" whereas for sites without boring log data—absent current research focuses, the methods are currently rated a "D."

3.1.6 Earthquake-Tsunami

Tsunamis are water waves that are caused by the sudden vertical movement of a large area of the sea floor during an undersea earthquake. (Note that an earthquake that occurs on land can trigger submarine slips, which in turn can create tsunamis.) The earthquake may be tectonic or volcanic in origin. Tsunamis are often called tidal waves, but this term is a misnomer. Unlike regular ocean tides, tsunamis are not caused by the tidal action of the Moon and Sun.

The height of a tsunami in the deep ocean is typically about one foot (30 cm), but the distance between wave crests can be very long, more than 60 miles (96.5 km). The speed at which the tsunami travels decreases as water depth decreases. In the mid-Pacific, where the water depths reach about 3 miles (4.8 km), tsunami speeds can be more than 400 miles per hour (644 km/hr). As tsunamis reach shallow water around islands or a shallow continental shelf, the height of the waves increases many times, sometimes reaching as much as 80 feet (24m). (During the eruption of Krakatoa in Indonesia waves of about 200 feet (or 61m) were observed.) The great distance between wave crests prevents tsunamis from dissipating energy like a breaking surf; instead, tsunamis cause water levels to recede and rise rapidly along coast lines.

Land-use zoning of coastal areas is another way used to reduce losses from tsunamis. Such zoning is based on the heights of tsunami waves expected for exposure times of 20, 50, and 100 years. Tsunami hazard maps, such as shown in Figure 3-5 for the island of Hawaii and Figure 3-6 for southern California are used in zoning and may be used for probabilistic analysis.

Areas not adressed, namely Alaska, the remaining Hawaiian Islands, northern California and Washington and Oregon coastlines need to be treated in like manner using all tsunami data for those regions. Maps are not yet available, however, the data needed to produce them are. No template is given for this hazard.

3.1.7 Earthquake - Seiche

A seiche is a natural standing wave in the water of a lake or bay. It can be caused by seismic disturbances, among other causes, and continues after the seismic shaking has stopped. Every enclosed body of water has a number of natural resonances. If you sit in a bathtub part full of water and rock back and forth you'll find that at the right period (about a second) you can easily get the waves to grow until they overflow the bath. The reasonant oscillation of the water is a seiche. Seiches are often generated in swimming pools by small oscillations from earthquakes – the oscillations happen to be at the right frequency for the swimming pools to "catch" them.

Seiching is the formation of standing waves in a water body, due to wave formation and subsequent reflections from the ends. These waves may be incited by earthquake motions (similar to the motions caused by shaking a glass of water), impulsive winds over the surface, or due to tsunami wave motions entering a basin. The various modes of seiching correspond to the natural frequency of the water body.

No discussion of probabilistic evaluation is developed here.

3.2 Landslide

The classification of landslide hazard severity is based on data from the national landslide overview map of the conterminous United States: USGS Open-File Report 97-289 (Godt 1997); see Figure 3-7. Landslide incidence categories in that map are defined according to the percentage of the area involved in landslide process (High: > 15% of area involved, Moderate: 1.5–15% of area involved, Low: < 1.5% of area involved). Susceptibility to landslide is defined as the probable degree of response of formations to natural or artificial cutting, loading of slopes, or to anomalously high precipitation. High, moderate, and low susceptibility are delimited by the same percentages used for classifying the incidence level. The hazard severity definitions for landslide are defined as:

High: High incidence or high susceptibility/moderate incidence or high susceptibility/low incidence
Moderate: Moderate incidence or moderate susceptibility/low incidence
Low: Low incidence

Landslides are a form of earth movement down slope under gravity loads. The speed of movement can be either slow or fast. Landslides can vary from less than one acre (4047 sq meters) to several square miles (2.59 sq km/mile) in extent and include a variety of types. Smaller landslides are predominantly rotational slumps. The larger landslides are usually earth-flows.

Debris flows are moving, fluid masses of rock, soil and debris. They are active geologic processes in the Rock Mountains, and historic debris flows have affected several communities. Debris flows usually start as shallow landslides on colluvial slopes which are steeper than about 50% as a result of intense thunderstorm precipitation or rapid infiltration of snow pack melt. The flows thin out and spread laterally on alluvial fans where hillside channels may join a main valley. The flows have the capacity of transporting very large boulders. When confined in steep, hillside channels flow depth can reach 20 feet (6.09 m.) or more. Flow depths on the fans are typically in the range of 2 to 15 feet (0.61m. to 4.57m.) with the greater depths near the fan heads. Flow velocities can vary widely depending on depth of flow, gradient and ratio of water to solids. Velocities in the range of 1 to 30 mph (1.609 km/hr to 48.3km/hr) are typical of debris flows.

Rock fall is the precipitous movement of newly detached rock blocks from a cliff or other very steep slopes. In the Rocky Mountains, rock fall is common on many highway cuts in jointed rock. Rock fall also occurs along cliffs which border many mountain valleys. In a few areas rock fall blocks have reached downslope developments and transportation corridors. Rock fall can occur anytime of the year, but it is most frequent in the spring when there is repeated freezing and thawing of water in the rock joints. After dislodging from the outcrop, rock fall blocks travel rapidly downslope generally in a relatively straight line by a series of leaps and bounces. Individual rock fall blocks can vary from less than one foot to (0.3m) tens of feet (3m) in size depending on the joint spacing at the outcrops.

Landslides can be identified by their geologic settings and topographic features based on: (1) field observations, (2) areal photograph interpretations and (3) topographic map interpretations. Features indicative of landslides are arch-shaped escarpments, ground cracks, ground hummocks, hillside benches, hillside ponds and disruptive drainages. Some landslides have had large displacements in historic time and are still near a critical state of stability. Others appear to have been dormant for a long period of time and may no longer be near a critical state of stability. Features are well-defined on recently active landslides, but with time and no further movements they become subdued due to weathering and erosion.

A method for estimating how long a landslide has been dormant based on surface features has been proposed for landslide inventory mapping. It is advisable, however, that apparent age of landslide dormancy not be relied on solely when assessing the current stability state of an existent landslide. For many landslides, judgment should be supported by: (1) subsurface exploration results, (2) slope movement and ground water assessment and monitoring and (3) stability modeling studies to give more accurate assessments of slide probability.

Precipitation and associated ground water changes have a preeminent influence on landslide stability. For example, landslide activity is reported to have increased during the period 1983 through 1987 as a result of higher than normal annual precipitation in Colorado. Precipitation change has apparently occurred in Colorado during the past five hundred years. Studies in the upper Colorado River drainage basin show that since the early 1500's wet cycles with an average duration of ten years have occurred about every 22 years. Long-term monitoring of a steep, colluvial slope in western Colorado has shown a correlation between winter precipitation (November through May) and annual slope creep. Most of the creep occurs during the spring snow pack melt. Consequently, gravity landslide propensity and, therefore, frequency depends largely upon the rainfall frequency-severity (inches per unit of time) of the region in question.

Landslides can be classified in many ways, each having some usefulness in emphasizing features pertinent to recognition and reduction of losses from landslides. Two criteria, (a) types of movement and (b) types of material, are typically used. Types of movement include falls, topples, slides, spreads, flows, and combinations of two or more of these five types. Types of material involved with a slide include two classes–bedrock and soils, with soils being divided into debris and earth materials (see Table 3-9).

All slides involve the failure of earth materials under shear stress. The initiation of the process can, therefore, be thought of in terms of the factors that contribute to increased shear stress and the factors that increase stress directly (load) and those that reduce shear strength (resistance). Although a single action, such as the addition of water to a slope, may contribute to both an increase in load and a decrease in strength, it is helpful to separate the various physical results of such actions.

The principal factors contributing to increased shear stress (load) are:

- Removal of lateral support by such means as erosion by streams and rivers, glaciers, or waves and longshore or tidal currents at the toe of a potential slide; previous slope failure; and results of adjacent construction, especially where cuts, quarries, pits, and canals are established, retaining walls and sheet piling are removed, or lakes and reservoirs are created and their levels altered.

- Loading by natural or human means provided by weight of rain water, hail, snow; accumulation of loose rock fragments or accumulated volcanic material; new stockpiles of ore or rock; new waste piles; and weight of new buildings and other structures.

Vibrations from earthquakes, blasting, machinery and traffic trigger an incipient slide (to be discussed further in a later section).

The principal factors contributing to a reduction in shear strength include:

- Inherent deterioration and weakening characteristics of the parent material–its composition, texture, structure, slope geometry.
- Weathering and other physicochemical reactions of the materials which tend to weaken them.
- Increases in water content and pore pressure in the soil structure.

A map of landsliding in the conterminous United States (Figure 3-7) provides an overview of the distribution and relative severity of landslide hazards. The map shows two aspects of landsliding–incidence and susceptibility. Incidence of landsliding refers to areas where landslides have actually occurred. For example, areas of high incidence contain more than 15 percent of discovered past slope failures. Areas of moderate incidence contain 1.5 to 15 percent of failed slopes in historic time. Susceptibility to landsliding refers to the strength of the earth materials in the area. Areas of high susceptibility are underlain by very weak or fractured materials.

Although not shown on the map, parts of Alaska and Hawaii also are severely affected by landslides.

Sample references for data and modeling techniques for landslide hazards are provided in Table 3-10. There are no known truly probabilistic analysis models available for landslides in all parts of the United States. There is only the map, rather coarse in nature. It has been produced by the USGS and cited in the “natural hazards template”, Table 3-11 (an attempt to summarize the hazard intensity data and intensity modification factors on one page).

The landslide “probability” descriptors for the USGS map shown in Figure 3-7 are difficult to quantify. It is suggested that the Geological Survey office for the state in question be consulted for landslide likelihood information about specific areas. Further, the general statement in the map that the loads may be produced by “natural or artificial cutting or loading of slopes, or to anomalously high precipitation” raises many questions. The cutting referred to is local in nature and is not included in a national mapping perspective. Only the rainfall can be evaluated as one of the driving forces that may activate a landslide. However, what constitutes an “anomalous high precipitation?” 1 in 50 years? 1 in 100 years?

The assignment of probability values to the various colored areas is strictly arbitrary. An in-depth study of the history, gradient, rainfall and other factors is required to develop a reasonable likelihood of land failure in areas covered by a specific water supply facilities district. For these reasons, this procedure is rated a “D” as indicated in Table 3-4.

3.3 Ground Movement

Ground movement hazards are defined as such because external forces or meteorological conditions affect the movement or failure of the earth materials. In the case of gravity landslide (including debris flows and rock falls), the external triggering force may be gravity coupled with moisture changes. This is differentiated from earthquake-generated landslide which involves gravity, but the landsliding action is initiated or triggered by the earthquake shaking action. Soil collapse is also initiated by gravity.

Expansive soil hazards are initiated by changes in moisture conditions (usually dessication) within certain kinds of soils. They expand differentially with the addition of water and contact or shrink differentially with desiccation.

Frost heave results in differential movement of the surficial soils that have water accumulated in the interstices between soil grains. When water freezes, the resultant ice gains about 10 percent in volume, thus causing differential movement.

3.3.1 Expansive Soil

Soils and soft rocks which tend to swell or shrink owing to changes in moisture content are commonly known as expansive soils. In the United States, two major groups of rocks serve as parent materials of expansive soils. Both groups are more common in the Western United States than in the Eastern United States. The first group consists of ash, glass, and rocks from volcanic eruptions. The aluminum silicate minerals in these volcanic materials often decompose to form expansive clay minerals of the smectite group, the best known of which is montmorillonite. The second group consists of sedimentary rocks containing clay minerals, examples of which are the shales of the semiarid West-Central United States.

No general, national models are known to be publicly available. The template for modeling expansive soil intensity likelihoods is shown in Table 3-12. The only known maps, each differing from the other, are those published in 1978 by the J.H. Wiggins Company (Figure 3-9), the map published by the USGS shown in Figure 3-10 and the map published in 1977 by the US Corps of Engineers, Waterways Experiment Station in Technical Manual 5-818-7 (Figure 3-11). These maps are all are based on coarse and general geological information associated with certain areas that is judged to contain montmorillonite minerals. It is suggested that each state Geologist be consulted about expansive soils details at specific sites.

The legends for “High” refer to soils containing large amounts of montmorillonite and clay (COLE >6%); “Medium” refers to soils containing moderate amounts of clay with some montmorillonite (3% ≤ COLE ≤ 6%) and; “Low” refers to soils containing some clay but of the low swelling type (COLE < 3%). Ratings correspond to the modified shrink-swell (COLE) categories of the National Resources Conservation Service of the U.S. Department of Agriculture.

The only hazard initiating parameter that would affect the intensity of differential movement of the clays in the soil is rainfall amount. Again, the question of what level of probability to use to trigger various amounts or degrees of differential movement and therefore intensity of the hazard is open to expert judgment. Further, both drought and excessive amounts of rainfall above and below the norm for an area can trigger the differential movement of clay rich soils. In contrast, landslide only needs excessive rainfall for a trigger. Drought is not a problem, usually.

Again, it is suggested that an annual rainfall amount of $\pm 2\sigma$ be used to activate differential movement in “high” susceptibility areas and $\pm 3\sigma$ be used as the probability for severe movement in “medium” susceptibility areas of whichever map is chosen as an expansive soil reference. These maps are presented in very small scale. Consequently, a “D” must be assigned to this method of probabilistic modeling without a much better idea of the soils character, thickness, and depth being known.

3.3.2 Soil Collapse

Soil collapse is broken down into three categories: (a) hydrocompaction, (b) natural subsidence and (c) man-induced subsidence.

The lowering or collapse of the land surface either locally or over broad regional areas, has taken place in nearly every State. Although collapse is usually not spectacular or catastrophic, it causes several tens of millions of dollars in damages annually in the United States.

Natural subsidence results from processes including the dissolving of limestone and other soluble materials. Large areas of the United States are underlain by limestone and other soluble materials. As underground water percolates through such materials, soluble minerals dissolve, leaving cavities or caverns. Land overlying these caverns can collapse suddenly, forming sinkholes of 100 feet (30m) or more in depth and 300 feet (91m) or more in width. Other times, the land surface can settle slowly and irregularly. The landscape created by such subsidence is called karst terrain. This type of subsidence usually causes extensive damage to structures located over pits formed by dissolving the soluble minerals. Although the formation of sinkholes is a natural phenomenon, the process can be accelerated by human practices with regards to ground-water withdrawal, land development, and disposal of water.

The major locations of karst terrain and caverns in the United States are in parts of many of the Southeastern and Midwestern States. Sinkholes also are found in some of the Western and Northeastern States. Alabama, where soluble limestone and other rocks are present in nearly one-half of the state, has thousands of sinkholes that pose serious problems for highways and construction generally.

Man-induced subsidence has increased dramatically since 1940 as a result of the withdrawal of oil, gas, and water. Because underground fluids fill intergranular spaces and support sediment grains, removal of these fluids results in a loss of grain support, reduction of intergranular void spaces, and compaction of clays. The land surface commonly subsides wherever widespread subsurface compaction has taken place, causing damage to canals, aqueduct and pipelines, and increasing the probability of flooding in some areas. The most dramatic examples of subsidence caused by withdrawal of oil, gas, and water are along the Gulf Coast of Texas, in Arizona, and in California.

Recent research suggests that subsidence caused by withdrawal of ground water can also cause fissuring or renewal of surface movement in some areas cut by pre-existing faults. Fissuring is the formation of open cracks. Surface faulting and fissuring associated with withdrawal of ground water are believed to have either taken place or to be a potential problem in the vicinity of Las Vegas, Nevada as well as in parts of Arizona, California, Texas, and New Mexico (Holzer, 1977).

Underground mining, especially shallow coal mining, is another significant cause of subsidence. The rocks above mine workings may not have adequate support and can collapse from their own weight, either during mining or long after mining is completed. Subsidence in areas of underground mining has caused hazardous conditions in parts of Pennsylvania and other Appalachian States, Colorado, North Dakota, Wyoming, New Mexico, Washington, Iowa, and Illinois. Subsidence-related damage to surface structures is common in the area around Pittsburgh, Pennsylvania where coal has been mined extensively. Subsidence depressions and pits, forming above abandoned underground mines, are a hazard in the Sheridan, Wyoming area.

Solution mining also can cause subsidence. In solution mining, water-soluble minerals such as salt, gypsum, and potash are dissolved and pumped to the surface so that the water can be evaporated. Huge underground cavities are formed, causing surface subsidence.

Hydro-compaction, or the settling of sediments after water is added, is another significant cause of subsidence, especially in the arid to semiarid Western and Midwestern States. Areas of known compaction include San Joaquin Valley, California, Hearth Mountain-Chapman Beach and Riverton, Wyoming areas. Hysham Bench, Montana, Columbia Basin, Washington, Denver, Colorado, Washington-Hurricane area in southwest Utah and central Utah, and Missouri River Basin. Hydro-compaction takes place when dry surface or subsurface deposits are extensively wetted for the first time since their deposition as, for example, when arid land is irrigated for crop production or an irrigation canal is built on loose dry uncompacted sediments. Wetting causes a reduction in the cohesion between sediment grains, allowing the grains to move and to fill in the naturally occurring intergranular openings. The result is a lowering of the land surface from 3 to 6 feet (0.9 to 1.8m), although subsidence as much as 15 feet (4.6m) has been recorded. The effects of hydro-compaction on the land are usually uneven, causing depressions, cracks, and wavy surfaces. As a result, canals, highways, pipelines, buildings, and other structures can be seriously damaged by these hazards. Natural subsidence, man-induced subsidence and hydro-compaction can have significant impact on the change in grade for gravity-flow conveyances.

Areas susceptible to hydrocompaction and natural subsidence are usually known by the geological survey professionals for each state. It is suggested that they be consulted about details at specific sites. No nationally available maps for hydrocompaction are known. For karst topography only Figures 3-12 and 3-13 are known. An example of a state geologist's knowledge of local collapse potential is exhibited by the state of Illinois. It has developed a map of karst areas in that state (Figure 3-14). Tables 3-13 and 3-14 list templates for modeling these hazards.

Collapse by hydrocompaction can be influenced strongly by heavy rainfall. Thus, those areas that are identified by each state geologist as having hydrocompaction potential of "High" to "Moderate" can be associated with rainfall amounts and probabilistically addressed in a manner similar to landslide and expansive soil. For the above reasons, this method is classified as a "D".

3.3.3 Frost Heave

Frost heave is the increase in volume experienced by soils when they freeze. Water moves to the upper horizons from below; when it freezes it forms segregated ice lenses which push apart the soil around them as they grow, causing the observed volume increase. Frost heave has a number of effects upon the soil and upon structures supported by or within the soil.

The potential intensity of ice segregation in a soil depends largely on the size of the void space and may be expressed as an empirical function of grain size. Inorganic soils containing 3 percent or more by weight of grains finer than 0.02 mm (0.0004 in.) in diameter are generally considered frost susceptible. Frost-susceptible soils are classified as: F-1, F-2, F-3, and F-4. They are listed approximately in the order of increasing susceptibility to frost heave from both ice formation or collapse from frost melting (Table 3-15).

The freezing index value should be computed from NOAA provided daily air temperature data (See Figure 3-15). Differences in elevations, topographical positions, and proximity to cities, bodies of water, or other sources of heat may cause variations in freezing indexes over short distances. Therefore, the air temperatures should be obtained from a weather station located as close as possible to the water system facilities of interest.

The depth to which freezing temperatures penetrate below the surface depends principally on the magnitude and duration of below-freezing air temperatures and on the amount of water present in the earth materials. A potentially troublesome water supply for ice segregation is present if the highest groundwater at any time of the year is within 5 feet (1.5m) of the proposed subgrade surface or the top of any frost-susceptible earth materials. When the depth to the uppermost water table is in excess of 10 feet (3m) throughout the year, a source of water for substantial ice segregation is not likely to be present unless the soil contains a high percentage of silt. In homogeneous clay soils, the water content that the clay subgrade will attain is usually sufficient to provide water for some ice segregation even with a deeper water table, however.

There are no known probabilistic models of frost heave intensities for the nation. It is recommended that the State Geologists in the area under study be consulted about their local knowledge and experience with frost heave conditions. NOAA has published a freeze probability map for (a) freeze free period, 90% probability, (b) spring freeze occurrence, 10% probability and (c) fall freeze occurrence, 10% probability. The latter map is shown in Figure 3-16. A template for modeling frost heave is provided in Table 3-16.

Areas that have (1) high water tables, (2) susceptible soil grain sizes, and (3) freezing index characteristics that are undesirable are to be included in any model, among other factors. Probably the central parts of the Midwest which are subject to many freeze-thaw circumstances during a fall-spring episode, as described in the earlier text, are the more susceptible areas of the country. However, without specific site information the modeling capability of this hazard must be rated at a "D-."

3.4 Wind

In defining wind hazard levels, the Guideline relies on two sources: the IBC 2003 and data from the National Oceanographic and Atmospheric Administration's (NOAA) Storm Prediction Center. The IBC provides a map showing basic wind speeds for design (see Figure 3-17). The IBC also provides two important definitions. It defines hurricane-prone regions as the U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed is greater than 90 mph and Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa. It further defines wind-borne debris regions as areas within hurricane-prone regions within 1 mile (1.6 km) of the coastal mean high water line where the basic wind speed is 110 mph (48.4 m/s) or greater; or where the basic wind speed is 120 mph (52.8 m/s) or greater; or Hawaii. Based upon this, the wind hazard severity designations are defined as follows:

High: Wind speed ≥ 120 mph, or a Gulf/Atlantic county whose basic wind speed is 110 mph or greater, or in Hawaii.

Moderate: Wind speed > 90 mph, but < 120 mph

Low: Not High or Moderate

For purposes of addressing tornado peril, this guideline defines observed tornado occurrences as tornados (F0 and greater) that appear in the database compiled by the Tornado Project (as its database existed on July 1, 2003). The Tornado Project's database contains data taken from NOAA's (1999) Historical Tornado Data Archive. Figure 3-18 shows the rate of tornado occurrence by state; Figure 3-19 shows these statistics by county. With this data, hazard levels for tornadoes only are defined as follows:

High: > 25 Tornadoes/10,000 sq.mi.
Moderate: 5-25 Tornadoes/10,000 sq.mi.
Low: < 5 Tornadoes/10,000 sq.mi.

3.4.1 General Severe Wind

General severe wind can occur and be evaluated for locations anywhere in the country using archived NOAA wind history data. Data is available by station for extreme 1%, 5%, 10% and mean wind speeds and by day, month of the year or by year. These four data points can be computed from weather station data. It can then provide a probabilistic profile of the severe wind characteristics for any site or region. Should the fastest-mile-of-wind or peak gusts over 30, 40 or 50 mph (48, 64 or 80 km/hr) be desired by wind engineers, these data are also available for virtually every station in the nation. Wind velocity, whether it be noted as a sustained speed or a 3 second or 5 second gust speed, is the key measure of intensity for this hazard. Maps of average annual wind speed produced for the Department of Energy for wind power evaluations are available at http://www.bergey.com/wind_maps.htm.

The wind speed data for any location can be obtained for any weather station and used directly as interpolated data, one station from another. Probabilistic wind maps have also been prepared by the American Society of Civil Engineers (Figure 3-20) which depicts the 50 year return period 3-second wind gust speed. An equation is presented for the computation of higher or lower probability wind speeds:

$$F = 0.36 + 0.1 \ln (12\, T) \quad (1)$$

in which

F = factor multiplied by the contour velocity

T = return period.

Thus, for T=100 years and T=1000 years the factor F is respectively 1.07 and 1.30

The average 90 mile per hour (145 km/hr) 3-second gust wind speed is converted to 96mph (154 km/hr) for 100 year probability and 117mph (188 km/hr) for a 1000 year return period likelihood. It must be noted that the equation is not recommended for use above the 500 year or below the 50 year return period levels of risk, however. A rough idea of sustained wind speed or fastest mile wind speed can be computed noting that the 3-second gust velocity is between 15% to 20% higher than sustained wind speed.

Because the data quality which produced the map is good and because the 90mph (145 km/hr) severe wind speed map for the 50 year return period has been developed over years by competent wind engineers, this probabilistic modeling method is rated an “A”.

3.4.2 Tornado

A tornado can be thought of as a simple vortex, a rotating, spiraling fluid, like those in a draining sink or bath tub. But behind that apparent simplicity lies a complexity of fluid dynamics, air/moisture interactions, and energy transfers. Tornadoes occur principally in the Midwest. Although Florida also can spawn a number of tornadoes, most of them of the weak variety associated with hurricanes.

Table 3-17 provides sample references for modeling tornadoes probabilistically. Table 3-18 differentiates tornadoes by the Fujita scale. Figure 3-21 shows the frequency of all tornadoes strikes for various regions of the country.

Wind speed experienced per year and therefore tornado class is the intensity parameter of interest. The area covered by the different wind speeds per 10,000 square miles/year (25,889 sq. km) is the risk parameter of interest. For example, Oklahoma has a return period for a strike by a tornado of any size of 1,300 years per square mile. However, by noting the area covered by mix of tornado classes in Table 3-19 the frequency of strike by these classes in Table 3-20, the likelihood of a point in Oklahoma being struck by any tornado is 1 in 2100 years.

The new data can be accessed either from Grazulis (1993) listing all reported tornadoes from 1680 to 1991 or from on-line resources that list all tornado data from 1950 through 2001 by state and by county. Holes in the data exist. The last 40 to 50 years is probably complete. For example, since 1950, Dade County in Florida has experienced 71 F0 tornadoes (<72 mph or 116 km/hr wind speeds), 19 F1 tornadoes (73-112 mph, or 117-180 km/hr, wind speeds), 5 F2 tornadoes (113-157 mph, or 182-253 km/hr, wind speeds), 1 F3 tornado (158-206 mph, or 254-331 km/hr, wind speeds) and no F4 or F5 tornadoes.

The data can be theoretically and statistically enhanced to provide a reliable data base up to 100 years. If done, this modeling method using the data for each state or county (wind speed, direction of travel, length, width, etc.) can produce a competent probabilistic risk analysis model rated “A”. No template is provided for tornado.

3.4.3 Hurricane–Tornado

The impact of hurricane-generated tornadoes will receive only cursory attention here for two reasons: First, the probability of this event affecting any given structure is quite small; second, the damage potential from such events is generally less than that of the sustained winds and gusts of a mature hurricane.

Hurricane tornadoes develop in the spiral rainbands, mostly in the right-front quadrant outside the areas of sustained hurricane or gale-force winds. Figure 3-22 shows the centroid and distribution of hurricane tornadoes. Although some hurricanes produce families of tornadoes, the individual event is a small, rope-type vortex similar to a waterspout. It has a short path length and maximum wind speeds are usually less than 120mph, (93 km/hr) (F1). Figure 3-23 shows the distribution of tornadoes that have accompanied past hurricanes.

No special evaluation is provided for hurricane-tornado.

3.4.4 Hurricane-Cyclone

Hurricanes develop from a variety of tropical weather disturbances and pass through several increasingly intense phases, classified as (a) tropical depressions (with sustained winds less than 40 mph, or 64 km/hr), (b) tropical storms (with winds between 40 and 73 mph, or 64 and 117 km/hr), and finally, (c) hurricanes (with sustained winds over 73 mph, or 117 km/hr).

The typical hurricane system has a diameter of about 300 miles (483 km), although winds of hurricane force are concentrated in a much smaller area. The air system in a hurricane in the northern hemisphere spirals counterclockwise toward the storm's low pressure center (Figure 3-24). The air absorbs heat and moisture from the warm ocean surface and gathers speed as it moves from higher to lower pressure. This heat and moisture constitute the hurricane's energy source, which is released again near the center where the converging air flows upward in a wall of clouds (the ring of strongest wind and rain). Inside the wall, in the hurricane eye, winds are much weaker, heavy rains cease, and the sky may even be clear. Table 3-21 provides sample reference for hurricane-cyclone.

The likelihood of occurrence of storms having varying strength as expressed on the Saffir-Simpson scale can be treated in several ways. First the landfall probabilities in various mainland gulf and Atlantic coastal states can be expressed by the top figure in Figure 3-25 which separates the major category 3-5 hurricanes from all hurricanes. A smoothed strike frequency can be constructed from this data for all tropical storms (see the lower figure in Figure 3-25).

Strike frequency by category has also been addressed by FEMA in Figure 3-26. A somewhat different inference is gained from this figure compared with those in Figure 3-25. Essentially, the amount of data that has been obtained since 1886, when tropical storm reporting was first formally instituted, is uncertain, have holes. This causes different investigators to interpret the available data and its quality lack differently, depending largely on their individual judgments.

Three methods are suggested for evaluating this hazard probabilistically, all of which will produce different probabilistic outcomes thus illustrating the uncertainties.

Method 1: The American Society of Civil Engineers in 2005 released a map (Figure 3-27) of gust iso- wind velocity for the gulf and east coast of the United States and for Puerto Rico and Hawaii. Designed to show the Gulf and Atlantic areas better, this map is an enlarged version of Figure 3-20. The return period shown for the constant velocity wind contours is 50 years. To compute other return period velocities the authors of the map suggest a formula for raising or lowering the wind gust velocities as a function of return period. We repeat equation (1) for ease of reference:

$$F=0.36 + 0.1 \ln (12T) \qquad (1)$$

in which

F = a factor multiplied by the contour velocity

T = return period.

This equation has the same limitations as stated in section A3.4.1. However, the mean tropical storm wind velocity is suggested as 45 mph (72 km/hr). This is the gust velocity for the smallest tropical storm.

The wind map was prepared by a committee of wind engineers. It does not exactly represent the history of tropical storm winds that have struck the United States, since records were first kept in 1896, however. Further, the quality of the data is questionable from 1886 to about 1930; it is much better from 1931 to about 1980; and is quite good from 1981 onward. Thus, a great deal of judgement must be used when incorporating older data from tropical storms to forecast wind speeds with any reliable probability. However, this map and the equation can be used directly to estimate probabilistic wind speeds assuming the most critical direction of wind travel for each above ground unit in a water facility.

Method 2: An alternative way of constructing probabilistic wind speeds at a site is to use Figure 3-27 for sustained wind speeds experienced at the coast together with the lower figure in Figure 3-25 showing strike likelihood. This figure is yet another way of interpreting the raw hurricane occurrence data to draw conclusions about storm likelihood and strength. Attenuation of sustained wind speed inland can be determined by interpolating speeds noted in Figure 3-27. Gust wind speed is roughly 1.15x sustained wind speed.

Method 3: A third procedure for constructing a set of realistic storms that replicate the hurricane hazard is to sweep by the site or region in question all of the historic storm tracks including tropical depressions and tropical storms that come within, say 80 miles (129 km). These may be obtained from the National Hurricane Center's website on the Internet.

1. To each of these a wind speed can be assigned based on the 50 year wind speed contours shown in the map (Figure 3-27) for the region in question together with the F formula noted above to make up a random set of storms.

2. A radius of maximum wind (RMW)must also be assigned in order to compute wind velocity at a particular site for each storm. An average value of 20 miles (32 km) is suggested, though RMW's ranging from as low as 10 miles to 50 miles (16 to 81 km) have been observed.

3. An average travel speed of 12 mph (19 km/hr) south of the northern border of North Carolina and 30 mph (48 km/hr) north of that border is also suggested. However, this parameter also has a great deal of variability and uncertainty.

4. Decay of wind speed on either side of the storm center from the eye wall to the 60 mph (97 km/hr) zone beyond which little damage is expected randomly varies like all other parameters that describe the characteristics of a storm. It is suggested that on the right side of the storm that the equation for decay from the eye wall perpendicular to the direction of travel is:

$$V=V_o^{c(1-K)} \qquad (2)$$

in which

V_o	=	the peak eye wall storm gust wind speed, mph
C	=	0.2 for RMW ≈ 10 miles 0.1 for RMW ≈ 20 miles
K	=	x/RMW with x ≥ RMW
x	=	lateral distance from the storm center, mile

The rate of decay perpendicular to the direction of travel on the left side of the storm beginning at the eye wall is the same as equation (2) above except that V_o is now replaced by $V_o - 2S$, where S is the forward speed of the storm.

Using each historical storm path noted and the perpendicular distance from each storm path to the site in question a set of maximum wind speeds for that site can be computed. For example, if a particular location experiences one tropical or greater storm every 20 years (see Figure 3-25), then 500 various wind velocities can be randomly simulated and computed from Figure 3-27 for each water system component site over a hypothetical 10,000 year time period. A mean peak gust velocity and C_V can then be computed for each component site from these 500 data points.

3.4.5 Hurricane-Storm Surge (Combined with River Flood and Headwater Flood)

About 90% of the deaths experienced in the past near the coast resulting from hurricanes are caused not by wind, but by storm surge. Storm surge is the rise of water above sea level at the time of storm onset. The height of storm surge along the open coast depends on a number of factors which include: (1) wind speed and associated barometric pressure, (2) depth of water or shoaling factor, (3) storm trajectory, and (4) speed of the storm (Figure 3-28). Coastal configuration in the form of estuaries or bays can cause a funneling or amplification effect. Coincidence with high astronomical tide will also increase surge height. Although the maximum surge usually affects only a relatively short length of coastline, combined storm surge and wave action may have damaging effects over 100 miles (161 km) away in either direction of a major storm center.

Wind-driven waves on top of the storm surge pose a number of added problems. First of all, the wave run-up can flood areas not reached by the surge itself. Second, the battering action of waves can transmit tremendous force inland through soil pore water pressure in the saturated soils to fairly distant structures. Third, the scouring power of waves is considerable.

The duration of storm surge is usually relatively short, being dependent upon the elevation of the tide which rises and falls twice daily in most coastal places and the speed of a storm's onset. However, maximum tide elevations can be identical on consecutive days. The high velocities of hurricane winds often produce wave heights higher than the maximum level of the prevailing high tide.

Table 3-22 contains a key reference for probabilistic modeling of hurricane-storm surge (combined with riverine flood and headwater flood). The U.S. Army Corps of Engineers has prepared a probabilistic analysis of storm surge heights on an open beach area. This is shown in Figure 3-29 together with some estimates by NOAA from Brownsville, Texas to Elizabeth City, North Carolina. Note the differences in the estimates. For Miami, the 100-year return period event is about 12 feet (3.7 m) using the U.S. Army Corps of Engineers estimate whereas the NOAA estimate is about 7 feet (2.1 m). Hurricane Andrew in 1992 produced a 17 ft. (5.2m) maximum run up height as a comparison. Andrew was about a 200 year return period storm, which would more closely match the Corps of Engineers estimate.

Figure 3-30 shows an example of the principally storm surge map created by FEMA showing the extent of the 100 year and 500 year storm surge and headwater flood, run up extent for Brazoria County, Texas. Run up can extend more than 5 miles (8 km) inland. Figure 3-31 shows the storm surge and headwater flooding extent for the Miami, Florida area. Storm surge extent is extremely small compared with headwater flooding extent. No template is required for storm surge.

Because FEMA has developed the flood maps which include storm surge this method of extent and depth estimate (combining the use of elevation data with flood extent) is considered an “A” grade for probabilistic modeling.

3.4.6 Combining Hurricane Effects

A hurricane can cause high winds, tornadoes, storm surges, riverine floods and headwater floods from the same storm all at the same time. Combining the likelihoods of hurricane winds, tornadic winds and the three flood sources along the storm’s path by estimating the probability of the individual hazard occurrence and then computing the intensities of each hazard using that storm likelihood is incorrect, except for storm surge and hurricane wind which are interdependent. Riverine and headwater floods can be caused by rains generated by other severe weather events. Tornadoes also can be caused by frontal systems as explained earlier.

To incorporate all the hazards probabilistically with each given hurricane event, the history associated with each past storm over its entire path length must be examined. What was the wind velocity and rainfall associated with each storm at each location along its travel path? What was the run up at each site for the storm in question? These are the questions that can be addressed for historic storms but requires that one consider the approximately 100 years of data as sufficient.

The data so derived must be combined for each of the 58 wind zones shown at the top of Figure 3-25 for each storm. Wind speeds will probably be missing from the NOAA data for most of the storms. Thus, they must be theoretically estimated using the forward speed of the storm and the pressure drop which can be correlated with wind velocity. Likewise, RMW must be obtained from the data or theoretically or statistically estimated in order to compute wind field velocities.

At the same time rainfall and tornado occurrence data for all sites along the path of a storm must be obtained and correlated with wind velocity or some other normalizing parameter. To repeat, this must be done for the entire storm path, since riverine flood and headwater flood can be severe inland, even though wind velocities have diminished. Rainfall data considered alone is not enough to compute flooding extent, unless this data is available, as well. The basins used to model the 100-year and 500- year return period FEMA flood maps must also be made available so that flood extent and elevation can be computed.

Obviously, this is a monumental task to perform, even with all the data. Even when the probabilistic analysis project is completed only about 100 years of data will have been accumulated. Therefore, higher risk probabilities will require a great deal of judgment and theoretical development in order to compute total hurricane loss outcomes which include cyclonic wind, tornado wind, storm surge, riverine flood and headwater flood hazards. This is the subject that proprietary risk models address.

No rating on this sketchy method of total hurricane risk is assigned.

3.5 Icing Hazard

In establishing the hazard level for ice loads, this guideline uses information contained in ASCE-7-05. Maps contained in ASCE-7-05 show 50-year recurrence interval uniform ice thicknesses due to freezing rain with concurrent 3-second gust speeds. Ice thicknesses are shown in inches. Figure 3-32 shows an ice maps for the contiguous U.S. Based upon this map, this guideline assumes high hazard areas correspond to those regions with ice thicknesses in excess of 1.0 in. In general, these areas include the Northeast, the Lake Superior region, and some parts of the Pacific Northwest. Moderate hazard areas are those regions expected to experience between 0.25 in. and 1.0 in. of ice. Low hazard areas are all areas expected to experience less than 0.25 in. of ice. These assignments are restated below:

High: ≥ 1.0 in.

Moderate: > 0.25 in. and < 1.0 in.

Low: ≤ 0.25 in.

3.6 Flooding

The classification of counties for flood hazards is based on whether Q3 data are available for that county. Q3 data are GIS files that contain information on flood areas as mapped by the FEMA Flood Insurance Rate Maps (FIRM). The Q3 maps cover 1,332 counties out of 3,141. “Q3” in Appendix A indicates Q3 data are available for the county, and “NOQ3” indicates that Q3 are not available. The Q3 maps were produced to support disaster recovery operations and are not officially recognized as a substitute for determining flood hazard from paper FIRM maps, largely due to map registration issues. Because the Q3 data are used in disaster recovery, counties with Q3 mapped generally correspond to areas with greater flood risk (see "Q3 Flood Data User's Guide" FEMA 1996; http://msc.fema.gov/q3users.shtml).

This guideline assumes that if data are available, then there is at least a 100-year floodplain mapped somewhere in that county. In this case, no distinction is made between low, moderate, or high hazards. If a Q3 map is available for that county, it was assumed that there is at least a moderate flood hazard level for that area. The user should be aware, however, that lack of a Q3 map does not imply the nonexistence of a flood hazard. If a “local” flood hazard is known to exist for the area under investigation despite the absence of a Q3 map, then the assessment should be upgraded to a Phase 2 evaluation. Therefore, the following assignments are used in gauging flood hazard levels:

Moderate/High: Q3 map available for county
Low: Q3 map does not exist for county

Floods have been and continue to be one of the most destructive natural hazards facing the Nation. Moreover, the probability exists that a greater flood will take place than any experienced in the past (see Figure 3-33).

A flood is any abnormally high streamflow that overtops the natural or artificial banks of a stream. Flooding is a natural characteristic of rivers. Flood plains are normally dry-land areas on either side of a river which act as a natural reservoir and temporary channel for flood waters when they come. If more runoff is generated than the banks of a stream channel can accommodate, the water overtops the stream banks and spreads over the flood plain causing social and economic disruption and damage to crops, lifelines and other structures. The ultimate parameter affecting damage to surface structures or crops, however, is not the quantity of water being discharged, but the elevation of the water surface above the land.

3.6.1 Riverine Flood

Taking place throughout the United States, riverine floods are caused by precipitation over large areas or by the melting of the winter’s accumulation of snow or both. Riverine floods differ from flash floods or headwater flooding in their extent and duration. Whereas these floods are of relatively short duration on small streams, riverine floods take place in river systems whose tributaries may drain large geographic areas and encompass many independent river basins and states. Floods on large river systems may continue for periods ranging from a few hours to many days.

Table 3-22 provides data sources for flood in general. Table 3-23 provides the template for modeling riverine flood. However, FEMA has developed flood extent maps, which include riverine flood for about 20,000 communities. These maps provide the 100 year and 500 year return period of riverine, headwater and storm surge flooding extent. Maps may be purchased whether in paper map form or in digital form on disks. The Internet can also be

accessed to obtain flood maps for any location in the United States (see Figure 3-34 as an example). In order to compute flood depth in addition to flood extent, a measure of flood intensity for rising waters, the FEMA flood maps must be overlain by elevation maps. These too are available on the web or in paper form at modest cost. Because FEMA has spent billions in today’s dollars to produce these very detailed maps we rate the use of FEMA flood maps for the two levels of risk an “A”. FEMA plans to upgrade the maps at a budgeted figure of $800 million more.

3.6.2 Headwater Flood

Headwater floods include those generated in relatively flat terrains or mountainous areas with ravines or gorges. The former can form where there is no stream. For example, abnormally heavy precipitation can fall on flat terrain at such a rate that the soil cannot absorb the water or the water cannot run off as fast as it falls.

Table 3-23 shows the factors and data necessary to create probabilistic headwater flood maps. They are the same as those for riverine flood with the exception that the rainfall data of interest are those of the 24 hour to 48 hour nature. (See the riverine flooding discussion in A-3.3.1 about the FEMA flood maps that are available for the 100 year and 500 year return periods which also applied to headwater flooding. These maps also include storm surge.)

Another understanding of headwater flood likelihood for various areas of the nation can be gained from viewing Figure 3-35. This figure was constructed using seven NOAA probability maps of mean precipitation (see Figure 3-36) for the 24-hour rainfall time period. The mapped return periods are: 1 year, 2 year, 5 year, 10 year, 25 year, 50 year and 100 year. Applying a hypothetical standard for incipient headwater flooding such as 8 inches in a 24 hour time period, Chicago would not be vulnerable up to a return period of about 3000 years; Oklahoma City for 45 years and; Miami for 5.5 years. Of course, each area has its own drainage and runoff characteristics which influence the capability of the various areas to handle the sudden accumulation of water. This capability also causes the hypothetical standard to vary from area to area.

Figure 3-35 shows the average rainfall that can be expected in a given duration of time for 1% chance of occurrence. The world record in 24 hours is 72 inches on the island of Reunion in the Indian Ocean at about 21° south latitude. This island is subject to major typhoons (hurricanes) which deliver this kind of rainfall. Consequently, tropical storms are a serious source of headwater flooding. By converting all of the losses from twentieth century floods affecting the United States, it can be shown that tropical storm and hurricane generated flooding cause greater losses than flash or riverine floods generated by other weather systems.

Therefore, the gulf and eastern coastal areas of the U.S. and their attendant heavy 24 hour rains are affected by tropical storms and hurricanes which strike these coastline areas dropping much of their moisture in the process. (Note also, how closely the rainfall contour map in Figure 3-36 resembles the wind contour map discussed later in Figure 3-27)

Because FEMA maps discussed in the earlier section on riverine flood also include headwater flooding hazards, using them to evaluate headwater flooding as well as riverine flooding and storm surge combined is rated an “A”.

3.7 Human Threats

The time-dependent nature of human threat levels, is based upon the five-color threat assessment levels established by the Department of Homeland Security (DHS)

> ***High***: DHS Orange (High) to Red (Severe)
>
> ***Moderate***: DHS-Blue (Guarded) to Yellow (Elevated)
>
> ***Low***: DHS-Green (Low)

The high hazard criteria is based on the threat assessment levels of Orange (High) and Red (Severe) established by the Department of Homeland Security (DHS). The high hazard level is based on the existence of specific, credible information about a human threat against the electric industry. The moderate hazard level is based on Blue (Guarded) and Yellow (Elevated) threat assessment levels. This selection is based on nonspecific, general information about the potential for a human-caused disruption of service. The low hazard level is based on the Green (Low) threat assessment level. This level is based on the existence of no known threats to the power industry other than normal human activities which are generally tracked through local law enforcement or reporting systems established by state public utilities commissions.

Human threats by their very nature evolve from adversaries or events that can disrupt water systems. This evolutionary process occurs over time. Law enforcement analyst or security specialists rely on information or data obtained from research or interviews gathered over time to form an opinion about general or specific threats. This information or data are referred to as intelligence and comes from such diverse sources as criminals, business competitors, hackers, foreign intelligence services, terrorists, and others.[2] Intelligence may come from open (published information or information from various news media) sources. In general, intelligence is treated as confidential information to avoid discovery by adversaries in an attempt to apprehend them before they have the chance to launch attacks. Intelligence is generally shared only on a need-to-know basis. As such, the quantity and quality of specific intelligence about a human threat (or conversely the lack of specific information about the potential for human threats) are not very useful for determining the appropriate level of investigation.

When short-term periods of intense politically motivated protests take place, however, the infrastructure community can expect that it may be attacked, regardless of its involvement in the event being protested. Protesters often view regulated utility companies, such as electric power companies, as part of the government, regardless of whether they are an investor-owned or a publicly owned utility. Even protests between two foreign nations can spill over into the United States, because the United States is a multicultural nation with a large global presence.[2]

As a result of the national aspect of human threats, the federal government has long been involved in developing intelligence through multiple law enforcement and intelligence agencies and coordinating that information dissemination with state and local government agencies.

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[2] National Infrastructure Protection Center, "Risk Management: An Essential Guide to Protecting Critical Assets," November 2002.

Table 3-1. Types of Publicly Available Models and Data for Creating Probabilistic Models of Natural Hazards Data

A. Computer Models of Natural Hazards Intensity
• Storm surge (SLOSH)
• Earthquake (HAZUS-MH)
    • Faulting
    • Shaking
    • Landslide
    • Lurching-Liquefaction
    • Tsunami*
    • Seiche*
• Hurricane (HAZUS-MH)
• Flood (HAZUS-MH)
B. Probabilistic Natural Hazard Maps
• Tsunami
• Severe Wind
• Hurricane Wind
• Storm Surge-River/Headwater Flood
• Earthquake-Shake
C. Indicative Natural Hazard Maps
• Landslide
• Expansive Soils
• Soil Collapse-Earth Subsidence
• Frost Heave
	D. Historic Hazard Initiation Data
	• Hurricane (size, track, pressure, speed, date)
	• Tornado (size, track length, width, date, time, location)
	• Air Temperature (location, date, time)
	• Rainfall Amounts (location, date)
	• Wind Speeds (location, date)
	• Earthquakes (location, magnitude, depth, date)
	• Major Floods (location, date, duration)
	• Tsunamis (location, source quake, run-up, date)
	• Active Faults (name, slip rate, location, length, characteristic magnitude, dip, width, return period, G/B A-value, b-values)
	• Costly Landslides (location)
	E. Hazard Conditioning Data
	• Earth Material Types and Thickness (location)
	• Elevation (location)
	• Water Table Depth (location)
	• Lake and Embayment Parameters (location)
	• Conflagration Parameters (location)
	• Earthquake Shake Attenuation (location)
	• Hurricane Wind Configuration (location)

Table 3-2. Organizations Supplying Pertinent Models, Maps, or Data for Modeling Natural Hazards Probabilistically

U.S. Government	Item or Data Supplied
• Natural Resources Conservation Service • National Oceanic and Atmospheric Administration (NOAA) • National Weather Service (NWSS) • National Hurricane Center (NHC) • National Climatic Data Center	• National Atlas • Earth materials maps • SLOSH (storm surge computer program) • Severe wind data and maps • Hurricane data and maps • Storm surge data and maps • Air temperature data • Tornado data • Rainfall data • Wind speed data • Flood data • Hurricane wind configuration data
• U.S. Corps of Engineers (USCE)	• Flood maps • Storm surge maps • Expansive soils maps
• Federal Emergency Management Agency (FEMA)	• HAZUS (earthquake hazard computer program) • SLOSH (storm surge computer program) • Flood maps
• U.S. Department of the Interior (USDOI)	• Tsunami maps and data
• U.S. Geological Survey (USGS)	• Earthquake maps and data • Landslide maps and data • Expansive soil map and data • Soil collapse data • Active fault data • Earth materials data • Elevation data • Water table data • Earthquake shake attenuation

Table 3-3. Sample General References for Data and Models for Developing Probabilistic Models of Natural Hazards

Climate History	**What is supplied?**
• http://www.nws.noaa.gov/oh/hdsc/max_precip/maxprecp.htm	Data for maximum rainfall throughout the world recorded in time periods ranging from 1 minute to 2 years. To be used with average annual rainfall.
• http://www.nedi.gov	The National Environmental Data Index (NEDI) provides direct access to environmental data and information descriptions, and thereby, improves awareness of and facilitates access to data and information holdings.
• http://www.nws.noaa.gov/oh/hdsc/noaatlas2.htm	2 yr 6 hr, 2 yr 24 hr, 100 yr 6 hr and 100 yr 24 hr rainfall in the 11 western states.
• http://www.srh.noaa.gov/lub/wx/precip_freq/intor_rtside.htm	1 yr, 2 yr, 5 yr, 10 yr, 25 yr,50 yr, 100 yr (30 min, 1 hr, 2 hr, 3 hr, 6 hr, 12 hr, 24 hr) rainfall in the states east of the 11 western states.
• http://www.wrcc.dri.edu/pcpnfreq.html	Western U.S. precipitation frequency maps (see site above for the eastern states).
• http://www.publicaffairs.noaa.gov/releases2000/dec00/noaa00084.html	Temperature, precipitation, wind, hail, tornado tracks.
• http://lwf.ncdc.noaa.gov/oa/documentlibrary/freezefrost/frostfreemaps.html	Risk maps for freeze free, spring freeze and fall freeze occurrence.
Earth Materials and Terrain	**What is supplied?**
• http://tapestry.usgs.gov/two/two.html	Includes all State Geologist websites.
Atlas of Hazards Locations	**What is supplied?**
• http://www.esri.com/hazards/makemap.html	Flood, recent earthquakes, historic earthquakes, historic hail storms, historic hurricanes, historic tornadoes, historic wind storms.
• http://www.nationalatlas.gov	Maps of many facts including: annual average rainfall, landfalling hurricanes and tropical storms, abandoned coal mines, coal fields, costly landslide events, costly regional landslide events, geologic map, landslide overview map, shaded relief, significant earthquakes.
• http://www.ngdc.noaa.gov/seg/hazard/resource/geohaz	Hazard index: seismic, geotech, landslide, software for same, sinkhole, tsunami.
• http://www.lib.ncsu.edu/stacks/gis/themes/term0240.html	GIS lookup—Natural Hazards: seismic, hurricanes, flood zones, fire, drought, tornadoes, landslides
• http://www.lib.ncsu.edu/stacks/gis/hazus.html	HAZUS: utility systems, SLOSH basin maps (hurricane maps), FEMA Q3 flood data.
• http://rsd.gsfc.nasa.gov/goes/text/interesting.servers.html	Websites for all types of ancillary information

Table 3-4. Natural Hazards Judged Capable of Being Probabilistically Modeled Using Available Data

Natural Hazard	**Relative Geographic Area Affected**	**Modeling Capability**
Gravity Landslide (I)	S	D
Expansive Soil (I)	L	D
Soil Collapse (I)	M	D
Frost Heave (I)	L	D--
Riverine Flood (I & DEP)	L	A
Headwater Flood (I)	L	A
General Severe Wind (I)	L	B
Tornado (I)	L	A
Hurricane-Cyclone (I)	S	A
Hurricane-Tornado (DEP)	S	-
Hurricane-Storm Surge (DEP)	S	A
Hurricane-Headwater Flood (DEP)	L	See ratings for headwater flood and storm surge
Hurricane-Riverine Flood (DEP)	L	See ratings for riverine flood and storm surge
Earthquake-Fault Rupture (I)	S	A
Earthquake-Shaking (DEP)	L	A
Earthquake-Landslide (DEP)	S	D (possible A)
Earthquake-Lurching (DEP)	S-M	D
Earthquake-Liquefaction (DEP)	S-M	C (absent boring log data)
Earthquake-Tsunami (DEP)	S	A
Earthquake-Seiche (DEP)	S	-

I = Independently Occurring Natural Hazard
DEP = Natural Hazard Occurrence is Dependent on Another Natural Hazard Occurring
S = Small-affects only local areas, usually smaller than 2 square miles (5.2 sq km).
M = Medium-affects moderately sized areas, between 2 and 30 square miles (5.2 and 78 sq km).
L = Large-affects an entire system, even very large ones over 30 square miles (78 sq km).
A = Data is available to model the hazard fairly completely. Conditioning data is spotty. Estimates for large return period events are questionable.
B = Much better than D but of lower quality than A. Only partial modeling capability is possible without a great deal of additional theoretical modeling and data, especially conditioning data.
C = Better than D but worse than B. Much higher quality and quantity of data and a lot of work developing theory is required to approach A.
D = Method only indicates the possible presence or absence of a problem. Probabilities are estimated only coarsely.

Table 3-5. Sample References for Modeling Earthquakes Probabilistically

Earthquake – General	**What is supplied?**
http://www.trinet.org/shake/archive/scenario.html	Earthquake scenarios in California with leads to many other sites, some dealing with probabilistic earthquake modeling.
Earthquake – Faulting	**What is supplied?**
http://geohazards.cr.usgs.gov/eq/faults/fsrpage01.html	Listing of 441 active faults used to construct shake maps. 39% are in California and 29% are in Nevada. (Note also that various State Geologists may have maps of surface faults, and that these are very detailed in California)
Earthquake – Ground Shaking	**What is supplied?**
http://mac.usgs.gov/mac/isb/pubs/forms/eqmaps.html	Probabilistic maps and epicentral maps of earthquakes.
http://geohazards.cr.usgs.gov/eq/index.html	Detailed probabilistic maps for earthquake shake.
Earthquake – Landslide	**What is supplied?**
http://geohazards.cr.usgs.gov/pubs/ofr/98-113/ofr98-113.html	Probabilistic seismic landslide hazard maps.
http://cvfeller.cv.ic.ac.uk/carlos.html	Earthquake induced landslide hazards
Earthquake – Seiche	**What is supplied?**
http://www.coastal.udel.edu/faculty/rad/seiche.html	Seiche calculator

Table 3-6. A Template for Modeling Fault Rupture Hazards

Principal effects of the hazard on water utility systems: Damage or destruction of construction both above and below ground					
Principal Activating Parameters	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
• USGS parameters noted in Appendix D	USGS/State geologists	Good	Good	All local faults	Good
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
• Likelihood of ground breakage (M)	Model used for frequency of fault rupture, randomization along fault	Uncertainty	+/- 100 yrs	Some	Good
• Fault displacement (M)	Available models (see also Appendix D)	Uncertainty	+/- 100 yrs	Some	Good
• Fault length (and width) (M)	Available models	Uncertainty	+/- 100 yrs	Some	Good
Websites or References Containing Data: See references and websites in Table 3-3 labeled “Atlas of Hazard Location” and “Earth Materials-Terrain” and Table 3-5 for “Earthquake-General,” and “Earthquake-Faulting.” **Available Probabilistic Models:** derivative of general models alluded to					

Table 3-7. A Template for Modeling Earthquake-Shaking Hazards

Principal effects of the hazard on water utility systems: inertial loads damage surface structures

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
• Earthquake faulting	USGS	Good	Good	yes	Good
• Earthquake history	USGS	Good to fair	Good	Yes	Good to fair
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
• Faulting depths	USGS	Good	Good	Some	Good
• Faulting azimuth	USGS	Good	Good	Some	Good
• Basement rock	USGS	?	?	?	?
• Site soil conditions	State geologists	Good	Fair	Some	Fair
• Attenuation characteristics	USGS/various	Varied	Varied	Many locations	N/A

Websites or References Containing Data: See references and websites in Table 3-3 labeled "Atlas of Hazards Locations," and "Earth Material-Terrain" and Table 3-5 for "Earthquake-Shake," "Earthquake-General," and "Earthquake-Faulting."

Available Probabilistic Models: Public models only applicable to small water utility systems

Table 3-8. A Template for Modeling Earthquake-Landslide Hazards

Principal effects of the hazard on water utility systems: (1) failure of structures situation on or in slide areas and (2) failure of structures below slide areas

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
• Earthquake shaking scenarios	USGS	Good	Good	Yes	Good
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
• Landslide conditions	USGS	Good	Good	Some	Good

Websites or References Containing Data: See references and websites in Table 3-3 labeled "Atlas of Hazards Locations" and "Earth Material-Terrain" and Table 3-5 "Earthquake-Landslide," "Earthquake-Shake," "Earthquake-General," and "Earthquake-Faulting."

Available Probabilistic Models: USGS in "Earthquake-Landslide" website and HAZUS

Table 3-9. Classifications and Definitions of Slope Movements (See Figure 3-8 for Examples)

Type of Movement	Type of Material		
		Soils (Earth Materials)	
	Bedrock	**Coarse-grained (debris)**	**Fine-grained (earth)**
Falls	Rock fall	Debris fall	Earth fall
Topples	Rock topple	Debris topple	Earth topple
Slides	Rock-block slide	Debris-block slide	Earth-block slide
Rotational	Rock slump	Debris slump	Earth slump
Translational	Rock slide	Debris slide	Earth slide
Lateral spreads	Rock spread	Debris spread	Earth spread
Flows	Rock flow	Debris flow	Earth flow
Complex	Combination of two or more of the above		

Table 3-10. Sample General References for Data and Models for Developing Probabilistic Models of Landslides

Landslides	What is supplied?
http://www.ngdc.noaa.gov/seg/hazard/resource/geohaz/ldslhaz.html	Gateway to landslide information. Maps
http://landslides.usgs.gov/html	Landslide maps
http://landslides.usgs.gov/html_files/landslides/nationalmap/legend.html	Landslide maps
http://cindi.usgs.gov/hazard/landslide.html	Landslide maps
http://landslides.usgs.gov/html_files/nlicsun.html	Landslide maps
http://edcwww.cr.usgs.gov/glis/hyper/guide/usgs_dem	Landslide maps
http://cascade.lcsc.ed/terrain/metadata/generic_dem.htm	Landslide maps
http://lwf.ncdc.noaa.gov/oa/ncdc.html	Landslide maps

Table 3-11. A Template for Modeling Gravity Landslide Intensities

Principal effects of the hazard on water utility systems: Fracture underground lines. Fail foundations of structures on the surface. Debris flow into above-ground structures.

Principal Activating Parameters	**Data Location**	**Data Quality**	**Data Quantity?**	**Data Gaps?**	**Data Condition?**
• Removal of lateral support	(?)	NA	NA	NA	NA
• New weight added (eg. water)	Rainfall (NOAA)	Good	Virtually all	± 100 yrs	Good
• Vibrations	Earthquake (USGS)	Good	Virtually all	± 100 yrs	Good
Principal Conditioning Parameters:	**Data Location?**	**Data Quality?**	**Data Quantity?**	**Data Gaps?**	**Data Condition?**
• Slope (grade)	USD0I	Good	Good	None	Good
• Earth materials	USGS/State Geologist	Not local	Spotty to poor—in most cases	(?)	(?)
• Weathering of materials	(?)	(?)	(?)	(?)	(?)
• Pore water pressure increase	NOAA	Good	Good	~ 100 yrs	Good

Websites or References Containing Data: See references and websites in Table 3-3 labeled “Climate History,” “Earth Materials and Terrain” and Table 3-10.

Available Probabilistic Models: None to our knowledge.

Table 3-12. A Template for Modeling Expansive Soils

Principal effects of the hazard on water utility systems: (1) Differential movement of surface structure foundations and (2) differential movement of buried pipelines and other structures.

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
• Excessive water	NOAA	Good	Good	± 100 years	Good
• Drought	NOAA	Good	Good	± 100 years	Good
• Presence of montmorillonite	USGS	Poor	Poor	Poor	Poor
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
• Depth of clays	State Geologists (See presence of montmorillonite)				
• Amount and thickness of clay layers	State Geologists (See presence of montmorillonite)				

Websites or References Containing Data:

- Wiggins, John H. et al, 1978, Natural Hazards: Earthquake, Landslides, Expansive Soils, J. H. Wiggins Company, NSF Grant #ERS-75-09998-AOI, AEN-74-23992
- See references and websites in Table 3-3 labeled "Climate History" and "Earth Materials and Terrain." State Geologists may also have pertinent maps.

Available Probabilistic Models: None are known.

Table 3-13. A Template for Modeling Soil Collapse-Hydrocompaction

Principal effects of the hazard on water utility systems: (1) Differential movement of surface structure foundations and (2) differential movement of buried pipelines and other structures.

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
Addition of water by					
• Rainfall	NOAA	Good	Good	± 100 years	Good
• Other local sources	(?)	(?)	(?)	(?)	(?)
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
4. Soil moisture	State Geologists	(?)	(?)	(?)	(?)
5. Soil composition	State Geologists	(?)	(?)	(?)	(?)
6. Plasticity index	State Geologists	(?)	(?)	(?)	(?)

Websites or References Containing Data: See references and websites in Table 3-3 labeled “Climate History” and “Earth Materials and Terrain”.

Available Probabilistic Models: None to our knowledge.

Table 3-14. A Template for Modeling Soil Collapse—Natural Subsidence

Principal effects of the hazard on water utility systems: (1) Differential movement of surface structure foundations and (2) differential movement of buried pipelines and other structures

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
• Underground water	(?)	(?)	(?)	(?)	(?)
• Excessive rainfall	NOAA	Good	Good	± 100 years	Good
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
7. Karst topography	USGS and State Geological Offices	(?)	(?)	(?)	(?)

Websites or References Containing Data: See references and websites in Table 3-3 labeled “Climate History” and “Earth Materials and Terrain”.

Available Probabilistic Models: None to our knowledge

Table 3-15. Frost-Susceptible Soil Groups

Frost Group	Susceptibility	Kind of Soil	Percentage Finer Than 0.02 mm (0.0004 in.) by Weight
F-1	Low	Gravelly soils	6 to 10
F-2	Moderate	Gravelly soils	10 to 20
		Sands	6 to 15
F-3	High	Gravelly soils	Over 20
		Sands (except very fine silty sands)	Over 15
		Clays, Plasticity Index > 12	--
F-4	Very High	All silts	--
		Very fine silty sands and	Over 15
		Clays, Plasticity Index > 12	--
		Varved clays and other very fine-grained, banded sediments	--

Table 3-16. A Template for Modeling Frost Heave

Principal effects of the hazard on water utility systems: (1) fracture underground lines and structures and (2) fail foundations of structures on the surface.

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
Upward water migration	(?)	NA	NA	NA	NA
Downward water migration	(?)	NA	NA	NA	NA
Unfavorable freeze-thaw conditions	(NWS)	Good	Virtually all	± 100 years	Good
(Freezing index)					
Principal Conditioning Parameters:	**Data Location**	**Data Quality**	**Data Quantity**	**Data Gaps**	**Data Condition**
Freezing index	NWS	Good	Good	± 100 years	Good
Water table depth	(?)	NA	NA	NA	NA
Earth materials, F value	(?)	NA	NA	NA	NA
Snow cover duration	NWS	Good	Good	± 100 years	Good
Rain fall	NWS	Good	Good	± 100 years	Good

Websites or References Containing Data: See references and websites in Table 3-3 labeled “Climate History” and “Earth Materials and Terrain”.

Available Probabilistic Models: None to our knowledge

Table 3-17. Sample References for Modeling Tornadoes Probabilistically

Tornadoes	What is supplied?
Thomas P. Grazulis, 1993, Significant Tornadoes, 1680-1991, The Tornado Project of Environmental Films, P.O. Box 302, St. Johnsbury, VT 05819	This lists all tornadoes by state, county, F-number, length of travel, width of track, time, date, deaths plus much more.
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dill?wwEvent~Storms	Listing of tornadoes
www.medi.gov/	Listing of tornadoes

Table 3-18. The Fujita Scale for Tornadoes

F Scale	Average Length	Average Width	Range of Wind Speed	Percent of Tornadoes in F Classification
F0	1.11 mi (1.79 km)	0.026 mi (0.042 km)	40-72 mph (64-116 km/hr)	19.9
F1	2.59 mi (4.17 km)	0.053 mi (0.085 km)	73-112 mph (117-180 km/hr)	44.0
F2	5.66 mi (9.11 km)	0.094 mi (0.151 km)	113-157 mph (181-253 km/hr)	26.6
F3	12.08 mi (19.44 km)	0.16 mi (0.29 km)	158-206 mph (182-332 km/hr)	7.2
F4	22.42 mi (36.08 km)	0.25 mi (0.40 km)	207-260 mph (183-418 km/hr)	2.1
F5	34.17 mi (54.99 km)	0.35 mi (0.56 km)	261-318 mph (419-512 mph)	0.2
All	**3.81 mi (6.13 km)**	**0.071 mi (0.114 km)**	**88-126 mph (142—203 km/hr)**	**100**

Table 3-19. Tornadoes Per 10,000 Sq. Mi. (or 25,889 sq. km) Per Year by State by Rank

All			>F2			F4/F5		
1	Florida	8.4	1	Oklahoma	2.4	1	Oklahoma	0.18
2	Oklahoma	7.5	2	Indiana	2.0	2	Indiana	0.16
3	Delaware	6.1	3	Iowa	1.9	3	Iowa	0.16
4	Kansas	5.8	4	Mississippi	1.9	4	Kansas	0.12
5	Louisiana	5.6	5	Alabama	1.8	5	Illinois	0.12
6	Iowa	5.5	6	Arkansas	1.7	6	Missouri	0.11
7	Indiana	5.4	7	Louisiana	1.6	7	Arkansas	0.10
8	Mississippi	5.0	8	Illinois	1.5	8	Mississippi	0.08
9	Nebraska	4.8	9	Kansas	1.4	9	Alabama	0.08
10	Illinois	4.7	10	Delaware	1.3	10	Nebraska	0.08
11	Texas	4.7	11	Wisconsin	1.2	11	Tennessee	0.08
12	Alabama	4.0	12	Florida	1.2	12	Wisconsin	0.07
13	Missouri	3.8	13	Texas	1.1	13	Kentucky	0.07
14	Massachusetts	3.8	14	Missouri	1.1	14	Ohio	0.06
15	Arkansas	3.7	15	Tennessee	1.1	15	Minnesota	0.06
16	Maryland	3.7	16	Ohio	1.1	16	Michigan	0.05
17	Ohio	3.5	17	Connecticut	1.1	17	Georgia	0.04
18	Georgia	3.4	18	Massachusetts	1.1	18	Connecticut	0.04
19	South Carolina	3.4	19	Georgia	1.0	19	Louisiana	0.04
20	New Jersey	3.4	20	Nebraska	0.9	20	Texas	0.04
21	Wisconsin	3.4	21	Kentucky	0.9	21	South Carolina	0.03
22	South Dakota	3.3	22	Michigan	0.9	22	South Dakota	0.03
23	Tennessee	2.9	23	South Carolina	0.9	23	North Carolina	0.02
24	Michigan	2.8	24	South Dakota	0.7	24	Massachusetts	0.02
25	North Carolina	2.8	25	North Carolina	0.7	25	Pennsylvania	0.02
26	Connecticut	2.8	26	Pennsylvania	0.7	26	North Dakota	0.02
27	North Dakota	2.5	27	New Jersey	0.7	27	Maryland	0.01
28	Colorado	2.4	28	Maryland	0.6	28	West Virginia	0.01
29	Minnesota	2.4	29	Minnesota	0.5	29	Colorado	0.01
30	Kentucky	2.2	30	Virginia	0.5	30	New York	0.00
31	Pennsylvania	2.2	31	North Dakota	0.4	31	Virginia	0.00
32	New Hampshire	1.8	32	New Hampshire	0.4	32	Wyoming	0.00
33	Rhode Island	1.7	33	Vermont	0.3	33	Florida	0.00
34	Virginia	1.6	34	Colorado	0.2	34	New Jersey	0.00
35	New York	1.2	35	West Virginia	0.2	35	Vermont	0.00
36	Wyoming	1.0	36	New York	0.2	36	California	0.00
37	Hawaii	0.9	37	Rhode Island	0.2	37	Rhode Island	0.00
38	Vermont	0.8	38	Hawaii	0.1	38	New Mexico	0.00
39	New Mexico	0.7	39	Wyoming	0.1	39	Maine	0.00
40	West Virginia	0.7	40	New Mexico	0.1	40	Montana	0.00
41	Maine	0.6	41	Maine	0.1	41	Idaho	0.00
42	Montana	0.4	42	Montana	0.1	42	Arizona	0.00
43	California	0.3	43	California	0.0	43	Washington	0.00
44	Idaho	0.3	44	Idaho	0.0	44	Utah	0.00
45	Arizona	0.3	45	Arizona	0.0	45	Oregon	0.00
46	Washington	0.2	46	Washington	0.0	46	Nevada	0.00
47	Utah	0.2	47	Utah	0.0	47	Alaska	0.00
48	Oregon	0.1	48	Oregon	0.0	48	Hawaii	0.00
49	Nevada	0.1	49	Nevada	0.0	49	New Hampshire	0.00
50	Alaska	0.0	50	Alaska	0.0	50	Delaware	0.00

Table 3-20. Tornado Zones By State By Greater Than anF2 Ranking per 10,000 Sq. Mi.

Zone (number per 10,000sq mi/yr)	Farwest	Midwest	East Coast
0 (0.0)	CA, ID, AZ, WA, UT, OR, NV, AK	--	--
1 (0.1-0.5)	HI, WY, NM, MT	MN, ND, CO	VI, NH, VT, WV, NY, RI, ME
2 (0.6-1.0)	--	NB, KY, MI, SD	GA, SC, NC, PA, NJ, MD
3	--	IL, KS, WI, TX, TN, OH	DE, FL, CT, MA
4 (1.6-2.0)	--	IN, IA, AL, AR, LA, MS	--
5 2.1-2.5)	--	OK	--

Table 3-21. Sample References for Modeling Hurricane-Cyclone Probabilistically

Hurricane – General	What is supplied?
http://www.eglin.af.mil/weather/hurricanes/history.html	Discusses the history of hurricanes in the western Florida Panhandle 1559-1999.
http://www.fema.gov/hu97/hmag.htm	5% probability of landfalling hurricane by category in the conterminous U.S.
http://www.lib.ncsu.edu/stacks/gis/data12/data1229.html	HAZUS: inland wind decay maps (hurricane maps)
http://www.fema.gov/hazus/wd_main.htm	HAZUS: wind loss estimation models to be released in 2002

Table 3-22. Sample references for Modeling Floods Probabilistically

Floods	What is supplied?
http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.024-00.html	USGS Flood Measurements Significant Floods of the 20^{th} Century Regional Floods Flash Floods Ice-Jam Floods Dam- and Levee-Failure Floods Debris, Landslide, and Mudflow Floods Flood Information on the Internet Other Internet Sites
http://www.nibs.org/hazus4c.htm	HAZUS Flood Loss Estimation model
http://www.esri.com/data/online/fema/femadata.html	FEMA Q3 Flood Data
http://www.lochsheil.com	Discs of digitized flood maps for FEMA can be purchased here.
http://www.fema.gov/mit/tsd/ft_hydro.htm#4	Discussion of modernizing FEMA's Flood Hazard Mapping Program
Storm Surge	**What is supplied?**
http://www.lib.ncsu.edu/stacks/gis/themes/term0167.html	Hurricane storm surges. Inundation areas.

Table 3-23. A Template for Modeling Riverine Flood Hazards

Principal effects of the hazard on water utility systems: (1) fracture underground lines and structures, (2) fail foundations of structures on the surface, (3) disable equipment and other components sensitive to direct water damage.

Principal Activating Parameters	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
Precipitation	NOAA	Good	Good	± 100 years	Good
Melting snow and ice	NOAA	Good	Good	± 100 years	Good

Principal Conditioning Parameters:	Data Location	Data Quality	Data Quantity	Data Gaps	Data Condition
Proximity to river banks	USGS/USACE/ FEMA	Good	Good	Few	Good
Elevation above river banks	USGS/USACE/ FEMA	Good	Good	Few	Good
Flow gradient	USGS/USACE/ FEMA	Good	Good	Few	Good
Surface roughness	USGS/USACE/ FEMA	Good	Good	Few	Good

Websites or References Containing Data: See references and websites in Table 3-3 labeled “Climate History” and “Atlas of Hazards Locations” and Table 3-22 for “Floods.”

Available Probabilistic Models: FEMA maps of about 20,000 communities and 1200 counties.

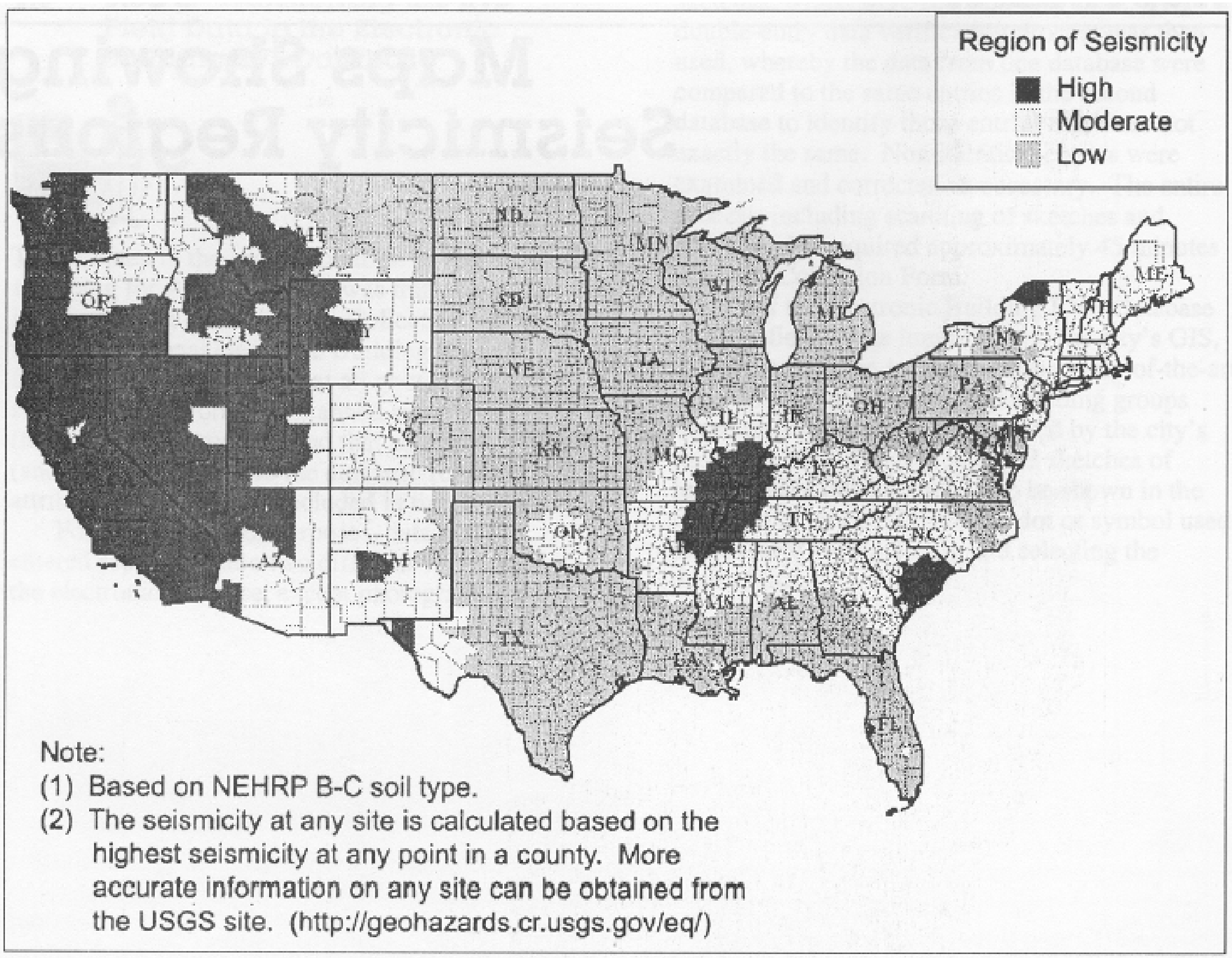


Figure 3-1. Map of Seismic Hazard Categories

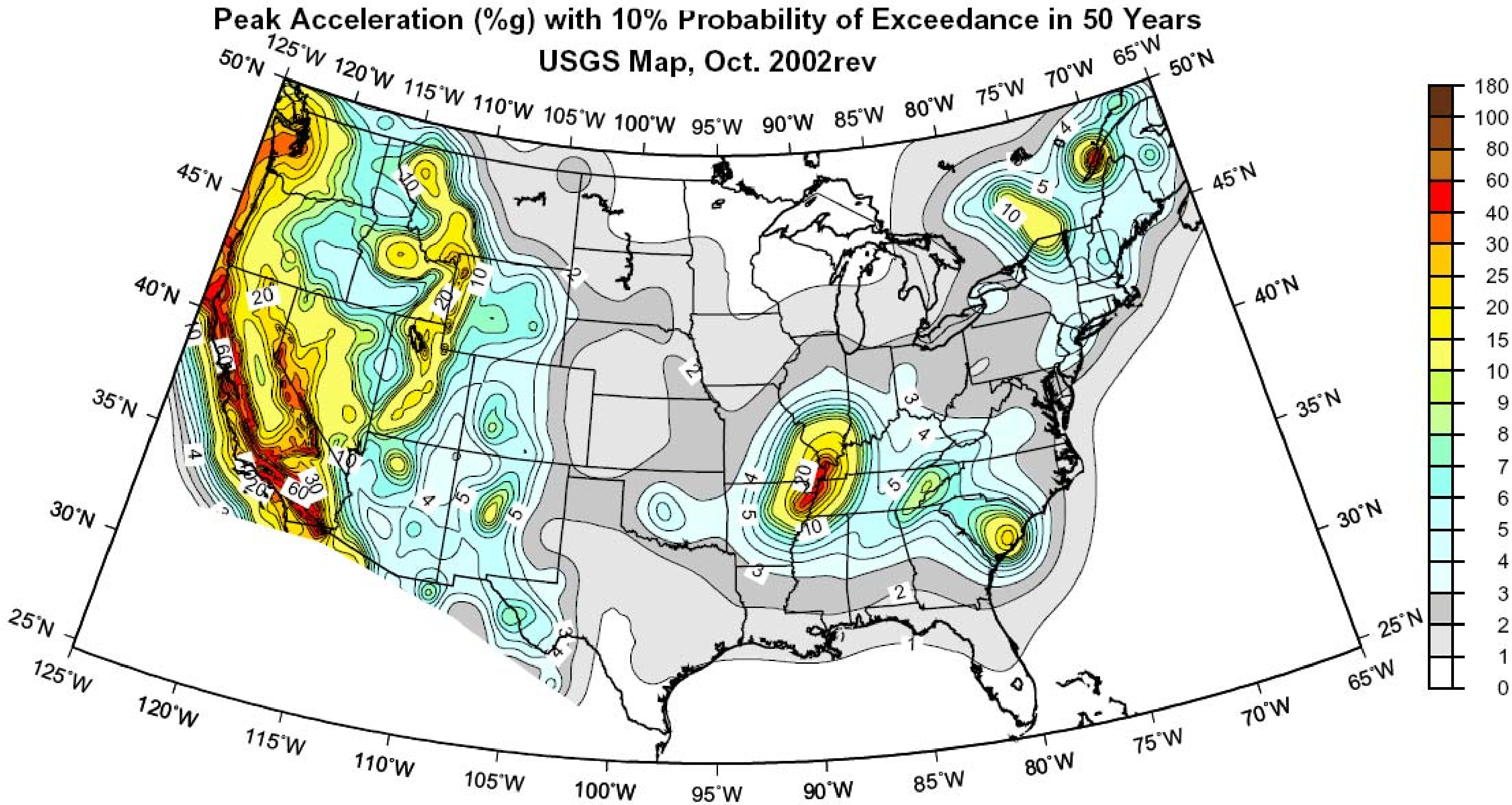


Figure 3-2: USGS Probabilistic Seismic Hazard Map (http://usgs.gov/isb/pubs/forms/eqmaps.ht)

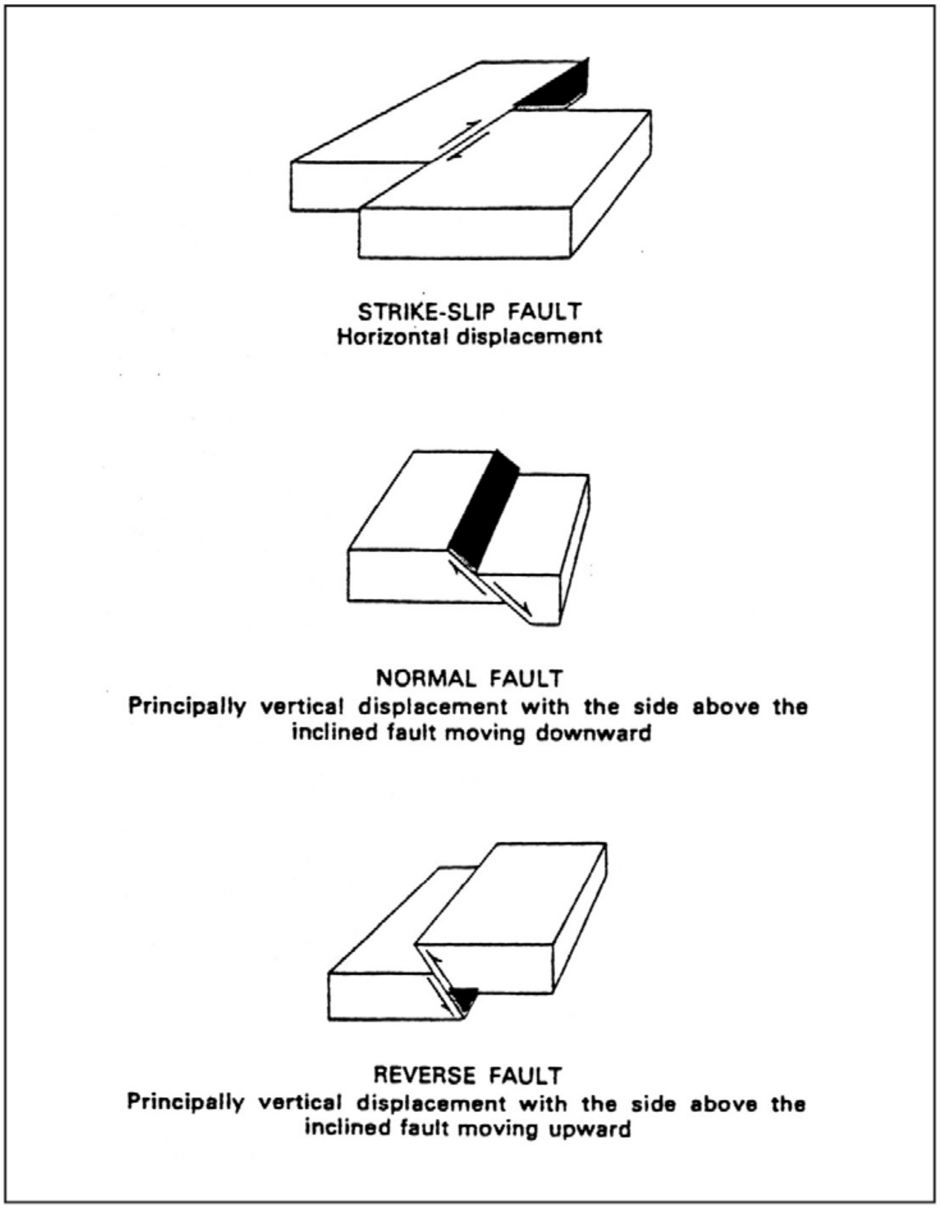


Figure 3-3: Three General Types of Fault Movement

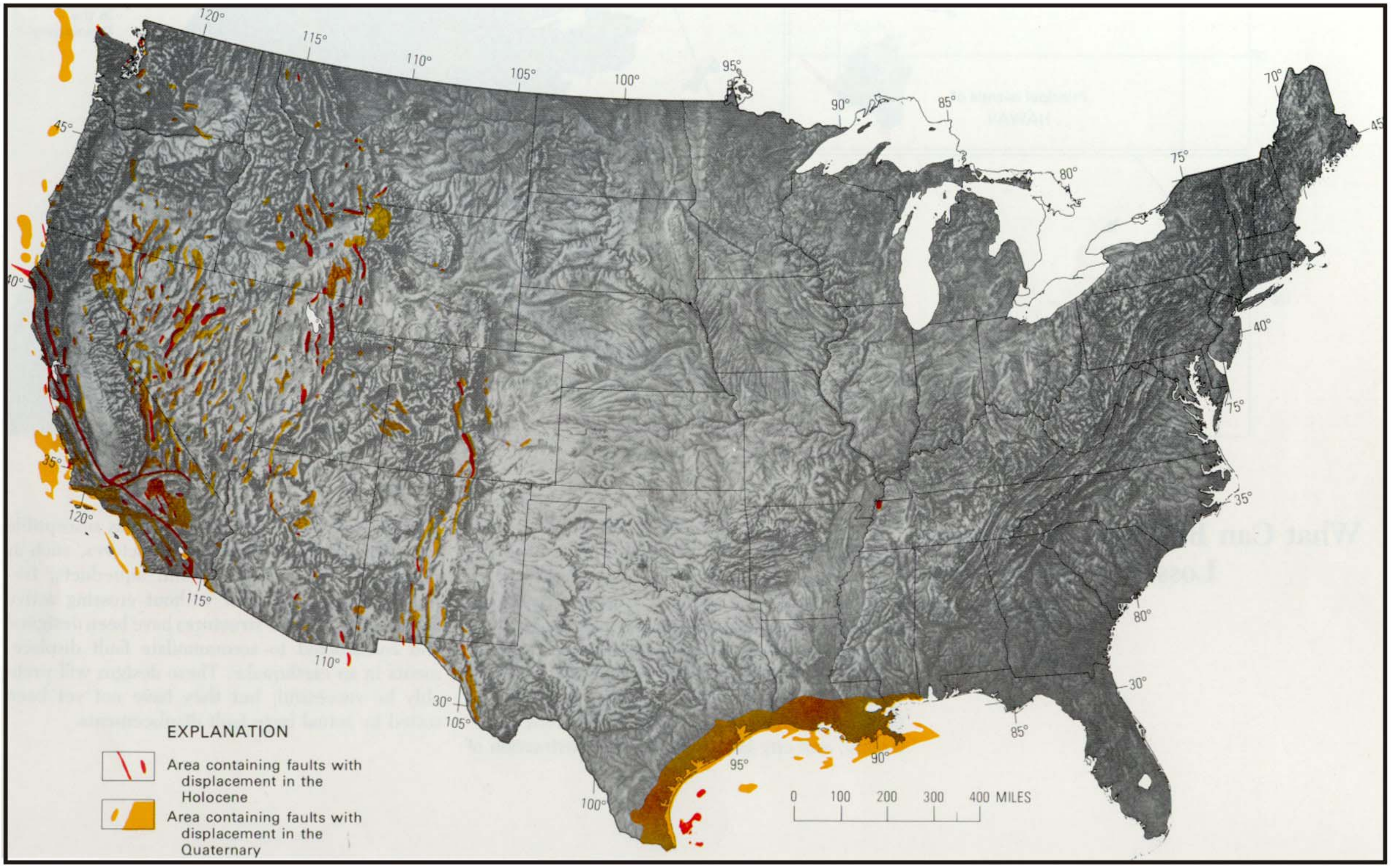


Figure 3-4: Map of Young Ssurface Faulting Zones

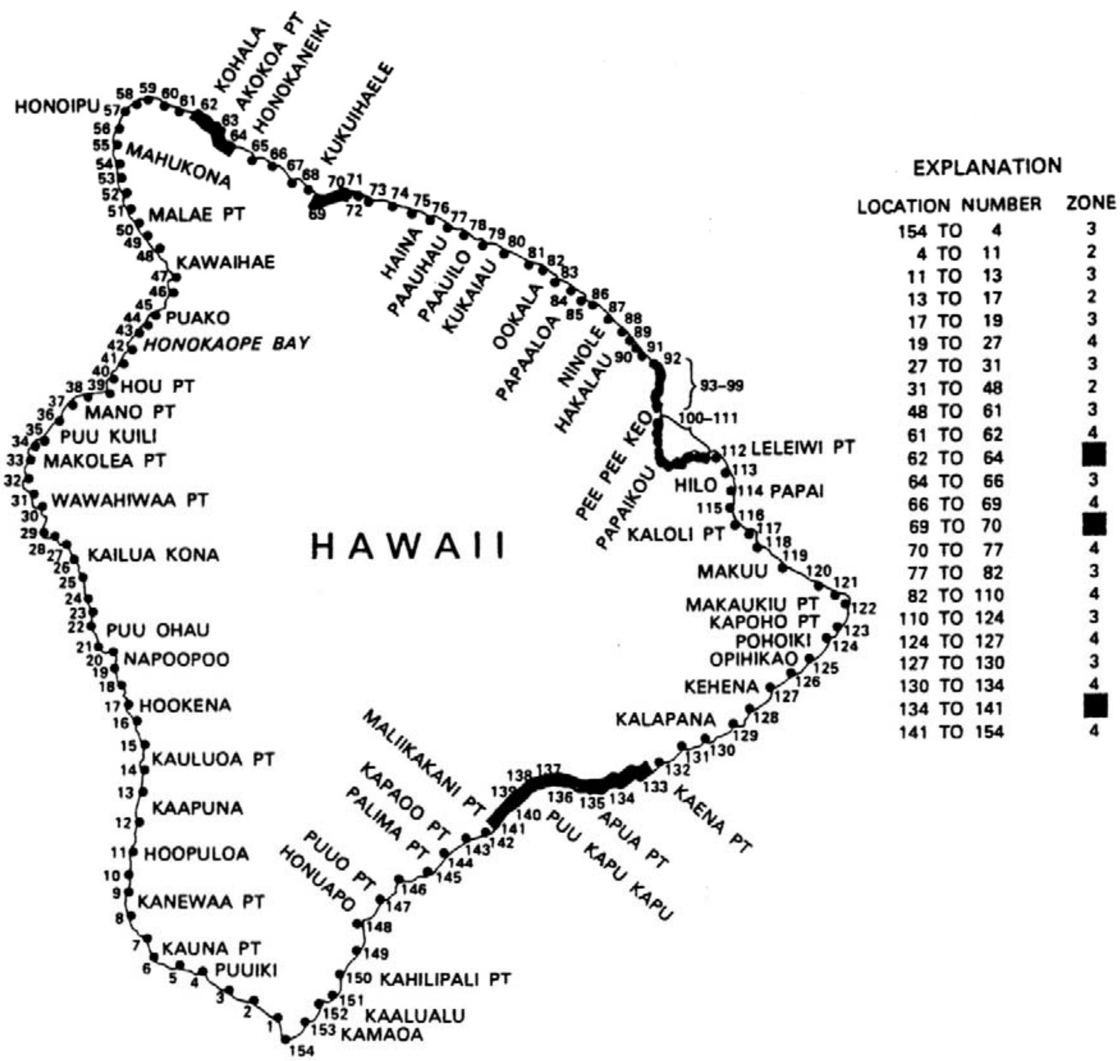


Figure 3-5: Map of the Tsunami Hazard for the Island of Hawaii

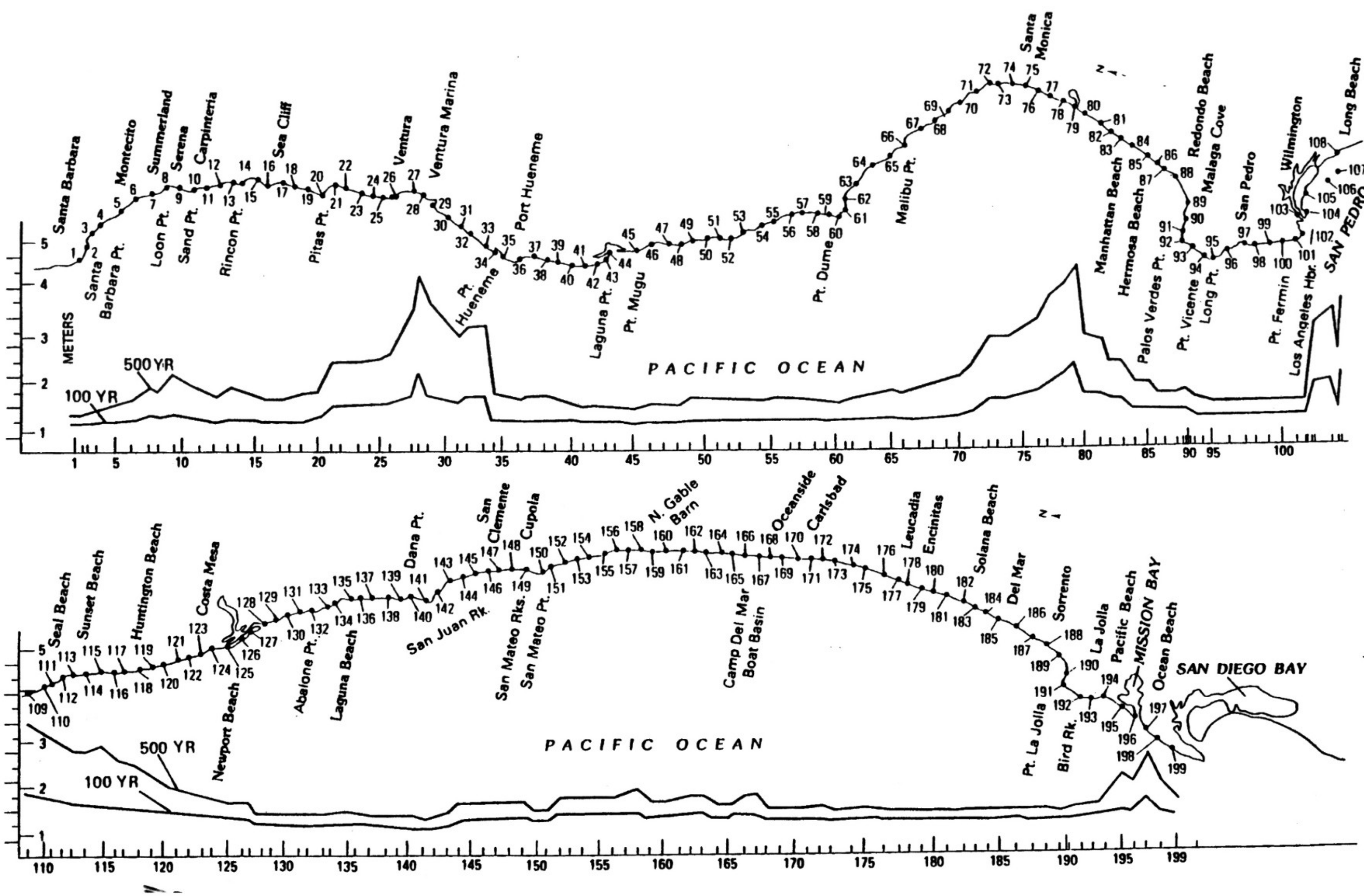


Figure 3-6: Heights of the 100- and 500-yr Tsunamis Along the Southern California Coast (Santa Barbara to San Diego)

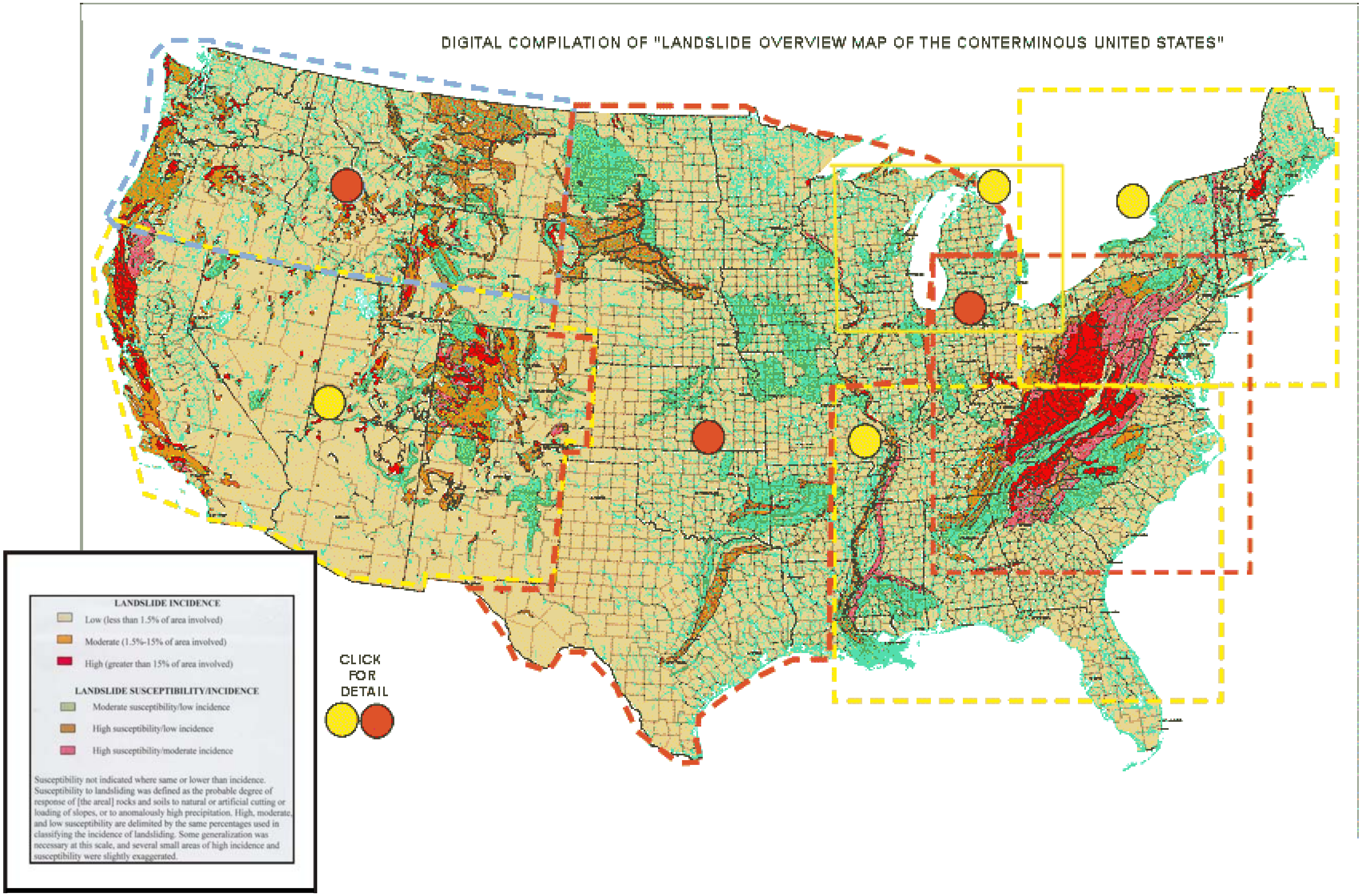


Figure 3-7. Landslide Map (USGS 1997a; for higher resolution images, visit (http://landslides.usgs.gov)

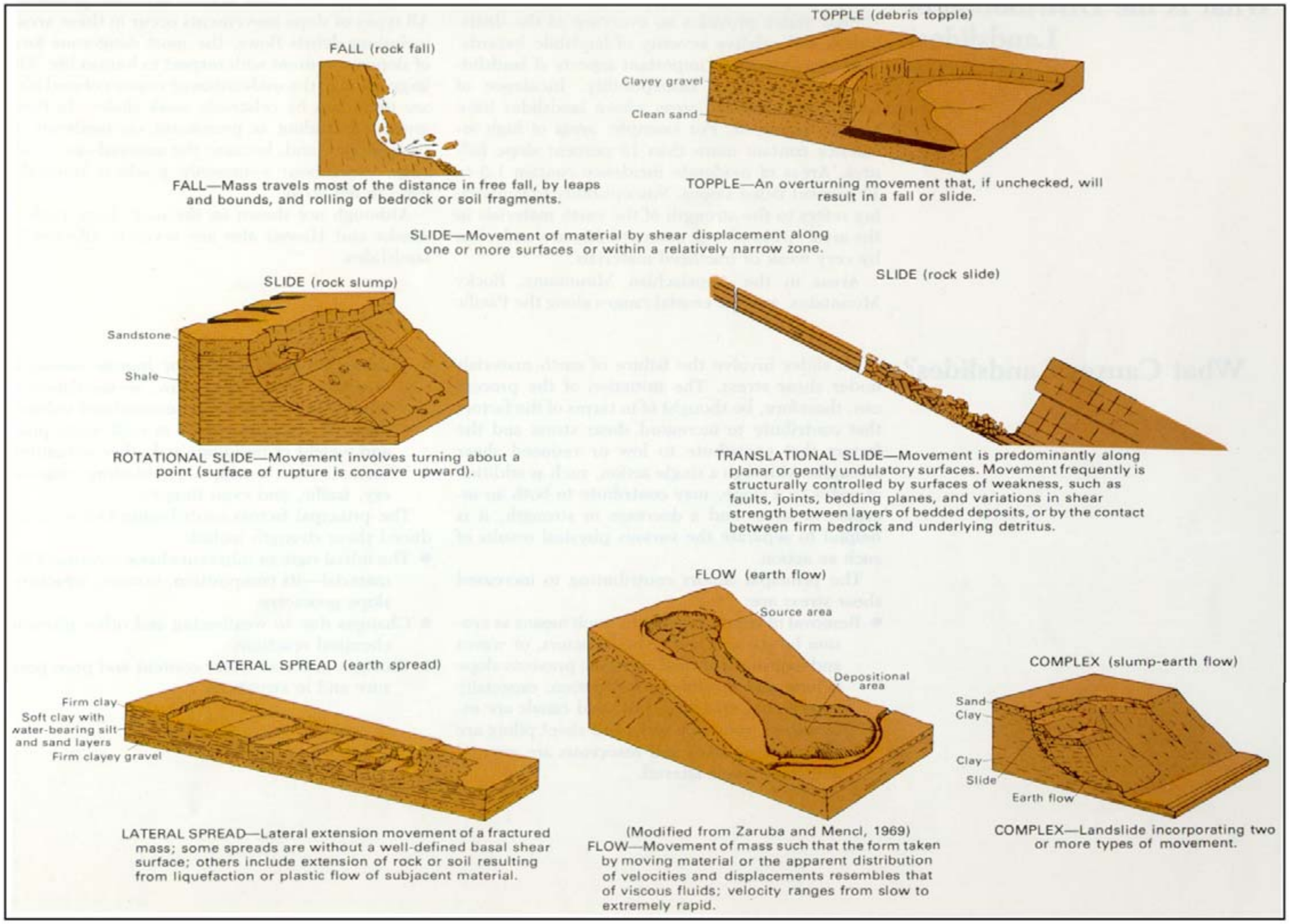


Figure 3-8: Examples of Landslides by Type of Movement

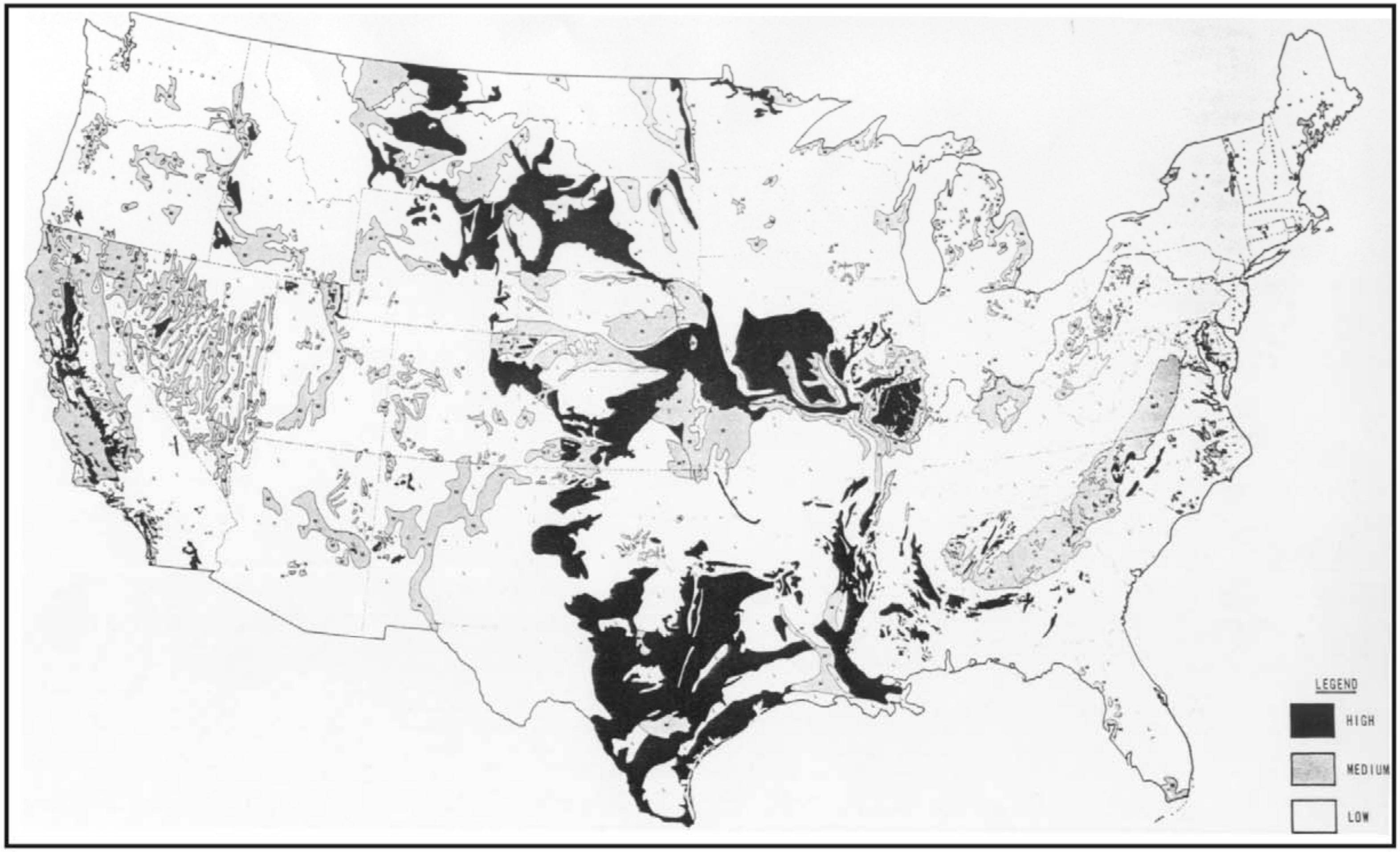


Figure 3-9: Expansive Soils Map

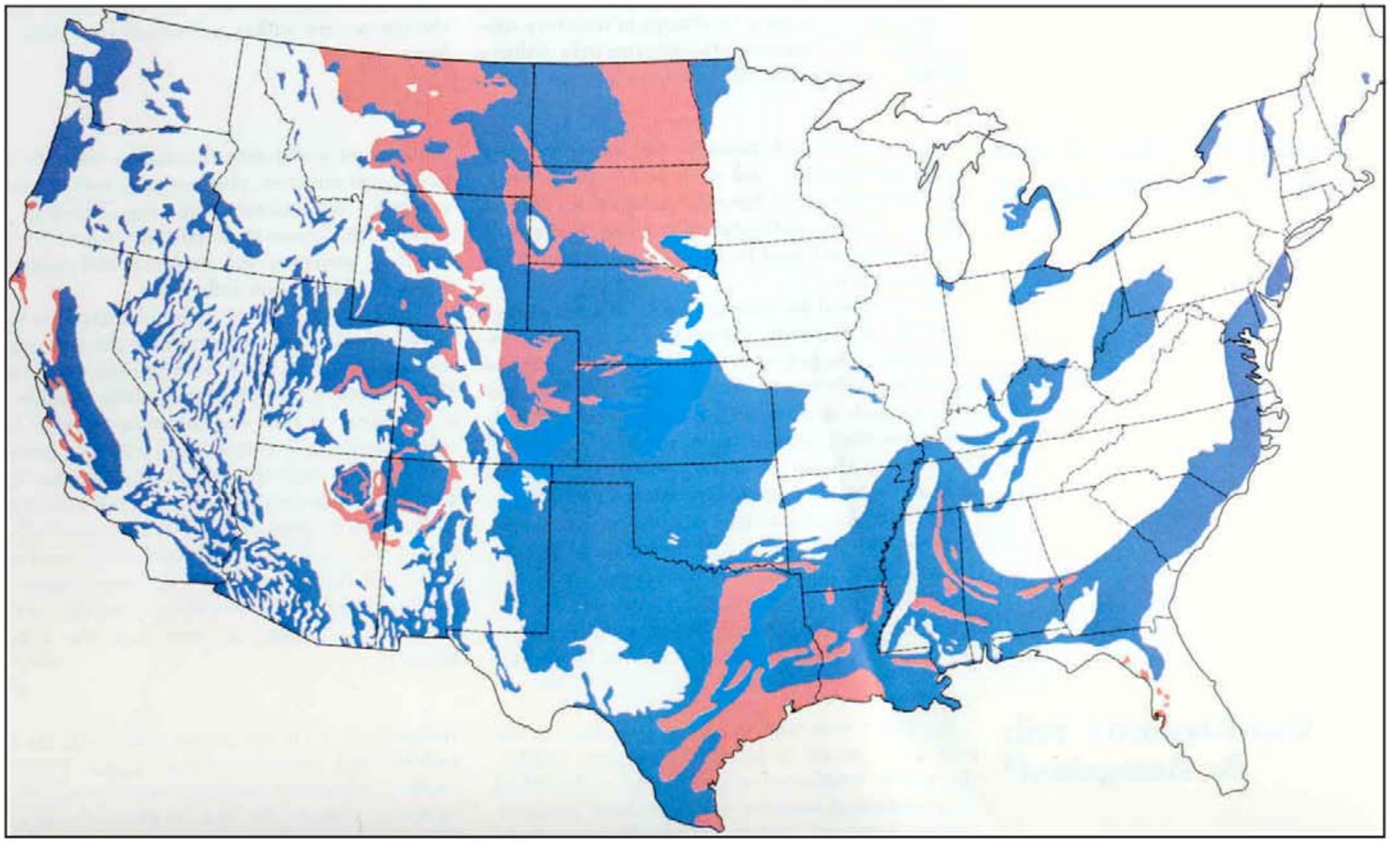


Figure 3-10: Overview Map of Smectite Rich Materials

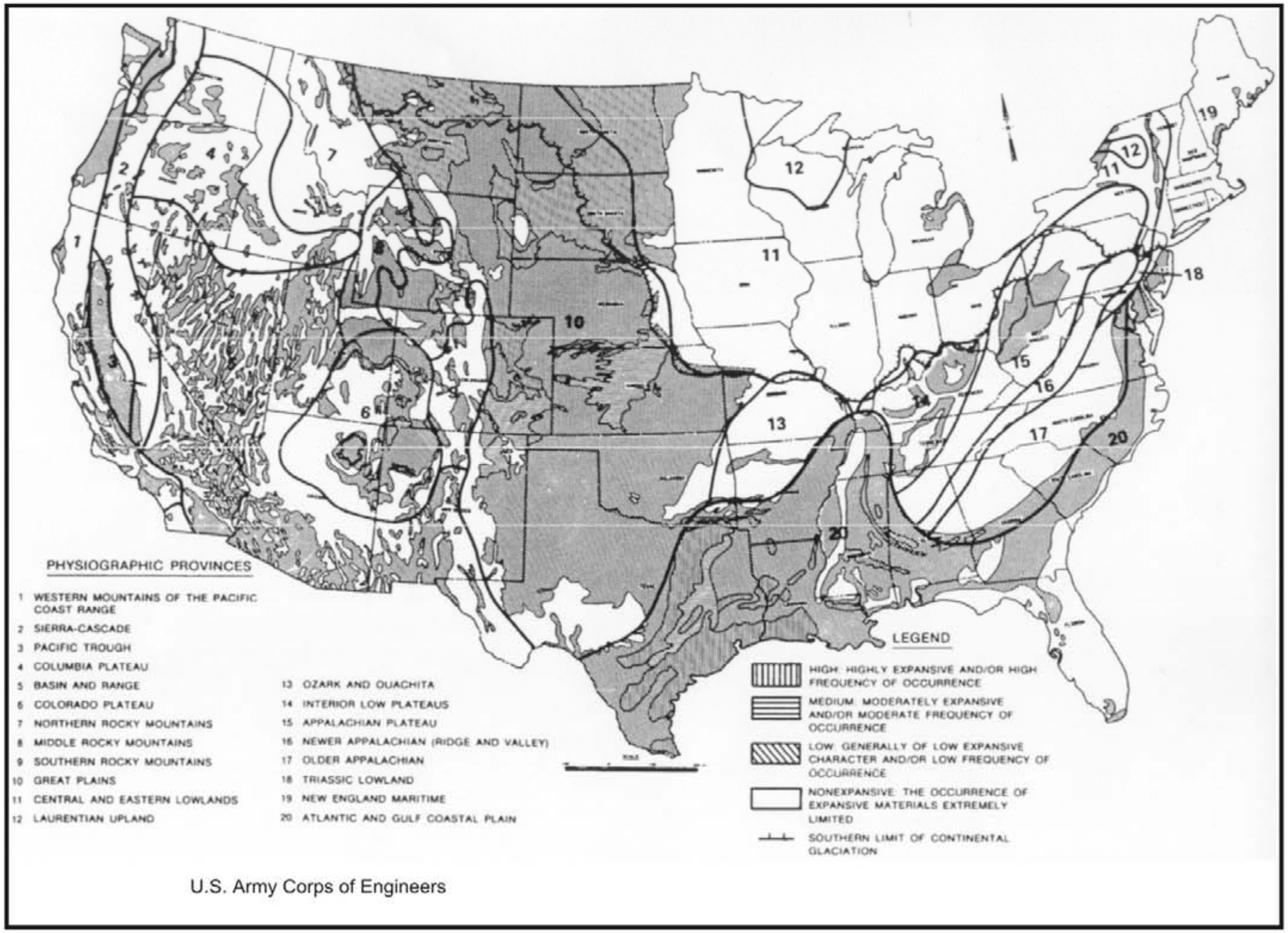


Figure 3-11: Occurrence and Distribution of Potentially Expansive Material

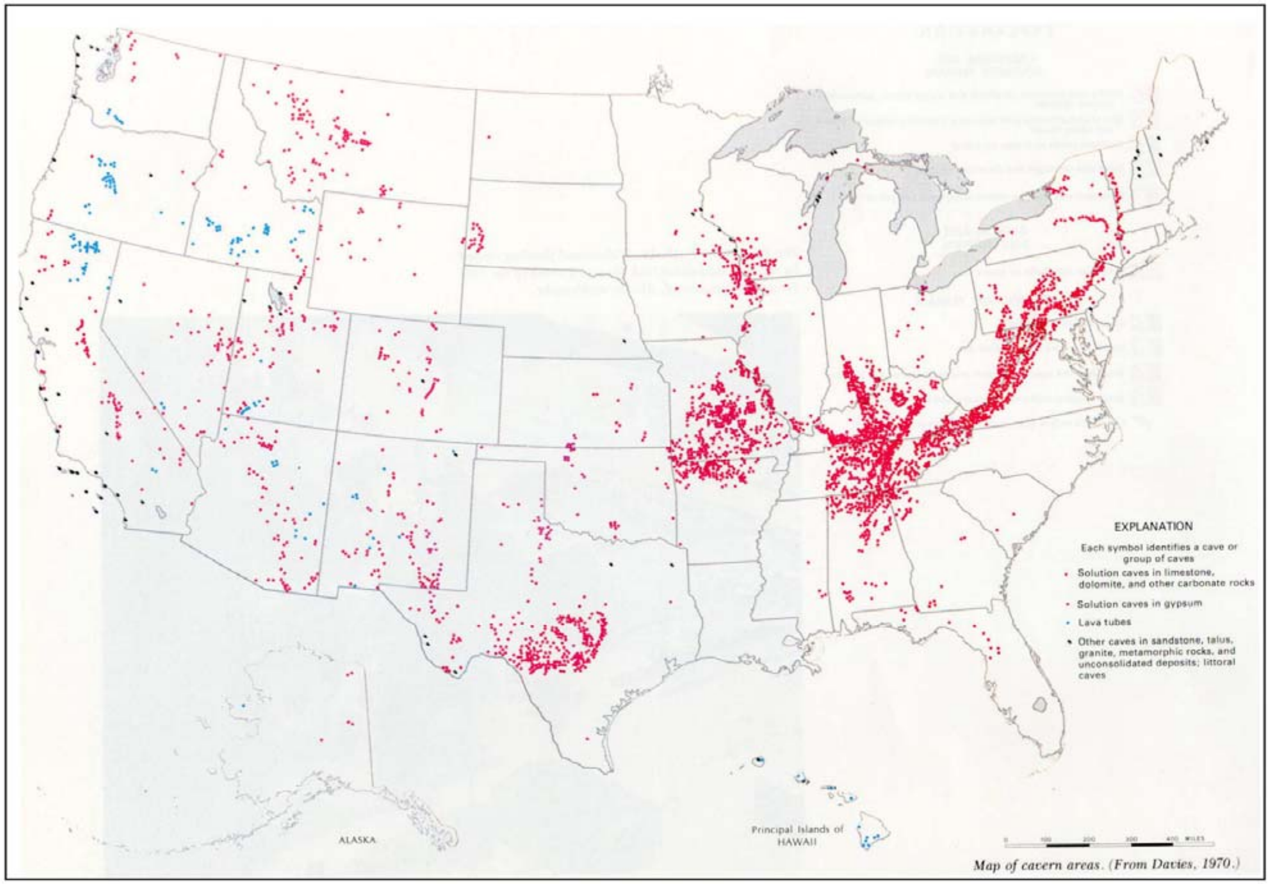


Figure 3-12: Map of Cavern Areas

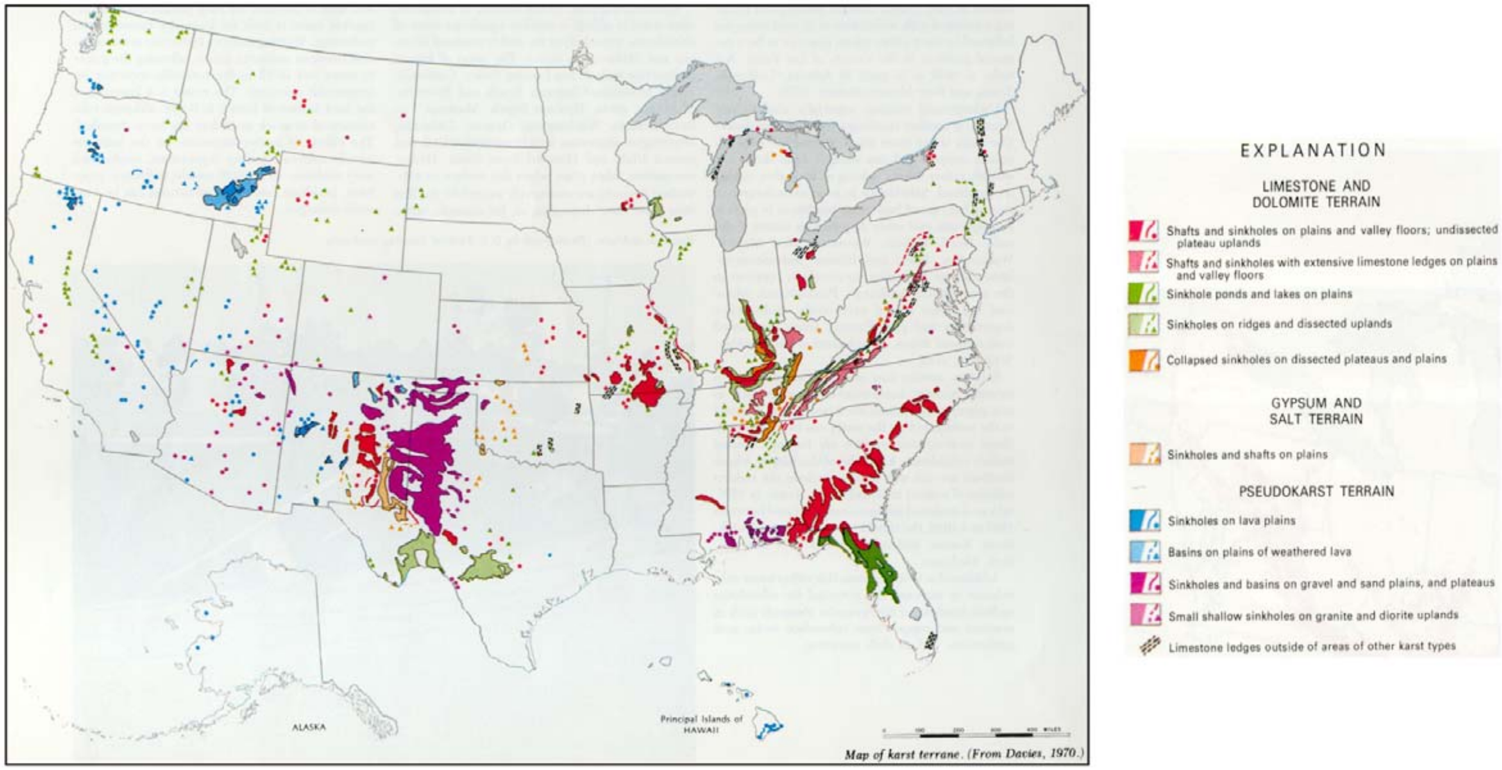


Figure 3-13: Map of Karst Terrain

Figure 3-14: Karst Areas in the State of Illinois

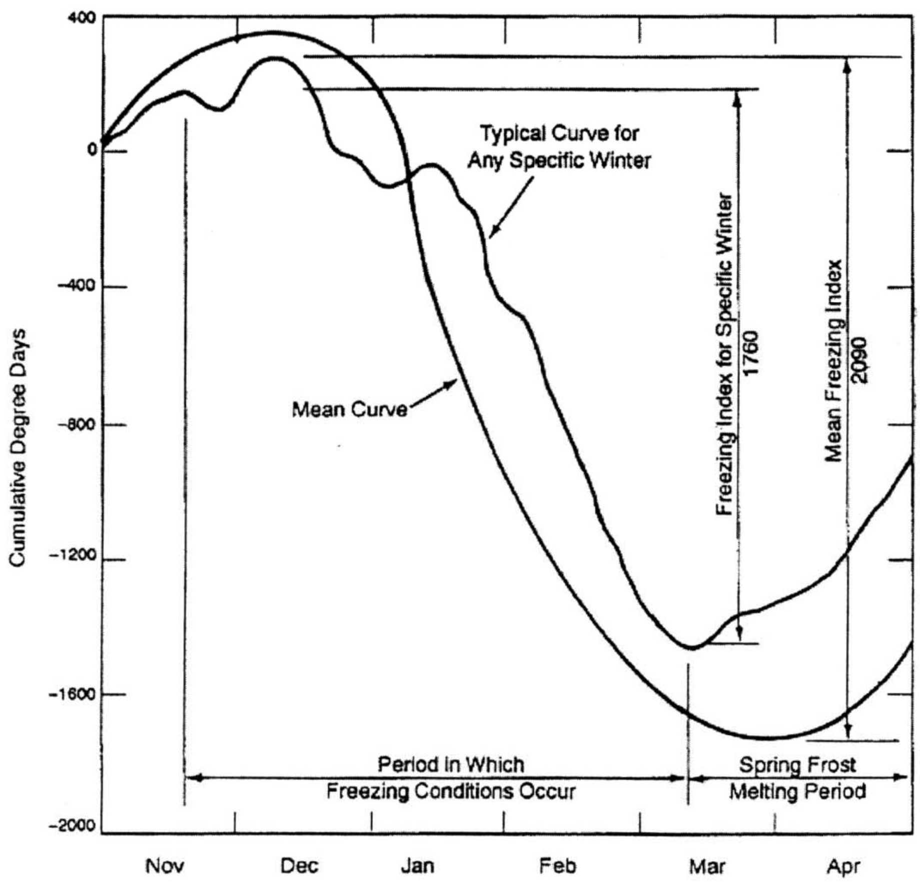


Figure 3-15: Determination of Freezing Index

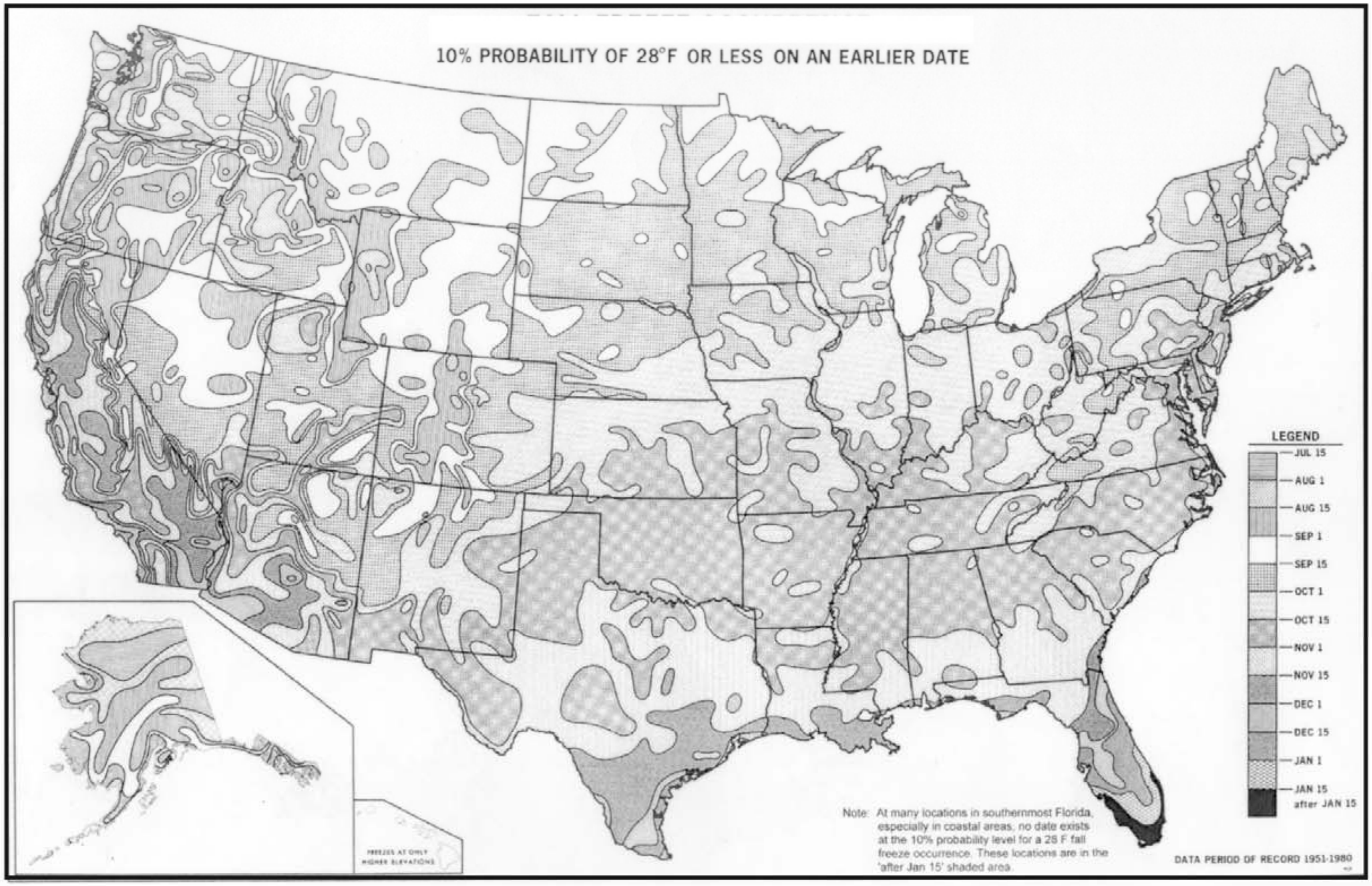


Figure 3-16: Fall Freeze Occurrence

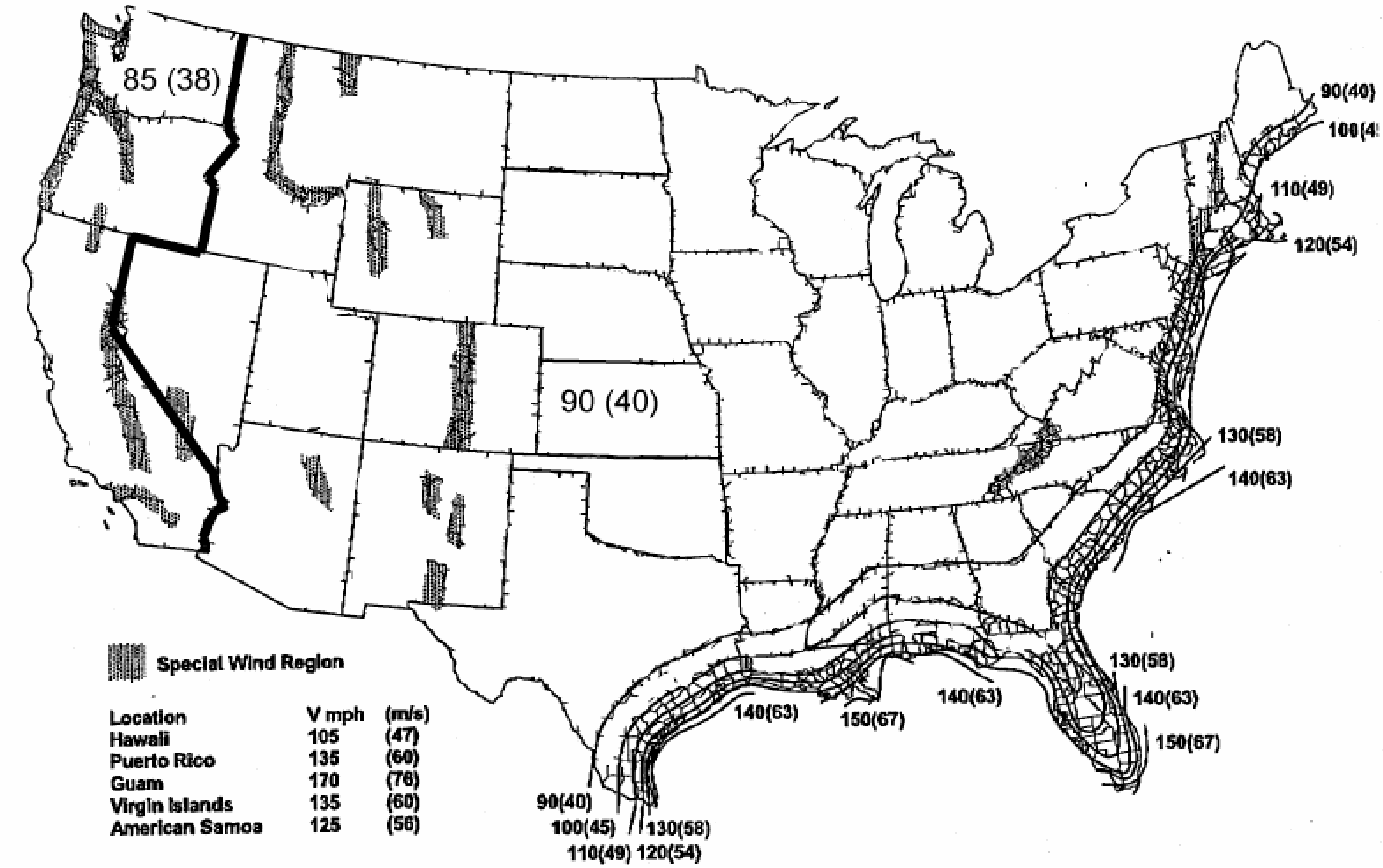


Figure 3-17. Basic Wind Speed Map (ASCE 2003)

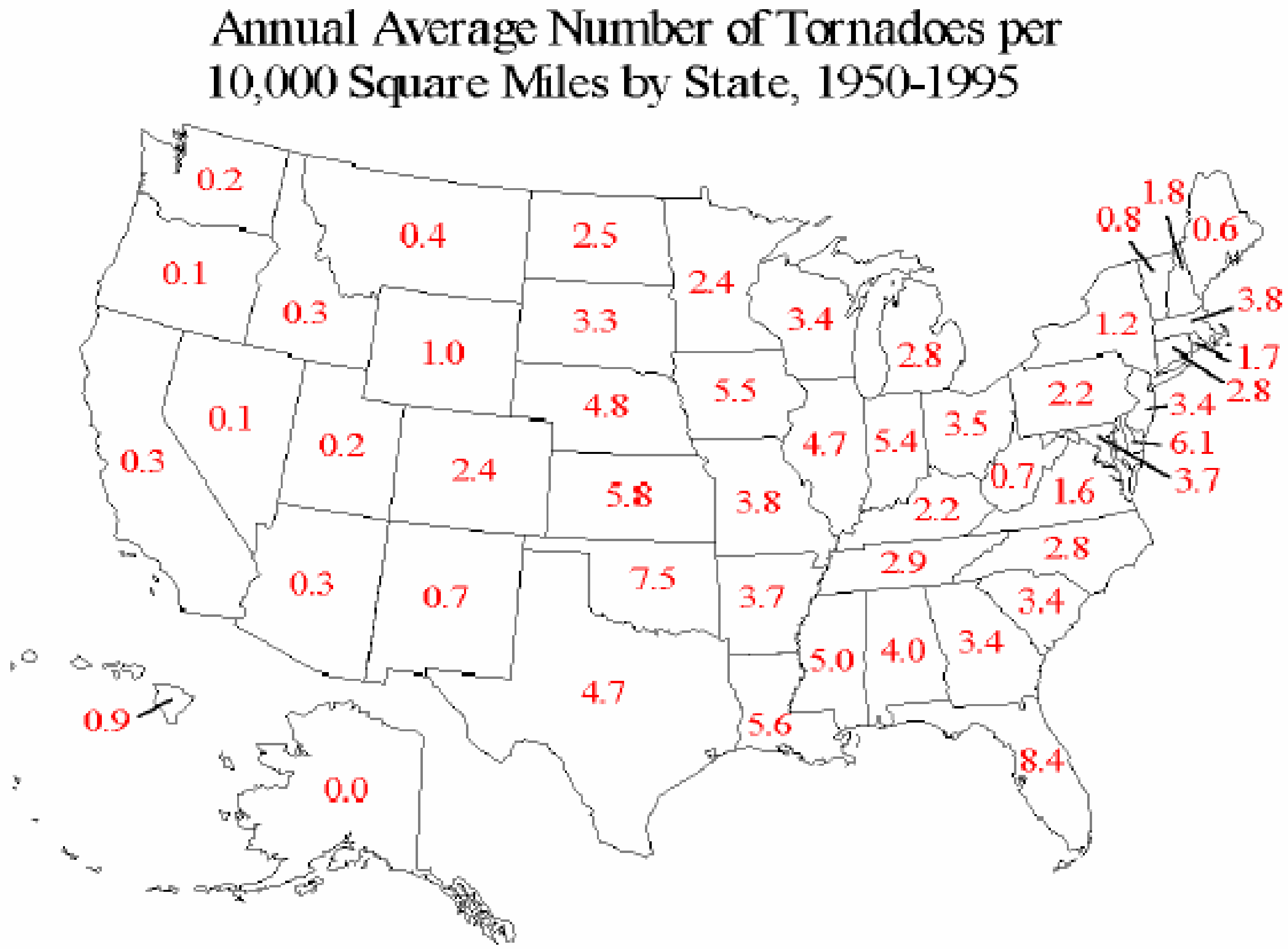


Figure 3-18. Annual Number of Tornadoes per 10,000 Square Miles, by State (NOAA 1999)

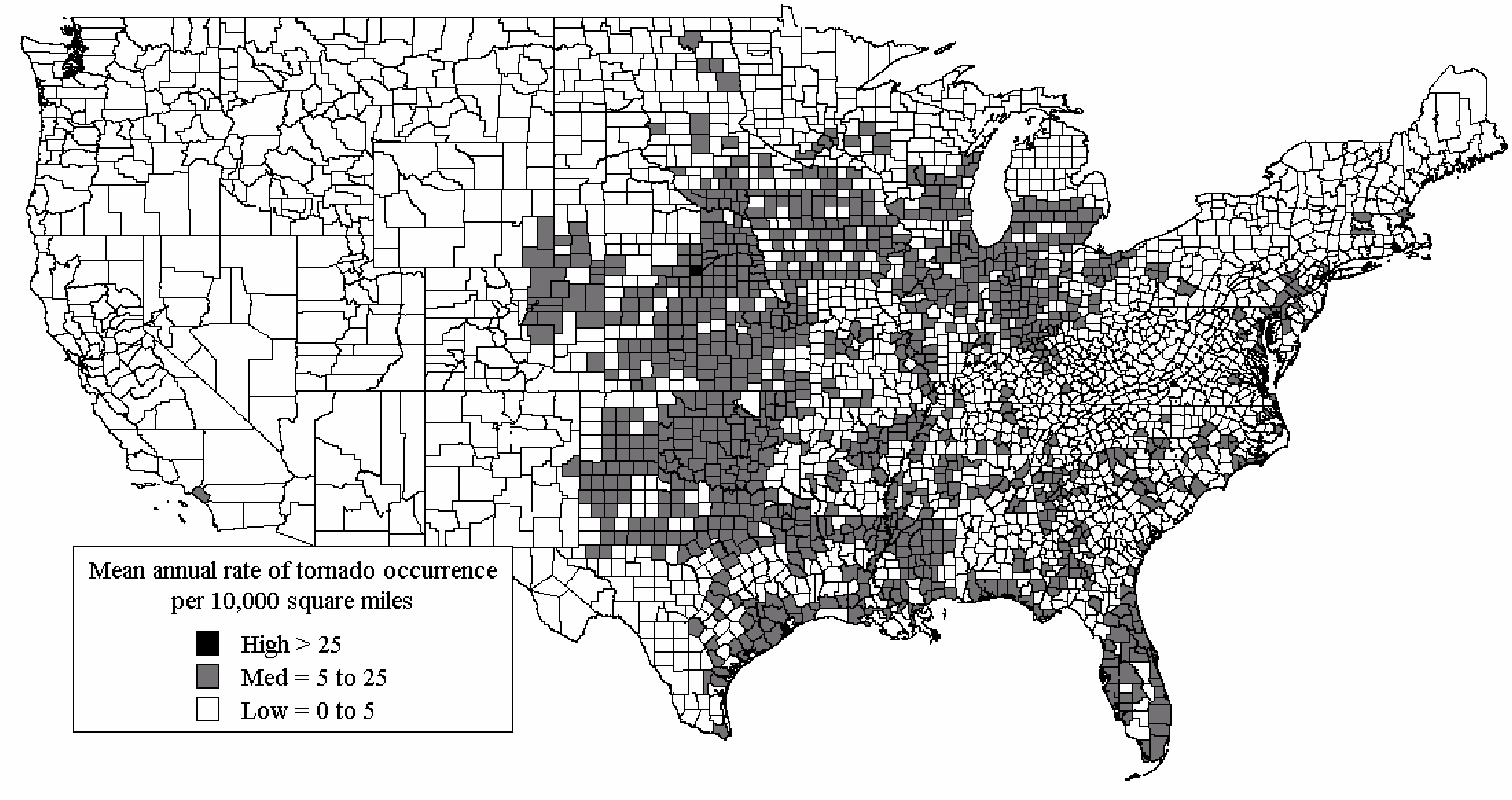


Figure 3-19. Average Annual Number of Observed Tornadoes per 10,000 sq. mi.by County

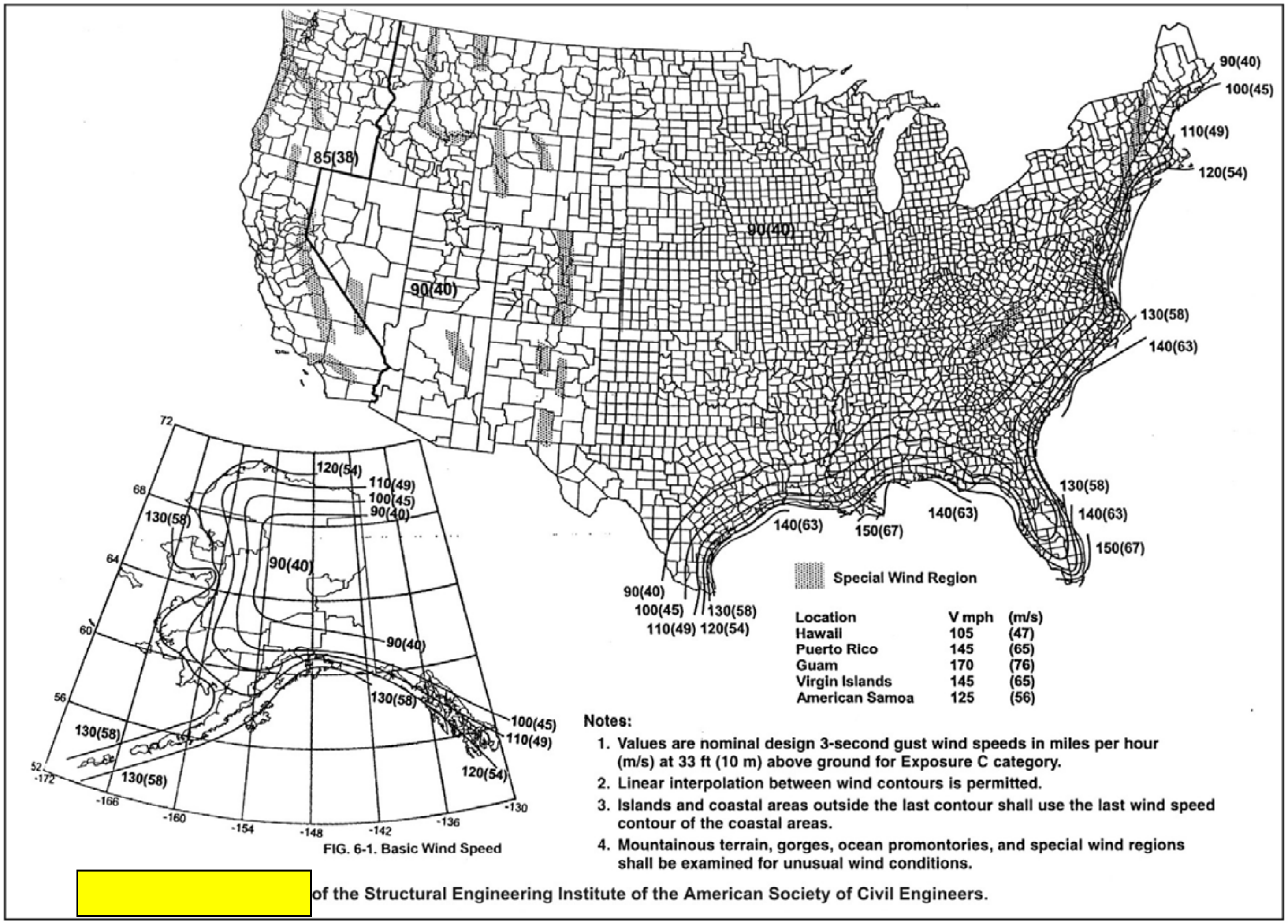


Figure 3-20: ASCE 50-year Return Period Map for Severe Wind and Hurricane Wind Gusts, 1999

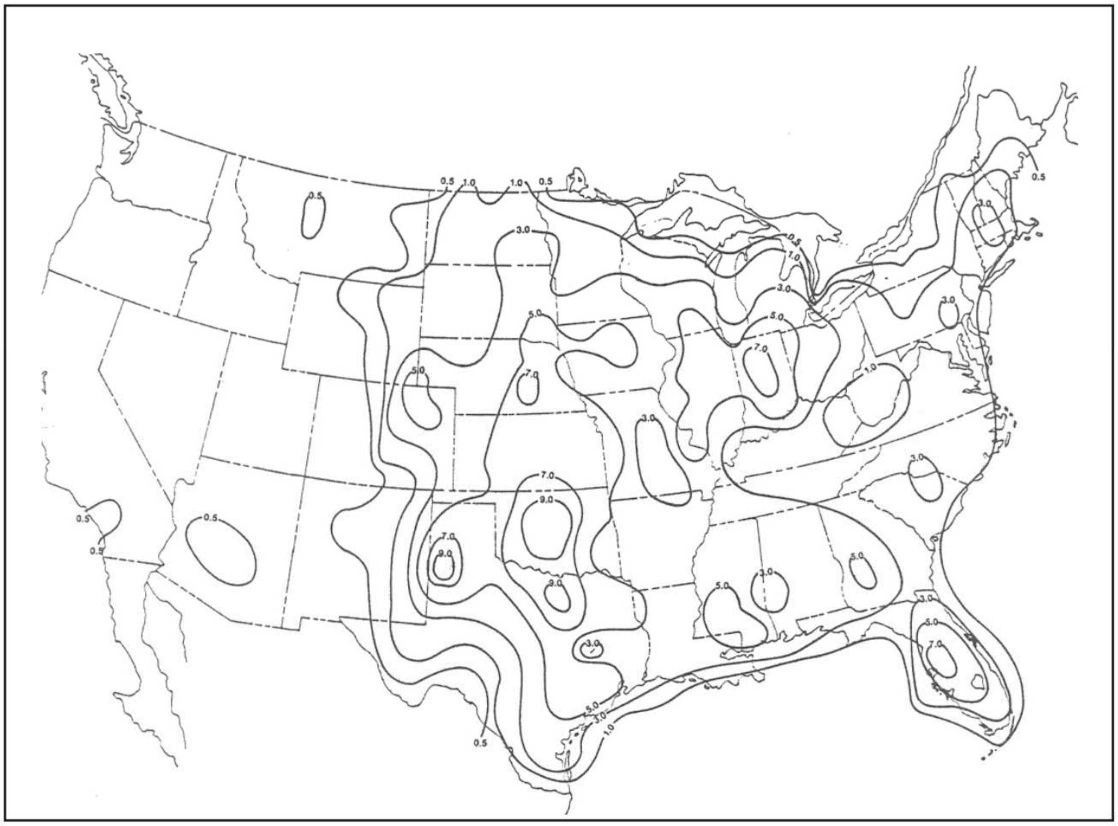


Figure 3-21: Average Annual Tornado Incidence per 10,000 square miles, 1953-1980

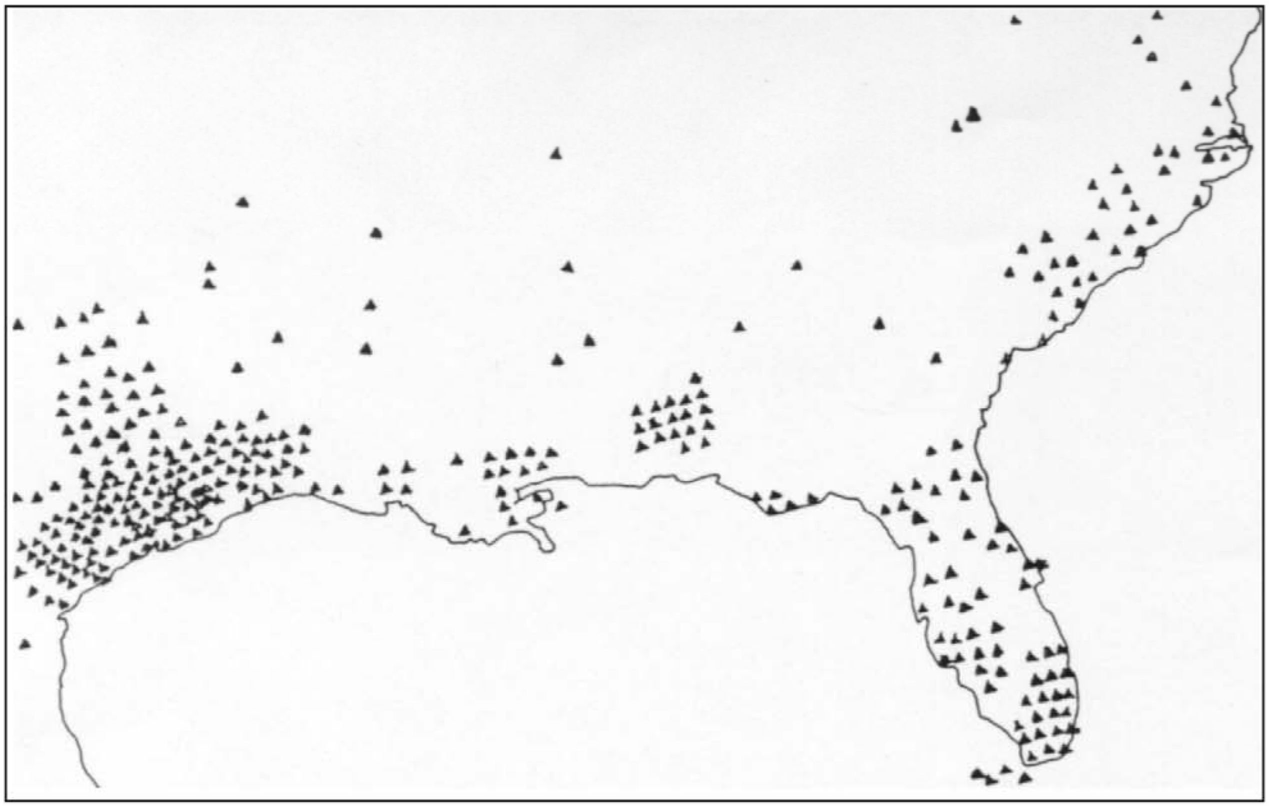


Figure 3-22: Typical Location of Tornadoes Accompanying a Hurricane

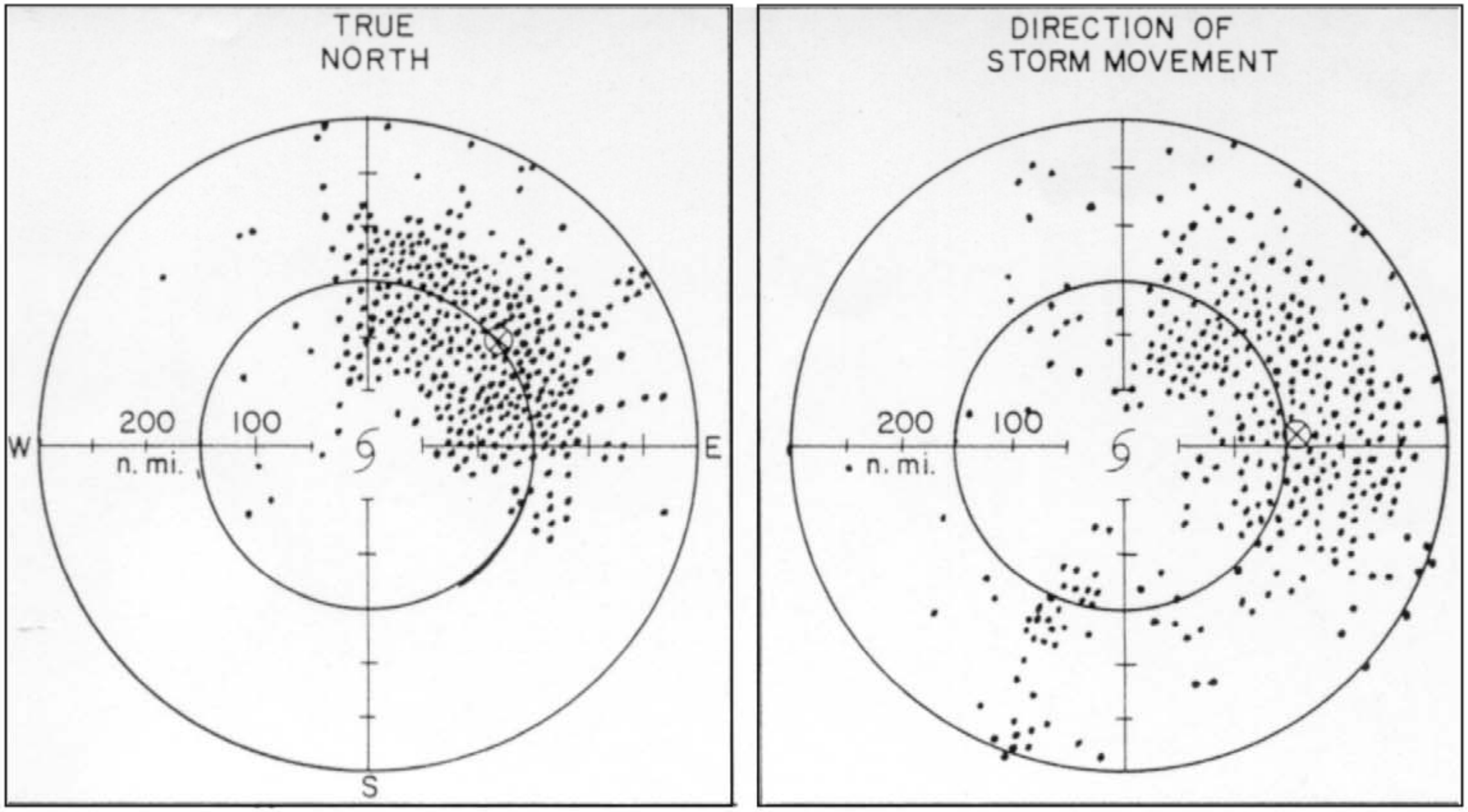


Figure 3-23: Distribution of Hurricane Tornadoes in the Hurricane Vorte

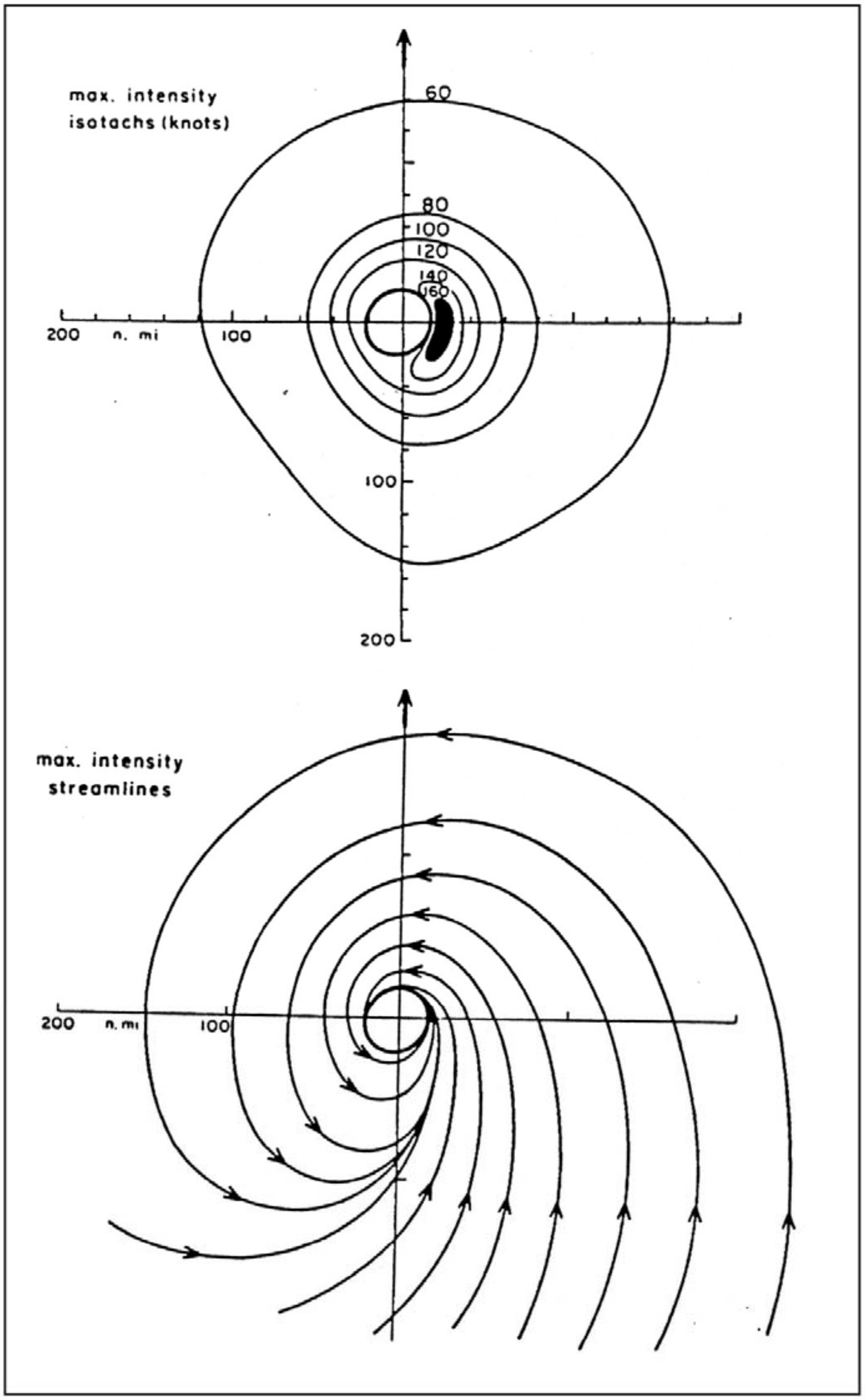


Figure 3-24: Model of Wind Speed Distribution and Streamlines for an Extreme (Cat 5) Hurricane (drawn with respect to direction of motion pointing upward)

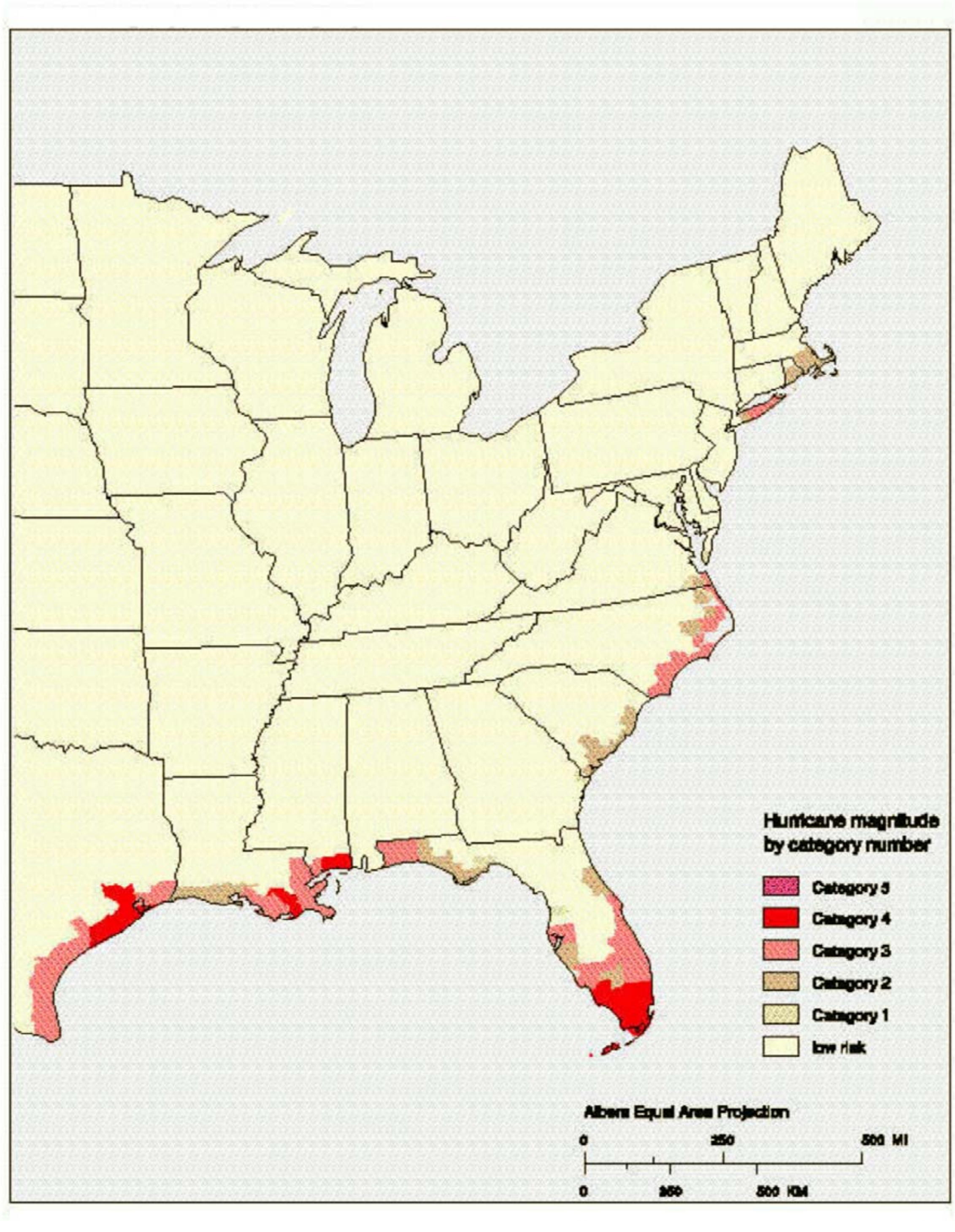


Figure 3-26: Coastal Counties and the 5% Exceedance Probability of Landfalling Hurricane (by category)

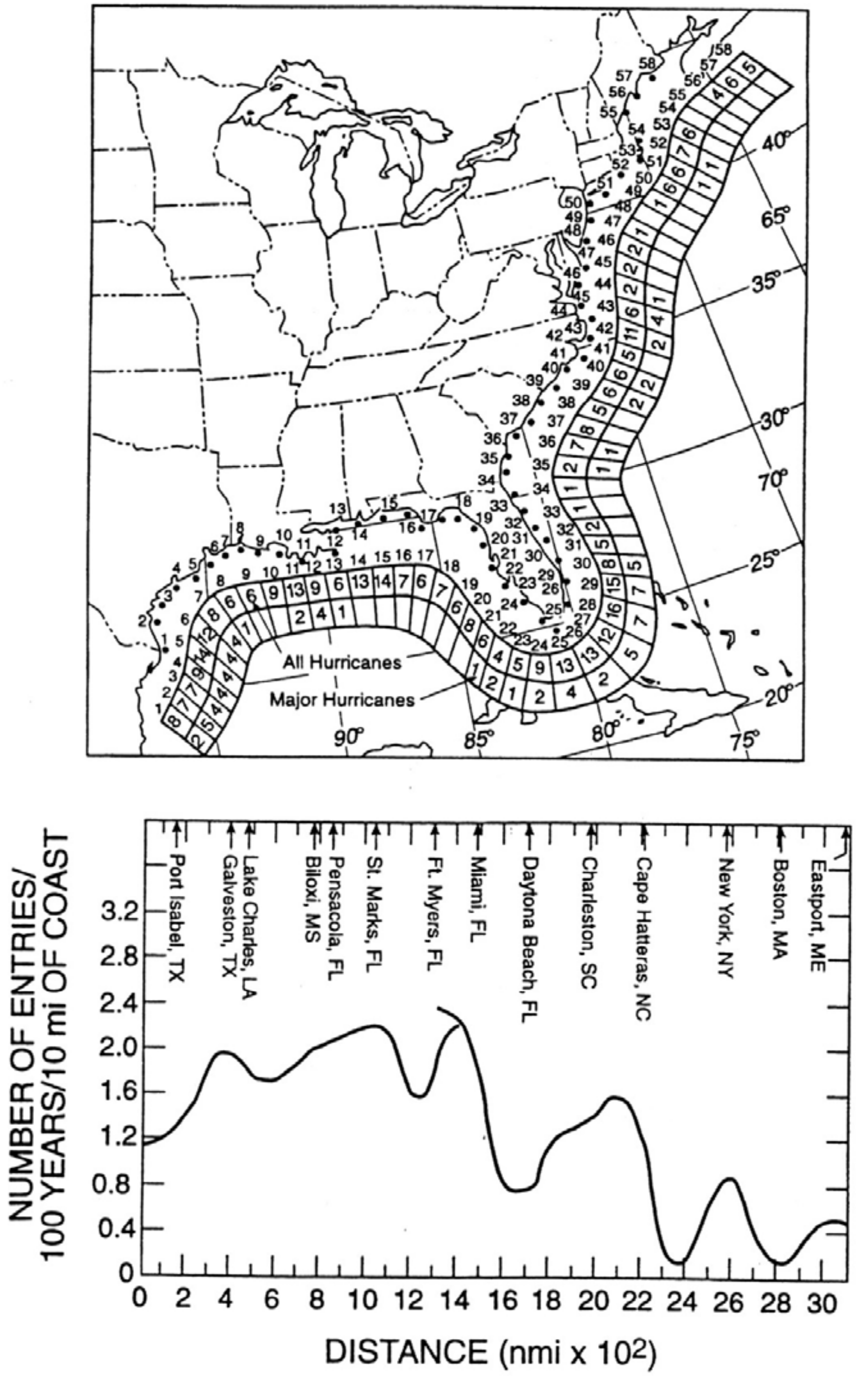
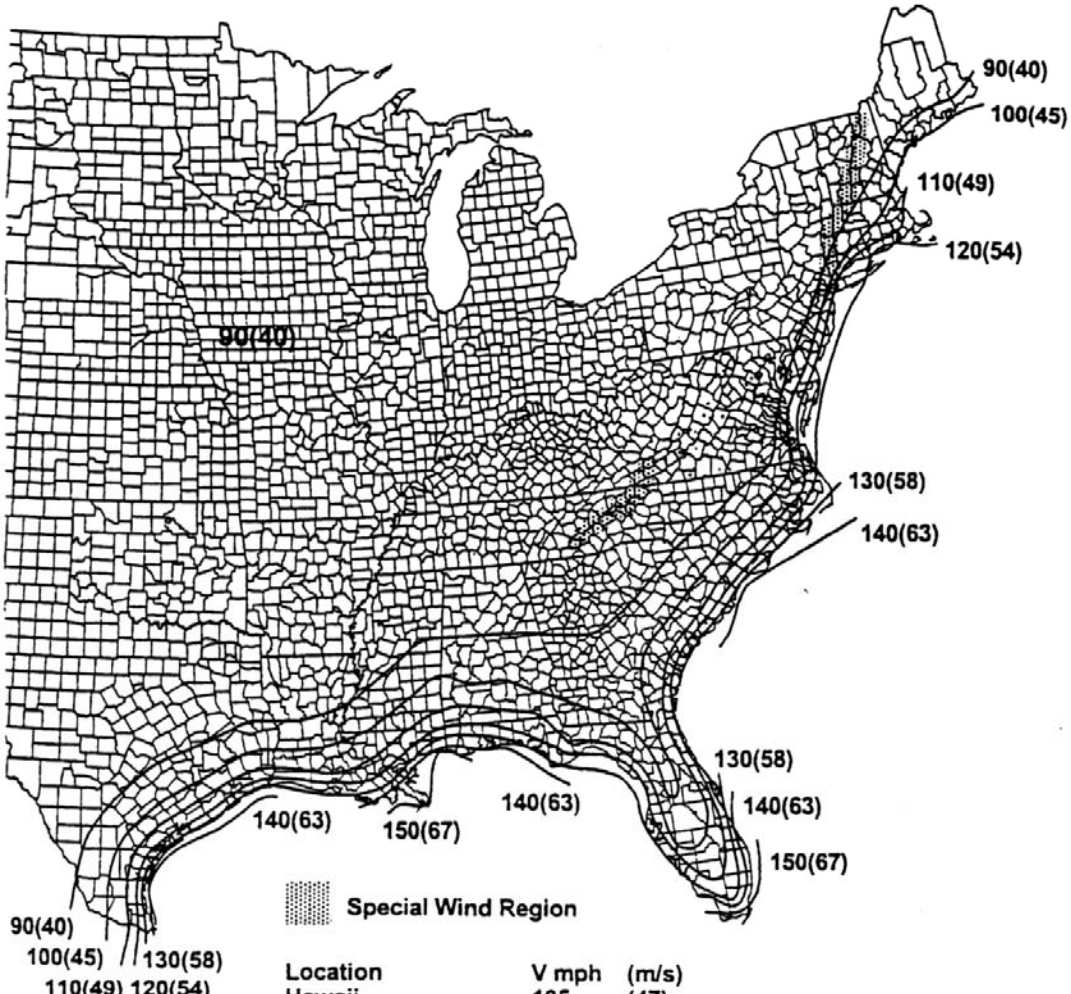


Figure 3-25: Analysis of Hurricane of Landfall Probabilities in 100+ years



Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Figure 3-27: ASCE 7-98 Gust Wind Speed Map for 50-year Return Period

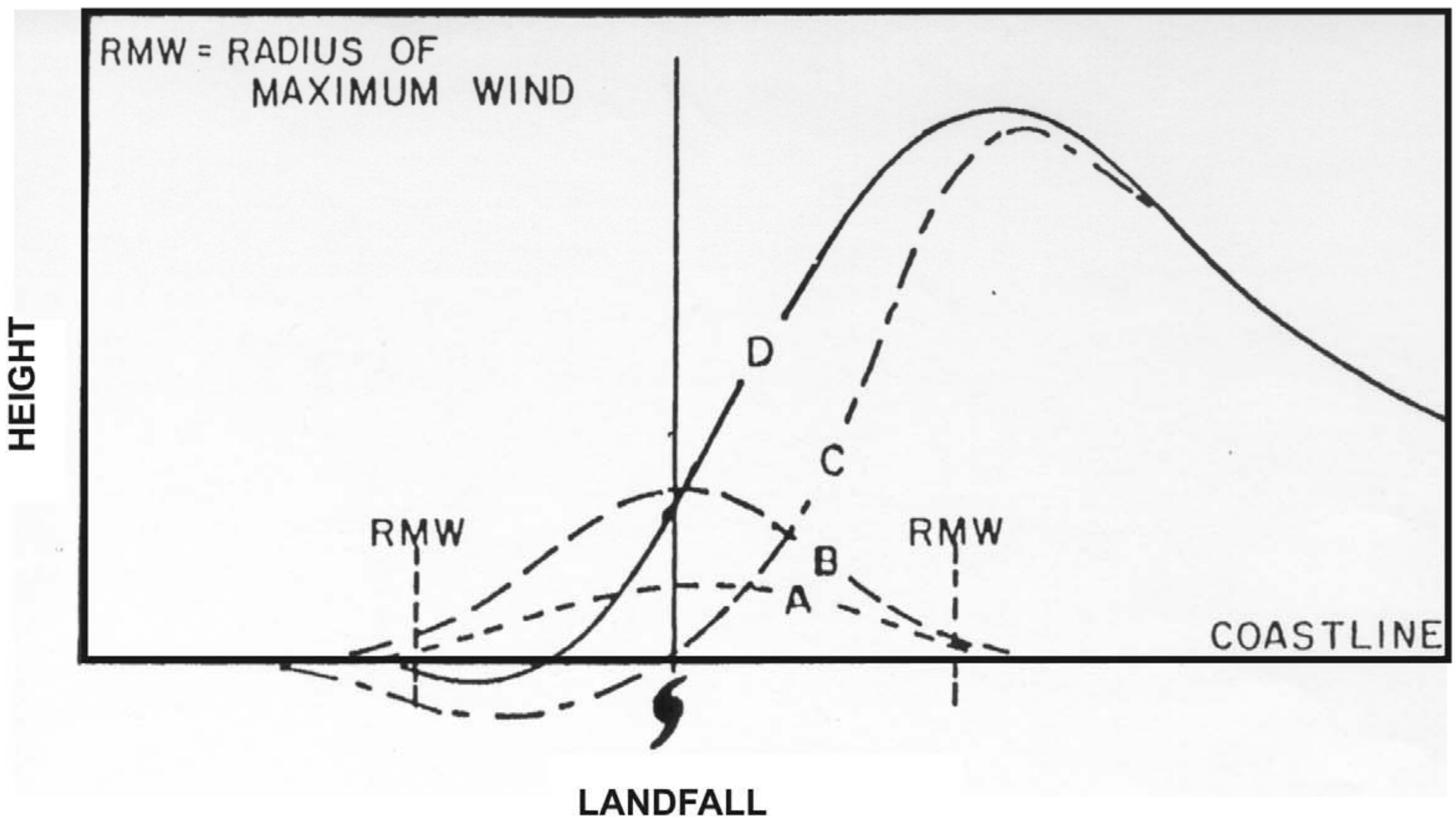


Figure3-2 8: Components of Storm Surge at a Point of Hurricane Landfall.

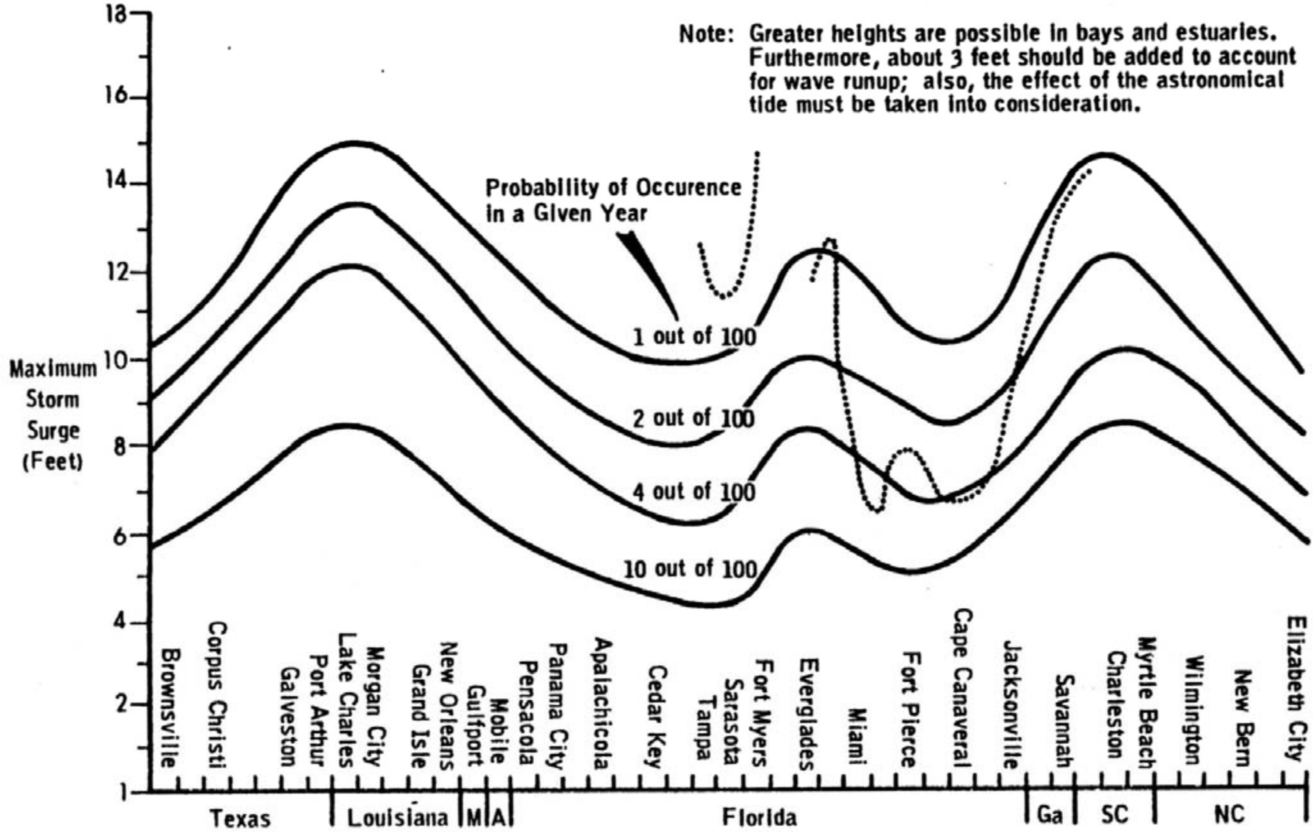
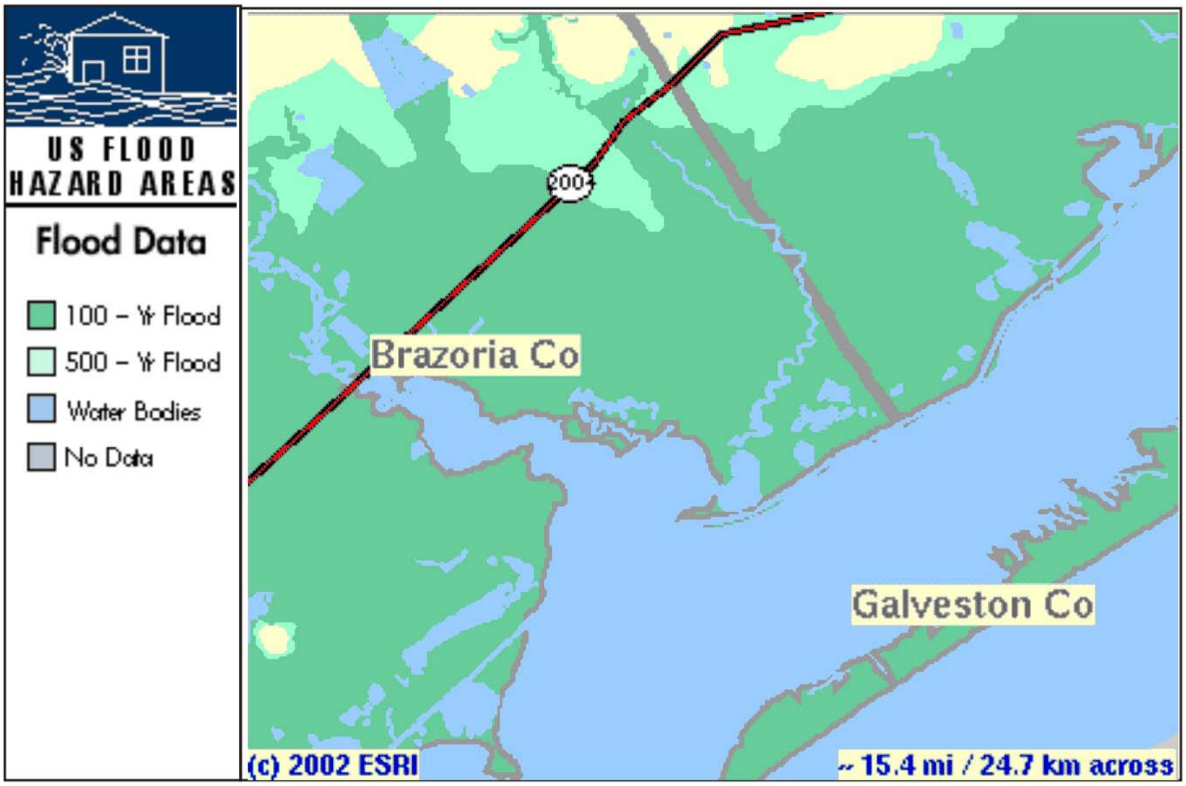


Figure 3-29: Composite Estimates of Expected Surge Height



Map Notes: The **FEMA Digital Q3 Flood Data** displayed on this Web site is developed by scanning the existing Flood Insurance Rate Map (FIRM) hardcopy and capturing a thematic overlay of flood risks. Digital Q3 Flood Data files contain only certain features from the FIRM hardcopy in effect at the time of scanning and do not replace the existing FIRM hardcopy maps. The Q3 Flood Data is being displayed here with basemap data from the GDT Dynamap/2000 data set. The Q3 Flood Data is currently available for approximately **1,200 counties** across the United States.

The maps displayed on this site should be considered an advisory tool for general hazard awareness, education, and flood plain management. The flood hazard maps displayed on this site are not the legal document to be used when making a single site flood hazard determination. For more information on these maps, please refer to the **Frequently Asked Questions** page.

Figure 3-30: Storm Surge and Headwater Flooding Extent for Brazoria County, Texas

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Figure 3-31: Storm Surge and Headwater Flooding Extent for the Miami, Florida Area

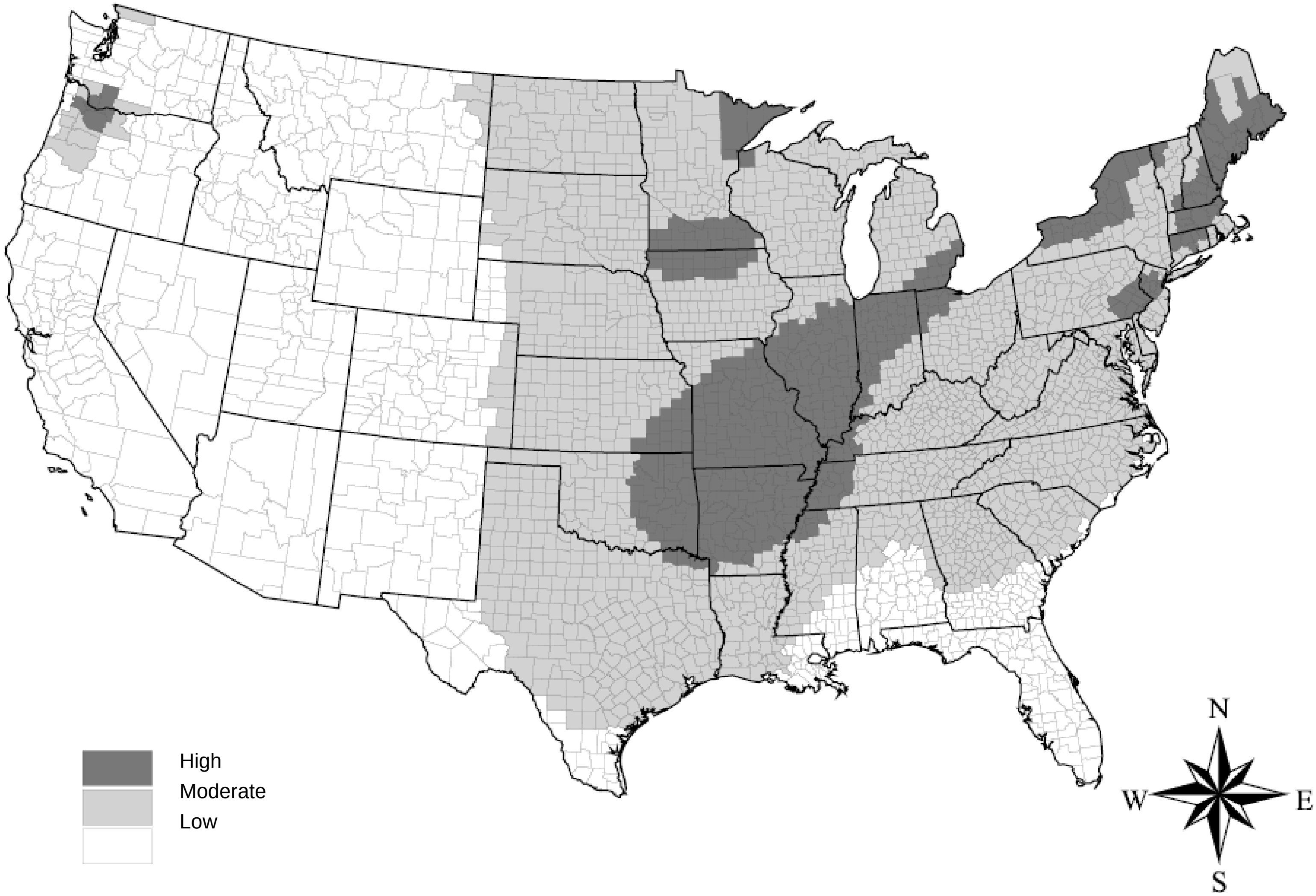


Figure 3-32. 50-Year Recurrence Interval Uniform Ice Thicknesses

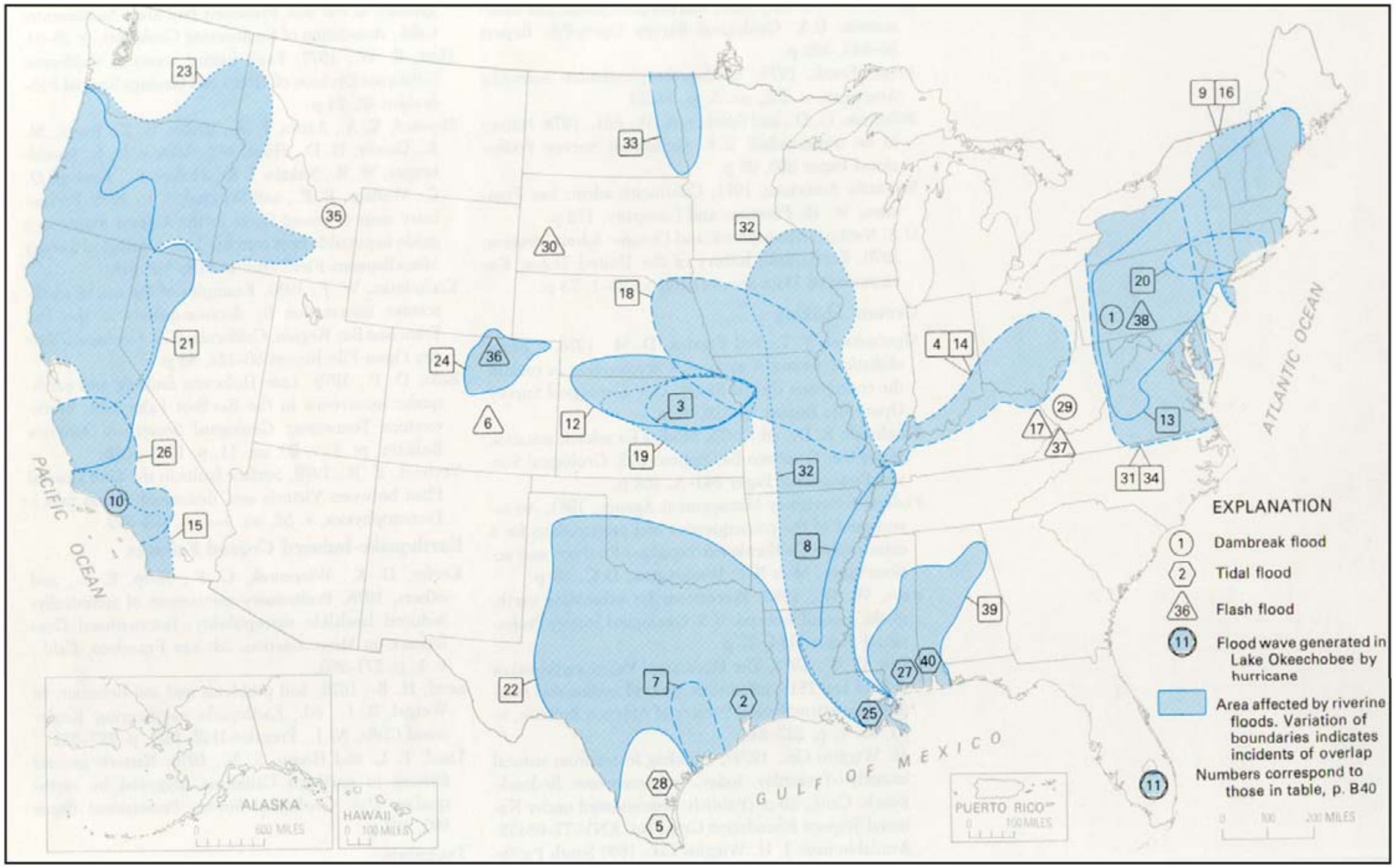
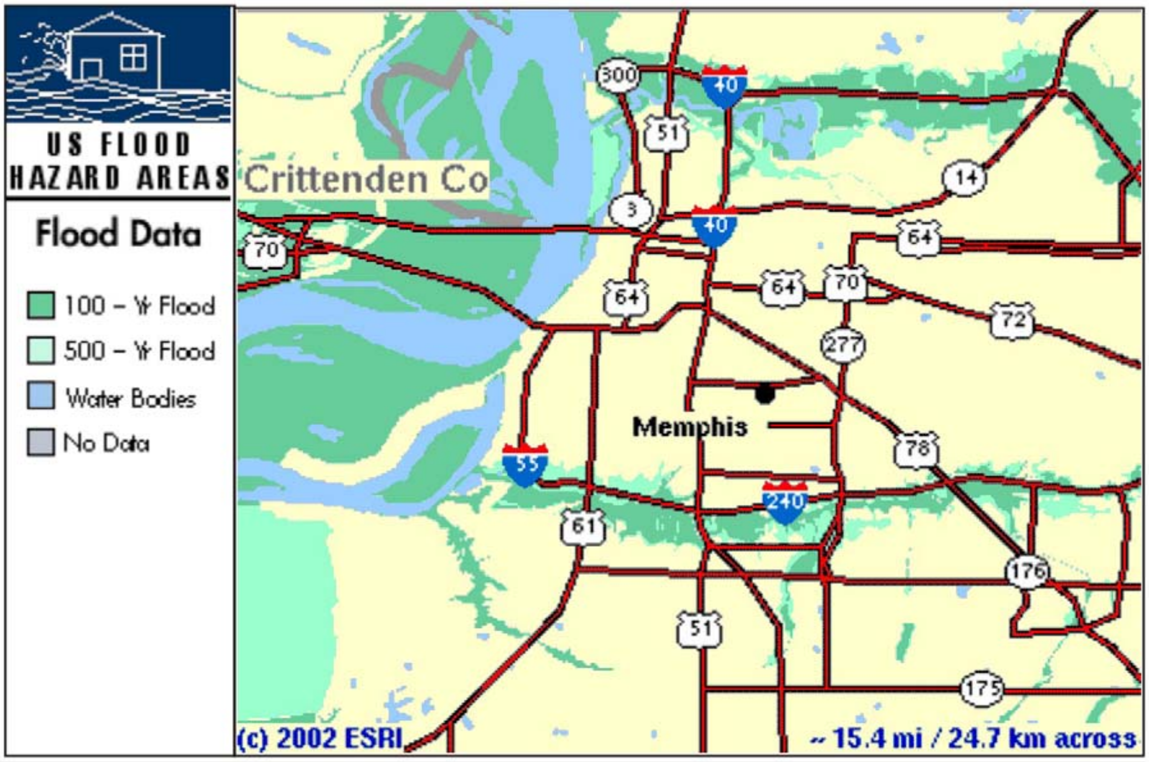


Figure 3-33: Map Showing Distribution of Great Flood Since 1889



Map Notes: The **FEMA Digital Q3 Flood Data** displayed on this Web site is developed by scanning the existing Flood Insurance Rate Map (FIRM) hardcopy and capturing a thematic overlay of flood risks. Digital Q3 Flood Data files contain only certain features from the FIRM hardcopy in effect at the time of scanning and do not replace the existing FIRM hardcopy maps. The Q3 Flood Data is being displayed here with basemap data from the GDT Dynamap/2000 data set. The Q3 Flood Data is currently available for approximately **1,200 counties** across the United States.

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Figure 3-34: Flood Hazard Area for the Memphis, Tennessee Area

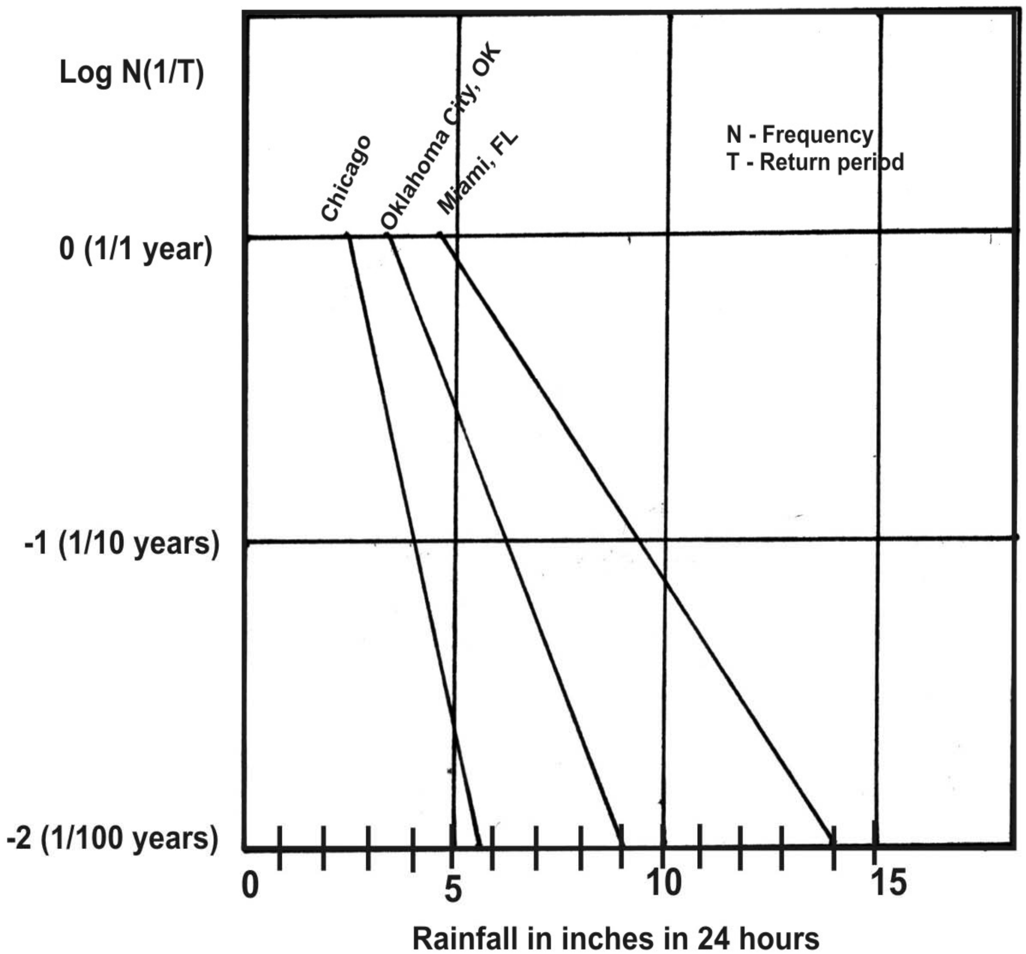

Figure 3-35: Frequency of Occurrence Versus Rainfall in 24 hours for Selected Cities

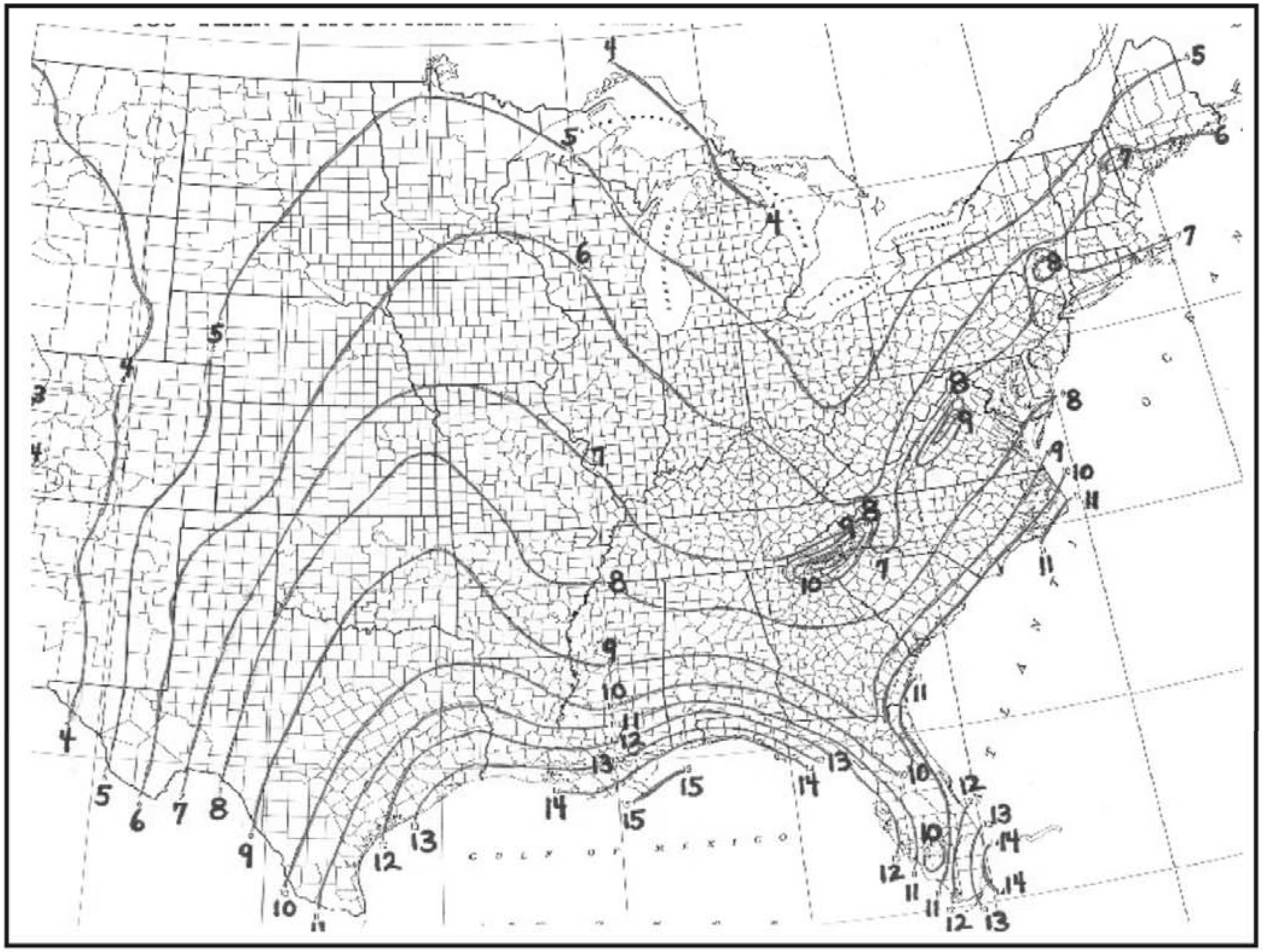

Figure 3-36: 100 year return period, 24 hour rainfall (inches)

4 - Supplemental Guidance on Assessing Potential Human Threats

This section provides additional guidance related to security vulnerability assessments, the considerations for evaluating the effectiveness of physical protection systems (such as fences and access control systems), and the vulnerabilities of cyber systems and operational systems (such as the procedures in place to respond to security breaches) are presented.

4.1 Defining Human Threat Hazard

Human threats comprise actions by an individual or individuals to inflict adverse impacts on system facilities and/or assets. Human threats are addressed separately from natural, technological and lifelines hazards in this document since such threats possess the following unique characteristics:

1. The causes that motivate a person to attack a portion of the system are not easily quantified in the way that a recurrence interval for most natural hazards can be. The evaluation needs to examine what threat is reasonable to protect against and select what the probability of attack is to be.
2. The nature of the damage caused can be significantly different from the potential damage anticipated from natural and other hazards: an attacker may attempt to introduce explosive material into the system that may subsequently detonate, for example.
3. The systems in place to reduce the vulnerabilities to human threats and enhance security are to some degree different than those for natural and other hazards. Such systems comprise physical protection, operating systems and cyber security.

In response to the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, the RAM-W methodology was developed by Sandia National Laboratories to assess human threats for water utilities. This methodology has been broadly utilized and generally accepted and is easily adapted to the assessment of water utilities. The RAM-W methodology forms the basis for the discussion in this chapter and the subsequent chapter. An additional methodology, VSAT, has also been developed for performing security vulnerability assessments of water systems. The elements and approach of the RAM-W^SM methodology are illustrated in Figure 4.1.

RAM-W utilizes the following risk equation:

$$R = P_A * (1-P_E) * C \qquad (4\text{-}1)$$

where:

R = Relative Risk (no units)

P_A = Likelihood (probability) of occurrence of the hazard/threat

P_E = System Effectiveness (subtracted from 1 equals vulnerability)

C = Consequences to the system of failure of a particular facility or component

4.1.1 Design Basis Threat

The design basis threat (DBT) is the "design criteria" for the security assessment, against which utility's current level of security will be compared. The DBT is a key element of the RAM-W[SM] methodology. It influences every parameter of RAM-W risk equation, directly impacting the assessment and final results. Potential threats to the system span a spectrum of acts, ranging for example from teenagers perpetrating acts of graffiti, through a cadre of dedicated state-sponsored terrorists with ample resources, to large military actions. Based on information furnished by local and regional law enforcement agencies, the security consultant, utility's own history of security threats and violations, a utility's preference to provide protection against a major security threat must be balanced against the understanding that the resources required to provide this protection may not be available. By consideration of these factors, the utility selects a DBT within the spectrum of possible DBTs (as illustrated in Table 4.1), as a starting point for the assessment of current security vulnerability, and the determination of possible improvements. Like any design process, the RAM-W methodology encourages a re-examination of the DBT, based on the outcome achieved from the initial starting point.

Defining the DBT has a five-fold purpose:

- The DBT reduces the terrorist spectrum to a manageable size and characterizing the threat to which utility may be conceivably exposed ("what is the threat?").
- The DBT reduces the broad field of potential adversarial actions that could conceivably be perpetrated against utility to quantifiable threats against which utility can reasonably defend itself **("**what is the threat against which utility can reasonably design its system, both physical and operational, to defend against?"); keeps this metric in the forefront throughout the analytical process.
- The DBT provides the basis for developing tailored physical, operating, and cyber procedures and countermeasures to reduce utility vulnerability.
- The DBT ensures senior management concurrence upon and support of the design basis.

In addition to understanding the DBT's purpose, it is important to recognize how the DBT is developed. The flow diagram depicted in Figure 4.2 illustrates the steps in the process and key constraints, including the existence of threats from which utility will not be able to protect itself, and resource limitations (time, dollars, personnel, political sensitivities).

As part of analyzing human threats, it is helpful to distinguish between three broad and generally accepted classifications of threat:

Outsider: an individual/group with no direct or indirect affiliation to the utility,

Insider: an employee, contract person, or other individual who has some degree of access to the utility, and

Cyber: an individual/group that poses a threat to system operation and/or utility functions via computer interfaces.

Each of these threat categories can possess some differences in characteristics with respect to motivation, access to facilities, knowledge of the system, tactics and others, and thus warrant separate examination. Table C.5.8 illustrates characterizes different levels of threat within each category.

Within each DBT classification, a number of sub-category threats are developed and each is scrutinized on the basis of *access*, *motive*, and *opportunity*. The process is iterative, incorporates multiple forms of information collection, and entails detailed characterization of threat capabilities. Site surveys and meetings with LEA bolster initial analyses of the DBT developed on the basis of the threat assessment. The DBT development process explores a broad adversarial spectrum and focuses on potential exploitation of both systemic and site-specific vulnerabilities. The spectrum is systematically reduced and culminates with the selection of a single generic profile for each classification (*outsider*, *insider*, and *cyber*). Indicative of its import, the DBT is briefed to and receives utility senior management endorsement before the RAM-W assessment continues.

The following is an example DBT.

- **OUTSIDER**: Three to four individuals of a small, largely unsupported and independent activist or loosely federated terrorist cell with minimal formal training in small unit operations; minimal training in water system design or operations; access to vehicles; capable of obtaining and operating heavy construction equipment; limited access to small arms; ability to assemble rudimentary improvised explosive devices; effective basic surveillance; very limited financial resources; and no insider collusion. The goal of the group is to disrupt normal operations.
- **INSIDER**: One disgruntled employee or contractor with basic knowledge of, and access to, the water system, system operation, and system controls. The goal of the insider is to inflict non-injury disruption of services to achieve personal vengeance against an employee.
- **CYBER:** A hacker with ability to compromise a SCADA system if access is gained without collusion. The intent is to disrupt utility services or cause damage in order to cause public loss of confidence or cause third-party consequential damages.

The RAM-W methodology assumes that the likelihood of attack should be seen as certain, which therefore influences the choice of the DBT – in effect, the choice of the DBT is based on an assumed eventual attack. However, if utility is alerted at some time that a threat exceeding their DBT may exist, the threat can be subsequently mitigated by emergency planning and pre-planned ad-hoc operational measures. Utility's emergency operations plan should include this potentiality.

4.1.2 Uncertainty of Probability of Attack

The likelihood of occurrence of a terrorist attack on utility facilities is very difficult to quantify. Unlike natural disasters which can be analyzed and probabilities of occurrence developed based on historical data and engineering principals, terrorism by its very nature and definition defies a reasonable level of predictability. While the relevance of the probability of attack, P_A, in analyzing risk is generally accepted, quantifying P_A is the subject of much debate. Relative to the analytical process outlined in Figure 4.3 it is generally contended that:

- The probability of a terrorist attack cannot be measured.
- The measure of effectiveness for deterrence of a terrorist attack cannot be gauged.

When focusing internally on the utility system and facilities, the likelihood of an attack on one part of the system versus another is extremely difficult to differentiate. For this reason, the probability of attack is assigned a value of 1.0. Regardless of the value assigned, other variables in the analytical process are sufficient to complete the assessment; these remain the principal variables that utility can influence: the reduction of vulnerability.

This is not to imply that deterrence does not have its place. Proactive deterrent measures can have significant impact on overall security. As an example, surveillance of a potential target is standard procedure for terrorists; if their surveillance reveals a well guarded, relatively hardened facility with alert personnel, they are far more likely to select a comparable target that is more vulnerable. The difficulty arises in measuring the effectiveness of deterrence.

Currently, there are no readily available means to accurately characterize the probability or likelihood of a state-sponsored terrorist attack. To the extent that national authorities gain such knowledge, it is highly classified. Continuing down the threat spectrum, through domestic terrorism, to disgruntled employees, to immature individuals, the likelihood for attack in general increases. The factors that influence the probability of attack can be effectively examined by utilizing an assessment tool termed CARVER. CARVER is an acronym that stands for:

- **C**riticality
- **A**ccessibility
- **R**ecuperability
- **V**ulnerability
- **E**ffect on Populace
- **R**ecognizability

The relative value of an attack determined through the CARVER methodology reflects the "targetability" of the system being examined. A higher number indicates a more "desirable" target; a lower number indicates a less desirable the target from the assailant's perspective. A potential target is rated on scale of *1-5*, with lower numbers being less desirable.

FEMA 426 has recently published a document entitled *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* (http://www.fema.gov/fima/rmsp426.shtm) that provides generalized information on assessing the potential for an attack. Much more information specifically on assessing the vulnerability of water systems to human threats can be obtained from the EPA at http://cfpub.epa.gov/safewater/watersecurity/index.cfm.

A highly pragmatic approach to estimating the probability of an attack on a water system may suggest that the actual likelihood is relatively low. If one assumes there are 400 large water treatment utilities in the US and that one significant attack will be conducted at a large utility every five years hence (an attack in which the system overall is significantly disabled), the average return period for an attack on any given large facility is 2,000 years. A similar estimation can be calculated for moderately sized utilities. If one assumes there are 8,000 medium and small utilities in the US, the return period, based on the same assumptions above, is 40,000 years. Return periods of these magnitudes represent extremely rare events, and help to put the actual expected likelihood of an attack into perspective. While much more in-depth theoretical discussion surrounds this issue, in the interests of providing reasonable and prudent recommendations, assigning a probability of attack of 1.0 is recommended.

4.2 Vulnerability to Human Threats

As part of discussions among the members of the vulnerability assessment team, an inventory should be developed to identify all facilities that contribute to the normal functioning of water system. Such facilities will typically consist of the following:

- Storage facilities
- Treatment and pumping facilities
- Transmission and distribution system(s)
- Maintenance facilities
- Administration offices

The identification of critical facilities typically does not provide enough information to proceed with the security vulnerability assessment. In reality, there are often key assets within each facility that, as a single point of failure, can significantly impair the system mission. Thus, a more detailed assessment of the key facilities is required, both to confirm the criticality of the facilities, and to identify if there are only a few assets, rather than the entire facility, which actually need to be protected.

4.2.1 Effectiveness of Physical Security Systems

A brief discussion of the relationship between the four elements of security—deter / detect / delay / and respond—will assist in understanding the assessment of the security effectiveness. A security system that lacks sufficient balance between these four elements is not sound. Two examples clearly demonstrate this: a state-of-the-art detection system with moderate-to-good delay features but only marginal response capabilities, or an excellent response service complemented by a viable delay system but poor detection. In the first case, the terrorist action may be detected but there is no mechanism for effective interdiction; in the latter, the response force is capable of responding quickly, but there is insufficient detection. In either case, security is compromised despite strong unilateral elements within the system.

Figure 4.4 depicts the relationships and interdependencies well. In virtually every example except a suicide mission, if $T_C > T_I$ the terrorist activity can be interdicted. If $T_C < T_I$—whether due to inadequate detection, delay, or response—the terrorist will succeed.

Table 4-1. Characterization of Potential Human Threats

[In the Prob (Probability) Column, VH=very high, H=high, M=medium, L=low, L-VL=low to very low, and VL=very low],

Prob	Adversary	Motivation	Examples	No. of Persons	Equipment	Knowlege	Weapons	Tactics
OUTSIDER								
VH	Immature	Showing off, boredom	Graffiti	1 to 3	Car, paint, tools of opportunity	None	None	None
H	Vandal or Vagrant	Showing off, boredom	Property damage, attack employee	1 to 2	Car, tools	None	None	Minimal pre-planning, opportunistic, generally non-force entry, defile and run
M	Criminal	Profit, revenge, spousal, irrate rate payer	Attack employee or property	1 to 4	Car, tools	Surveillance or collusion	Small arms	Assault, coercion, hostage, sabotage, multiple vehicles
M	Disgruntled	Revenge, spousal, union issue, irrate rate payer, “savior”	Attack employee or property	1	Car, tools	Surveillance, unwitting employee	Small arms	Assault, coercion, hostage, sabotage
L	Sociopath	Pathological	Damage major equipment, poison supply	1	Car	Limited	Small arms	None
L – VL	Domestic Terrorist	Political, social cause	Major system disruption, destroy sources or system	1 to 15	Car, radios, surveillance equipment, tactical gear	System study, rudimentary military training	Small arms, heavier weapons, home-made explosives	Sabotage, collusion
VL	International Terrorist	Political, religious, ethnic	Major system disruption, destroy sources or system, poison supply	Possibly multiple 1 to 3 person cells operating independently	Simple tools, on-site heavy equipment, car, radios, surveillance equipment	Limited technical knowledge or tactical training	Small arms, explosives	Sabotage of relatively accessible sites, some willing to sacrifice life, look for easiest target for objectives, seek highest casualties, patient
INSIDER								
M	Administrative personnel	Disgruntled, termination, spousal, collusion, union issues, “savior”	Threats, property damage, disrupt record keeping, attack personnel	1	Car, tools, computer	Administrative system, policies, procedures	None	Sabotage, capitalize on access
M	Information technologist, data processor	Disgruntled, termination, spousal, collusion, union issues, “savior”	Threats, property damage, disrupt service, attack personnel	1	Car, tools, SCADA, security system interface	IT systems, policies, procedures	None	Sabotage, capitalize on access
M	Operations planner, watch stander	Disgruntled, termination, spousal, collusion, union issues, “savior”	Threats, property damage, disrupt service, attack personnel	1	Car, tools, SCADA, sampling	System, policies, procedures	None	Sabotage, capitalize on access
M	Maintenance personnel	Disgruntled, termination, spousal, collusion, union issues, “savior”	Threats, property damage, disrupt service, attack personnel	1	Car, tools, heavy equipment	System, policies, procedures	None	Sabotage, capitalize on access
M	Contractor	Disgruntled, termination, spousal, collusion, “savior”	Threats, property damage, disrupt service, attack personnel	1	Car, tools, security system	System	Small arms	Sabotage, capitalize on access
VL	Terrorist	Political, religious, ethnic	Destroy sources or system, poison supply	1	Car, tools	System, policies, procedures	Small arms, explosives	Sabotage, capitalize on access, fatalities
CYBER								
H	Amateur	Opportunity, challenge	Disrupt e-mail, denial of service, deface website	1	Computer, internet access, hacking software	None	None	Internet penetration, hacker virus, e-mail attachments
M	Expert hacker(s)	Challenge, disgruntled	Cyber intrusion into SCADA, billing, administrative services to disrupt or destroy data.	1 to 4	Computer, internet access, hacking software	None	None	Internet penetration accessing SCADA, billing, alarms, etc.
L	Cyber insider or vendor	Disgruntled, termination, spousal, collusion, “savior”	Cyber intrusion into SCADA, billing, administrative services to disrupt or destroy data.	1	Computer, internet access, hacking software, internal computer, virus software	SCADA and internal administration	None	Internet penetration accessing SCADA, billing, alarms, etc.
VL	Terrorist	Political, religious, ethnic	Cyber intrusion into SCADA, billing, administrative services to disrupt or destroy data, cause loss of life	1 to 10	Sophisticated computer, high-speed internet access, hacking software, internal computer, virus software	None	None	Internet penetration accessing SCADA, billing, alarms, etc.

It is typically unrealistic to presume that sufficient private security personnel can be maintained 24/7 to respond adequately to intrusion alarms across the system, or that public law enforcement agencies will be able to respond in sufficient time to disrupt a perpetrator. A far more responsible and realistic approach is to design a system that determines if sabotage is imminent or might have occurred and takes measures to minimize risk to the public and environment. This can only be accomplished through integration of physical protection systems (PPSs) and operating systems (OSs). PPSs are the physical elements of a security system and OSs are the operational elements. Assessing the vulnerability of each of these, as well as the vulnerability of cyber systems (which have PPS and OS elements) will be addressed in the following subsections.

4.2.1.1 Access Control

Too frequently, access control is viewed as only controlling physical access to operational facilities. In fact, access control applies to every form of access to include physical plants; transmission and distribution systems; supporting services; SCADA and IT systems; administration; intellectual property; and any other aspect of the utility wherein unfettered access could lead to a compromise of security.

Standard unmanned personnel access control systems include cipher locks, electronic recognition, biometrics, or combination of these mechanisms; all can provide a tracking, cataloging, and multi-level control capability. All have some *deterrent* value, limited *detection* capability, and varying *delay* value. Each affords a degree of effectiveness and the cost of installing and maintaining can vary significantly from system to system. For example, cipher locks are relatively easily compromised by poor code security (individual or systemic shortcomings); electronic recognition comes in various forms and provides greater overall access control than cipher locks; biometrics provide even greater control and are the most difficult to defeat. Because biometrics cannot be lost, stolen, or shared, they provide a higher level of security than badges and/or access cards.

One important element to designing an effective access control architecture is maintaining defense-in-depth without making it overly intrusive on operations. A system-wide standard controlling access to general facilities can be augmented by an additional, more strenuous control system around critical elements.[3]

Manned access control typically encompasses gate guards or closed-circuit television (CCTV)[4] and remotely controlled access (receptionist, guard, system operator). The access system must provide for granting access to non-card-carrying personnel. This is most easily accomplished by integrating CCTV camera and remote control features to allow a designated the utility employee (generally, the receptionist) to positively identify the visitor and his vehicle and then remotely trigger access through the designated visitor gate/door. This integrated system is referred to as the ***entry-access CCTV***. It is important to note that systems that include a human interface can be either more or less effective than non-human systems; their effectiveness being largely

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[3] For example: access to the administrative office could be controlled by electronic card reader while access to the SCADA network, IT servers, and motor pool would require additional, more restrictive access control in the form of a "higher" card authorization or a secondary system (biometric).

[4] This CCTV system is separate from intrusion detection CCTV systems. It allows the individual monitoring to visually confirm visitors before granting them admittance to a facility.

dependent on the professionalism of the responsible individual(s). Additionally, the resources required to sustain an effective manned system are not insignificant.

Access control systems can vary significantly in size, complexity, and application. Their employment can be as narrow as preventing unauthorized access to the most restricted areas or as expansive as a company-wide, graduated system that regulates and monitors the comings and goings of all employees and visitors. Over-reliance on a particular hardware (e.g., CCTV, padlocks, fencing) can seriously skew the *deter/detect/delay/respond* balance and weaken overall security system effectiveness. Response to attempted intrusions can run the gamut: local warnings or alarms, system lock down, revocation of access, or any number of other reactive measures. Caution must be exercised to prevent such systems from being administratively burdensome and operationally intrusive. Care should also be taken to configure the system to meet the user's current and longer-term needs. Access control system design and implementation must weigh life cycle security, operations, maintenance, safety, cost, and personnel vetting considerations.

A graduated access control system provides the highest level of security and includes a number of advantages:

- Definitive access authorized and controlled by system manager.
- Designed on the basis of need and clearance to control personnel, vehicular, and systems access controlled via levels or zones
- Integrates well into administrative and/or IT systems.
- Can provide "real time" as well as archival alerts and documentation.
- Can be expanded to meet corporate growth.
- Expeditious cancellation of access in event of employee termination, loss of badge, or other form of potential compromise.
- Relative ease of implementation and management.
- Badges provide a visible as well as electronic form of access verification.
- Avoids single point of failure within access control system.

If level/zone control is to be implemented, authorization/access standards and protocols should be jointly developed by a team of the utility management, operations, and administration representatives to determine (1) which areas should be afforded higher access control and (2) who—by position—should have access to what. Zone access should be determined on the basis of two criteria: an individual's (1) *authorization* to have access to an area/system and (2) his *need* to actually gain access to the area. As an example, senior management may be authorized to have access to all areas and systems, but unless a senior individual needs access to an area/system (specifically those listed below), it may be more appropriate to limit that manager's access to "escort required" or "pre-approval by controlling authority" status. Access cards should be electronically and visually coded so that both card readers and other employees can determine "at a glance" an individual's authorization to be in a restricted area and regulate access. A careful balance must be achieved between insufficient access control to sensitive areas and overly limiting access and disrupting operations.

At a number of sites, multiple entities (e.g., landscapers/maintenance) have access. These represent a complication to effective access control. In order to maintain a balance between effective security and unduly impeding operations of both the utility and the organizations requiring access, an accommodation must be reached. The use of padlocks and lockboxes affords little effective access control, particularly given the typical ubiquity of keys and lack of a key control system. While emergency access is a consideration in some cases, the vast majority of access is administrative. Extending a badge access control to these other entities may be impractical and a potential administrative nightmare. Furthermore, some sites are not readily adaptable to electronic access control systems. To maintain effective access control under these conditions short of revoking site access, a utility has a number of options, several of which are listed below.

- Require either check-in/out of a utility-controlled key or digital access control.
- Require admittance and lock-up through coordination with a roving utility unit.
- Establish and remotely control electronic locks on gates to the sites.
- Allow limited distribution of access keys and employ incentives/penalties if entities do not follow prescribed entry/lock-up procedures (the principal ones being advance notification of entry and notification of lock-up).
- Institute a more effective and tightly controlled lockbox program.

It is impractical to place access controls on every entrance portal and gate at every facility. A combination of regulated access points, remote alarms, and local sensor and alarms can reasonably ensure security integrity. Technology should be supplemented by procedures prescribed in the utility Emergency Action Plans governing response to intrusion alarms, coordination with law enforcement, and periodic testing.

Guards - Manned access control typically encompasses (1) gate guards or (2) CCTV and access remotely controlled by a receptionist, guard, or other employee. In addition to sentry positions, guards can be employed as roving patrols (either vehicular or on foot) and as a response force. Regardless of the type or design of a system or the guard's specific role, a human-technology interface occurs. Conventional thinking maintains that the earlier the interface occurs during an intrusion, the greater the likelihood of a successful intervention. However, it can also be argued that with technology, the human-technology interface can effectively and more safely occur later in the sequence of events. Irrespective of timing, human nature plays a critical role. Historically, the human element has proven to be both the strongest and weakest link in the chain. While system effectiveness is largely dependent on the professionalism of the individuals involved, human complacency is the primary element undermining guard efficacy. Any number of procedures and systems exist to reduce complacency and enhance guard force readiness and responsiveness. Guards can be of very limited value even for rudimentary deterrence. Unless they are present in sufficient numbers to demonstrate viable coverage and effectively interdict an intrusion at the critical facilities, even an unsophisticated intruder can easily avoid them. Undeniably, a guard presence contributes to security but the cost-benefit must be weighed.[5] As an alternative to employing or outsourcing guard services (most often to reduce corporate

[5] As a rule of thumb, the number of personnel required to maintain 24/7 presence of one guard ranges from 5 to 7 (due to training, rotations, sickness, time off, and turnover). Depending on whether a guard force is maintained in-house or outsourced and a number of other parameters, this can equate to between $150K - $250K per annum.

expense), companies often attempt to impose guard responsibilities on internal employees. This is neither a sound security nor business strategy as it tends to distract the employees from their primary job and does very little in terms of enhancing security. Owing to the potential resource demands associated with increased security, outsourcing of guard or roving patrol services to include intrusion alarm monitoring) is often prudent. That said, the need for an on-site guard presence at system facilities can be effectively eliminated with a properly designed security architecture and proactive, security-minded employees.

Controlling access of the general public and service companies with business at system facilities requires a careful balance. Administrative measures such as requiring ratepayers to call ahead to schedule appointments or limiting customers exclusively to telephonic and mail-in services should be considered. From a purely access control standpoint, having a system that requires some form of personal identification prior to entering a compound or building is the most effective. The reception-monitored entrance, locking of other outer doors, and “buzz-in” from reception to employee working areas currently employed in the Administrative Office are a definite step in the right direction. However, a determined individual could quickly compromise these measures simply by hurdling the reception counter. With some reconfiguration of the entrance area, integration of CCTV, hardening of the foyer, and revised buzz-in/emergency response protocols, security of the district complex and its personnel could be significantly strengthened during and after working hours. In addition to access control, such measures constitute very effective *deterrence*.

Tailgating and Vestibules - Tailgating through access control points and propping open of controlled portals is a persistent problem. Tailgating—by both vehicles and pedestrians—must be minimized. One of the most effective ways to minimize tailgating is to create a vestibule-like configuration or series of barriers that preclude (or control) a second vehicle/person from entering a limited access area until the first vehicle/person has cleared it. This is particularly applicable to Administrative Offices.

Constructing vestibules or effective vehicles barriers can be expensive, can significantly encroach on working areas, and will generally require some form of monitoring to ensure violations do not occur. To be effective, certain basic steps must be taken; for example:

- Visitors should be required to state their name and business and provide identification before being “buzzed in.”
- All entrances to the building/parking areas (to include roof accesses and delivery gates) must be equally secure.

The vestibule concept can be flexible to allow ratepayers into the building but control their access to a designated customer service area situated within a hardened zone.[6] The objective of the vestibule (in conjunction with access control measures discussed below) is to prevent a malevolent actor from gaining access to personnel while still allowing efficient conduct of business and retaining an atmosphere of customer-friendliness.

Safe Rooms - A safe room is an area situated and configured to provide emergency protection in the event of a hostage-like situation. Typically, it is a fairly centralized, easily accessed, and easily secured room capable of accommodating a reasonable number of personnel for a short

[6] Zone configurations can range from elevated counters(similar to what currently exists) to roll-down barricades to bulletproof enclosures and intercoms (similar to drive-up banking).

duration. Ideally, it can offer a viable emergency escape route and/or be protected from the threat of fire, bombs, or other malevolent acts. In cases such as an administrative office, a full-fledged safe room may not be required. Rather, a safe haven that provides simple protection from the DBT for staff cloistered within the room for a short period until the police arrive should suffice. Reinforcement of a room to create that safe haven can be elaborate or simple. Unless a major potential threat exists, the simpler and less expensive option is recommended.[7] In addition to security considerations, the design and provisioning of the safe room should support basic personnel safety requirements.

Parking Restrictions - Restricting parking to specific areas–typically not adjacent to important buildings—and funneling pedestrian traffic to specific entrances are simple and effective first steps. Controlling access to employee parking via access control measures and physical barriers, establishing separate visitor parking, and funneling pedestrian traffic to designated entrances are all effective measures. Fencing, barriers, landscaping (e.g., trees, earthen berms), and large planters are all viable barrier options and provide varying degrees of aesthetics.

In more remote areas, denial of access as a means of security should be weighed against public access issues and engaging the public as part of the system's security architecture. One potential alternative is permitting public access for recreation if feasible and inviting the public to report suspicious activities. This enhances *deterrence/detection/response* through increase public presence, awareness, and involvement.[8]

Intrusion Detection - Redundancy is a fundamental tool in maximizing PPS and OS effectiveness. Whether discussing intrusion detection, communications, monitoring/response, or systems, at a minimum redundancy reduces susceptibility to single-point-of-failure and increases emergency action options. Applications of PPS and OS redundancy include:

- Alarm notification of multiple personnel
- Concurrent visual, audible, and electronic alarms
- Progressive sensors/alarms
- Redundant operations and communications systems

Progressive Intrusion Alarms - One concept of viable intrusion detection is one of progressive detection. Multiple sensors are integrated to detect both an intrusion and a sequence of action portending malevolent acts. Through a simple but carefully crafted design, this approach reduces false alarms, provides a higher standard for response, and is far more effective for distributed systems. Complementing access control measures, progressive intrusion detection represents arguably the most effective defense against the utility security incursions. While detection systems are limited in their ability to dissuade or prevent terrorists or other serious "bad actors" from perpetrating a crime, they play a critical *indications and warning* role. Progressive intrusion detection will, in conjunction with other countermeasures, provide reasonable forewarning and a measure of intent sufficient to allow operators to respond proactively to protect both systems and consumers.

[7] In keeping with the "reasonable and prudent" standard, a safe room must offer protection but should not be so cumbersome, expensive, or operationally impractical as to significantly impair daily operations.
[8] This is particularly relevant to areas in close proximity to housing developments.

A variety of external and internal intrusion sensor technologies exist, to include seismic, motion, thermal, closed circuit television, beam interruption, pressure, acoustic, and various combinations. Each has unique capabilities and limitations. Operational constraints and overall efficiency varies, as do procurement, installation, and maintenance costs. A system that integrates complementary technologies in a cost effective manner generally provides the best overall long-term security.

To provide both defense-in-depth and progressive alarms, a minimum of two alarms should generally be installed at sites where critical systems are potentially exposed. These alarms must be configured to clearly demonstrate *progressive intrusion toward sensitive system elements*—thus confirming malevolent intent—when activated. They should alarm sequentially to a centralized alarm system—preferably a commercial security service and a designated Duty Officer.[9] Electronic sensors that alarm remotely should be accompanied by on-site day/night visual alarms to alert passing security/law enforcement/roving units to the intrusion. Alarm power sources and antennas must be protected from compromise. If possible, all antennas, power sources, and wiring should be located well within the first intrusion perimeter, hardened, and preferably at a point well beyond reach or compromise.

To achieve effective "progressive alarms" for the more remote sites, the first alarm must be triggered as the intruder approaches the target (for example, a lift station). For most lift stations, the access hatches and ventilation shafts presents the most likely avenue of approach. For above-ground tanks, the access ladder presents the most likely avenue of approach. The second alarm must be activated if the containment is breached. As vaults will most likely be breached via either their access portals or ventilation, the second sensor must be triggered if these are compromised (for example, a motion detector could be placed within the vault). For above-ground tanks, the second sensor must be activated if the hatch is opened. Regardless of the detector configuration, sensors must be sufficiently protected to ensure that corrosion of sensors, power sources, or signal relays from ambient conditions (e.g., UV, exposure, high humidity) does not occur. Intrusion detection should be designed so that attempts to tamper with sensing/transmitting components will also generate an alarm.

A basic system of perimeter intrusion sensors—typically infra-read (IR) beams—can provide first echelon, 360° intrusion detection around critical buildings. Depending on their installation, sensitivity, and the environment, such sensors can be subject to an unacceptable false alarm rates and unfavorable operating conditions (e.g., rain, fog). Additionally, unless configured in comprehensively overlapped patterns, the beams can be easily bypassed. Other types of intrusion alarms deployed around a perimeter are subject to similar limitations.

While perimeter intrusion sensors can be used to protect water facilities, on a practical and cost-benefit level, they are of limited value. The proximity of water facilities to private residences and public areas severely limits the value of perimeter intrusion detection. By reducing perimeter detection, the time available between detection and a response is obviously reduced. However, as a practical matter (1) the time required for authorities to effectively respond to most sites would exceed even a prolonged detection window and (2) the generation of false perimeter alarms would very quickly nullify their potential value. Perimeter intrusion alarms may have

[9] The utility utilizes the services of an alarm monitoring service. See later discussions of *outsourcing* and *duty officer*. Alarms that alert simultaneously to a duty officer (via beeper, cell phone, or other immediate means of notification) and the monitoring service are typically the most effective.

application at the most critical facilities, but far more effective is a system that provides with a very high degree of certainty a warning of malevolent intent. And if a suitable level of detection can be achieved via alternative intrusion alarms, *perimeter* intrusion alarms may be unnecessarily redundant.

A level of detection deemed most effective for water facilities encompasses three types of alarms. These are typically employed in pairs and/or various combinations in order to confirm *progressive intrusion toward sensitive system elements*. These are:

- Contact alarms: activated when a door, hatch, window, cover, or other form of portal access is opened and an electric circuit is broken.
- Motion detection alarms: activated when motion outside ambient norms is detected in or across an area.
- Video alarms: parameters established via software and CCTV monitors trigger an alarm if specific criteria are met (i.e., personnel or vehicular movement, percentage picture change, designated security areas compromised).

Temporary sensors—employed during periods of heightened security and/or to identify repeat intruders—can be effective (particularly against vandals and trespassers).

Outsourcing **-** Many utilities outsource alarm monitoring to a commercial service; this is the recommended manner for monitoring and reporting sensor alarms. However, improvement of both the *detection* and *response* procedures to alarm notifications (operational (OS) and security (PPS)) warrants improvement.

Related to outsourcing is the issue of critical personnel. The temporary loss of an operations or maintenance person will not typically disrupt system operations. It is not uncommon for the IT organization to be "one deep" and the loss of the key individual could prove catastrophic under certain circumstances. Cross-training and or outsourcing are two ways of reducing the vulnerability created by single-person point of failure.

Surveillance **-** Experienced intruders and trained terrorists will frequently conduct surveillance of potential targets prior to executing an attack. Particularly in the case of more remote sites, they will often test security by activating detection systems and gauging the response from afar. This is particularly effective to determine law enforcement agency response times, neighborhood reaction, lighting sequences, and actions taken by security at the scene. In this regard, effective detection, meaningful delay, and/or timely response can serve as a significant deterrent. Conversely, a weak security system is quickly evaluated as such and may confirm the intruder's target selection.

Physical Protection **-** Fences—particularly in remote areas—are analogous to padlocks in that they largely keep honest people honest. While they have a practical application, their value is often misunderstood. A fence can be a deterrent and delay an attack. However, its utility is significantly diminished in situations where it can easily be by-passed (as occurs in more remote sites). Erecting a high, razor tape-topped, buried cable cyclone fence around a remote facility may deter the casual passerby but does very little to deter a determined intruder. Cost-benefit assessment often reveals that resources expended to purchase and install such a fence would be better spent on installing a rudimentary detection system and a very simple fence.

Visitor parking at the administrative offices should be separated from employee parking and kept more distant from the building (see earlier discussion under *Access Control*). Several vehicle control options exist:

- Install a separate visitor gate and parking lot.
- Install an employee access control system and keep the gate closed at all times except when vehicles are passing through.
- If employee/visitor parking is not segregated, institute reception-controlled parking access for visitors.

Package Screening **-** Physical protection and access control must extend beyond personnel/vehicles to include packages, mail, and other forms of delivery. The utility can receive numerous visitors and/or deliveries a day. If package handling/security procedures are not currently in place, the entire compound effectively is placed at risk. Standard package handling procedures reduce the likelihood of dangers emanating from deliveries and are an integral part of both access control and physical protection.

Hazardous Chemicals **-** Particular consideration should be given to the protection of hazardous chemical storage. Progressive intrusion alarms can be utilized. If a hoist is installed, electrical deactivation of the hoist would reduce the likelihood that chlorine cylinders could be stolen.

In Extremis Situations **-** Another dimension of access control is *in extremis* situations where personnel are subject to hostage-taking or similar crises. For this eventuality, consideration should be given to *panic buttons* and a *safe room*. Panic buttons are simply hidden switches judiciously located in key areas and accessible by individuals likely to be the target of or observe a situation that could escalate into a serious confrontation. Alarms are typically configured to alert law enforcement and corporate security personnel without alarming the antagonist(s). Emergency Action Plans should provide clear guidance with regard to panic buttons, bug this information should be limited to those with "the need to know" to minimize the chances of the system being compromised by an insider.

Provision of an *under-duress* signal allowing the sender to transmit an alarm that, unbeknownst to the aggressor, communicates the fact that the sender is under duress is a further security measure. This could prove critical in a situation where an operator or roving unit is taken hostage and coerced into neutralizing alarms or other plant operations. A simple code signifying that the action is being taken *under-duress* alerts the security company of a situation and allows them to notify authorities immediately.

A *safe room* is a designated room or area where employees can quickly gather to preempt or avoid a hostage situation. At a minimum, *safe rooms* are typically configured with:

- Relatively central location to maximize immediate access by all concerned.
- Access routes, which anticipate personnel in possible states of fear or panic, with disabilities, and under conditions of emergency lighting.
- Primary and secondary communications to law enforcement
- Key telephone numbers for law enforcement agencies and senior management

- As appropriate, emergency water, food, ventilation, fire extinguishing, and bathroom (port-a-potty)
- CCTV to monitor activity in building outside the safe room.
- Emergency exit (if practical)

The existence of and procedures associated with *panic buttons* and *safe rooms* are, by their very nature, sensitive. Senior management discretion should be exercised in discussing and coordinating this emergency provision to minimize concern and knowledge of the room's purpose. As with all security protocols, the procedures are at least as important as the notification process, and Emergency Action Plans should provide clear guidance regarding *panic buttons* and *safe rooms*. Furthermore, emergency procedures should be rudimentary in recognition of typical human reaction during an *in-extremis* situation.

Equipping vehicles with satellite and ground-based tracking systems should be considered as a means of improving both personnel safety/security and fleet management. These systems allow tacking/monitoring of the car, emergency assistance, limited remote operations, and notification of authorities under *in-extremis* situations.

Vault Access **-** Critical system valves and interties can be situated in relatively exposed in-ground vaults accessed through heavy—but minimally protected—horizontal doors. Mounting locking bars with simple padlocking systems over the doors can cost-effectively reinforce these.

Contamination of Treatment Process **-** Manholes and service connections provide potential access for contamination of the treatment process.

Duty Officer - Formally designating a 24/7 the utility Duty Officer and daily security protocol is a highly effective means of sustaining security. This involves designating a rotating Duty Officer who, for the period of his "watch" (typically 24 hours), has the responsibility of overseeing both operational and security procedures and systems. No different than traditional typical duty officer responsibilities, this is a collateral duty personnel to be qualified, trained, and proactive. It is not mandatory (and seldom necessary) for the Duty Officer to be on the premises 24 hours a day, but the Duty Officer should figure predominantly in all aspects of security. Properly instituted, a Duty Officer program fosters a climate of security, institutes daily review and exercise of basic security procedures, and ensures continuity of effort and personal involvement.

4.2.1.2 Alarms, Sensors, and Security Systems

Much of the discussion regarding alarms, sensors, and security systems was covered previously under access control and intrusion detection. There are several simple techniques that can significantly strengthen overall effectiveness; among these: integrating sensors and personnel alarms. As addressed earlier, combinations of different types of sensors can prove to be one of the most effective means of securing an area. Sensors vary in their ability to detect different types of intrusions, pose different challenges to intruders seeking to neutralize or bypass them, and have different susceptibilities to climatic and other conditions; some are already partially utilized by the utility. Their applications can vary from local or remote enunciation to controlling system operations. Among the personnel alarms are *panic buttons* and *under-duress* signals discussed earlier; both are intended to forewarn of a situation that may endanger the utility operations or personnel. Incorporation of these into the alarm architecture and response planning requires considerable forethought to ensure viability and effectiveness and should be treated as sensitive information.

Portable Sensors/Alarms **-** During periods of heightened security, portable intrusion alarms can be deployed to high priority facilities to augment existing systems. This requires having units on-hand, reserving sufficient bandwidth to incorporate sensor signals in to the communications backbone, and maintaining in-house expertise (for set-up and maintenance). The trade-off between augmenting security through increased technology or increased guards/patrols is typically based on resources, priorities, and simple practicalities. Such measures should be considered during periods of heightened alert.

Lighting **-** Lighting can be a significant deterrent to nighttime intrusions. Intrusion-activated lighting is an even greater deterrent and can serve as a means of detection. Intrusion-activated lighting integrated into intrusion alarms systems and augmented by CCTV monitoring is perhaps the most effective means of maximizing nighttime deterrence, detection, and—to a limited extent—delay.

4.2.2 Vulnerability of SCADA Systems

In today's Internet environment, computers, networks and applications evolve at a very fast pace. Competing demands—heightened cyber security, simplicity and ease of operation, and non-intrusiveness on daily operations, to name a few—impact cyber security as much as physical security. It is imperative that utilities design and maintain a cyber security architecture that protects the security of information, integrity of the system, and privacy of communications. While the cyber environment may be more dynamic because the threat evolves more rapidly, underlying security principles remain the same as those of physical security. Implementing graduated access control and an effective intrusion detection system for the SCADA is neither difficult nor revolutionary. Safeguarding the SCADA system implies safeguarding the physical systems and computer access. In addition to PPS and software security, hardware access control must be employed. Here, again, a variety of options arise from biometric devices to sophisticated passwords to other controls. Continual attention to access control is warranted and user awareness must be continually reinforced. As with the PPS, SCADA SOPs and Emergency Action Plans addressing cyber security must be established and maintained.

4.2.2.1 Two-Man Rule

In addition to technological measures, there are other basic measures that can contribute significantly to both access control and intrusion detection/prevention. Principal among these is the *two-man rule* to defend against insider threats. The *two-man rule* simply requires that two individuals act jointly to affect change or authorize an action; unilateral action is not sufficient and may well cause an alarm to be sounded if attempted. Widely used in sensitive government programs, this technique is based on a proven concept that it is much more difficult to compromise two insiders than just one. Additionally, there is always a possibility that a key individual can be coerced to take some action that threatens the system. Useful in physical, operations, or cyber settings, this rule is often applied to situations where supervisory oversight is appropriate but there is no need for constant supervisor participation or to prevent *under-duress* unilateral compromise. A potential application of the *two-man rule*: allowing no major system alterations or settings to be made to the SCADA without senior management "on line" approval. While this would not guarantee system security, it could provide safeguards to minimize access and/or consequences and provide notification of unauthorized attempts.

4.2.2.2 Outsourcing

Earlier discussion touched briefly on outsourcing physical security. This applies equally to cyber security. Too frequently, IT personnel are simply expected to assume and become conversant in all aspects of cyber security. Given the dynamic nature of cyber threats and the continual advancements in both technology and counter-technology, outsourcing provides a viable and often essential alternative to in-house cyber security efforts. A further advantage of outsourcing is that, properly leveraged, it can prevent a single employee from gaining complete access to, knowledge of, and the ability to compromise key elements of cyber security architecture.

Outsourcing of both physical and cyber security offers several advantages; among these:

- Allows utility personnel to focus on their primary job, the one for which they are trained.
- Prevents untrained personnel from acting in capacities requiring security training.
- Increases likelihood that security systems, training, and processes will be kept abreast of market developments.
- Facilitates standardization across the company.
- Reduces impact on growing organization whose growth in personnel is purportedly not keeping pace.

4.2.3 Vulnerability of Operating Systems

Assessment of operating system vulnerabilities involves assessment of the following:

- Personnel vetting
- Communications
- Training, education and exercises
- Emergency action plans
- Cooperative, interagency and mutual support
- Management

4.2.3.1 Personnel Vetting

Closely aligned with access control is personnel vetting—the process of confirming an employee's or potential employee's qualifications, aptitude, and suitability for a position. Vetting is not limited to new hires; it applies equally to clearing an individual for promotion and increased responsibility/access. Effective pre-screening procedures offer a powerful deterrent in and of themselves as potential malevolent actors faced with a proactive and thorough background job application process will likely seek employment elsewhere. Pre-hiring protocols should include closer scrutiny of past employment and military/government service, written permission to conduct detailed financial background checks for personnel handing finances; more in-depth background checks if an individual is hired and subsequently considered for a position of greater responsibility; and polygraphs for critical positions. Screening procedures often need to be coordinated with unions.[10] Company policies should also look beyond direct employees to include vendors, sub-contractors, security services, and building lessees—all of whom have greater access than the general public and represent a potential cover for someone seeking unauthorized access to the premises.

Personnel vetting should not be considered a "one time" event. If personnel are promoted, demoted, or undergo a significant shift in responsibilities, a review process may be appropriate. Additionally, employees can become disgruntled; this is often evinced long before a serious situation arises. Personnel vetting of demoted or similarly impacted employees and general awareness training for all employees can reduce the potential of disgruntlement going undetected.

4.2.3.2 Communications

Communications is typically an area of security vulnerability. Whether due to a lack of equipment, insufficient system redundancy, susceptibility to compromise, incompatibility with other emergency systems/services, weak emergency procedures, or a combination of these, communications has the potential to immobilize response in emergencies. Be it voice, SCADA, security, or RF data relay from PLC to the master SCADA terminal—all forms of communication are susceptible to both intentional and unintentional compromise. ***Redundancy*** and ***simplicity*** of emergency communications procedures are two key means of reducing communications vulnerability.

An often-overlooked area related to communications is protection of information that can be acquired from corporate websites and through written requests. Caution must be exercised to avoid divulging sensitive information that could be exploited by terrorists. Review and revamp of websites to preclude the release of sensitive information is an easy first step. A second—and equally simple—step is to establish a standard procedure in response to any request for information. In response to a request, the requestor should be required to provide specific background information, references, and demonstrate a clear need for the information. Not only will this allow the utility to properly screen the request, it serves as a strong deterrent to requestors with malevolent intent.

Another important consideration regards outside communications with SCADA systems. Potential vulnerabilities of any communication links should be closely examined and considerations should be made to improve security. For example, while having accessibility to SCADA via the Internet provides significant flexibility to operations staff, such connections are potentially vulnerable to cyber attack even with carefully planned access controls. An alternate approach, for example, is to use secure radio communications links between designated computers and the SCADA system. Such links can be designed to continuously vary the frequency of communication for added security. Procedures, of course, should also be implemented in this case to protect physically and electronically protect computers fitted with such links. It is imperative that any SCADA system that has control capacity be completely isolated from the internet.

In some cases, utility information is already in the public domain owing to (1) EPA and other agency regulations which previously permitted/required release on information due to "the

[10] In the case of unionized employees, management should stress the role and importance of security protocols in ensuring a safe working environment for all employees.

public's right to know" and (2) access created by the Freedom of Information Act.[11] Two prime examples are annual hazardous material reports and risk management plans. Once mandated to be accessible to the public, access to these and other sensitive reports was curtailed after 9-11. Unfortunately, in addition to those document already released by the government, many remain available on websites such as one maintained by Green Peace. These examples demonstrate the need for vigilance and prudence in preparing or releasing sensitive information. Though current EPA guidelines are designed to prevent the release of sensitive information, it is recommended that utilities carefully scrutinize and minimize the information it releases to that material it would not be uncomfortable releasing to the public.

Shredding of sensitive documents—either in-house or out-sourced—is an effective means of safeguarding information and reducing proliferation of printed material.

4.2.3.3 Training, Education, and Exercises

An active training program in compliance with water industry and hazardous material requirements is valuable. This encourages employee self-improvement through education and such foresightedness should extend to security training and exercises. Opportunities for training and exercise participation in security, interoperability, and emergency management exist at individual, corporate, and interagency levels and should be fully explored to keep personnel abreast and engaged.

Historically, when money becomes tight, the first two areas where management focuses its budget cuts are training and security. This inclination can only be successfully countered through effective training, management awareness, and emphasis on maintaining a reasonable and prudent security standard. Awareness of management's fiduciary responsibilities and potential liabilities is also important.

4.2.3.4 Emergency Action Plans

Emergency action planning encompasses a broad spectrum—from planning for routine system outages and natural disasters to conceptualizing how to deal with complex crises. As discussed previously, emergency action planning is a continuous process. Plans should be designed to avoid as well as mitigate emergencies. Emergency operations guidelines assist operators in taking proper action at remote sites during an emergency. These are indispensable at the "operator" level but the actions outlined must dovetail with the emergency actions planned at higher levels. In developing these guidelines and other Emergency Action Plans, appropriate coordination with city and county emergency management agencies and other water utilities should not be overlooked.

From a terrorism prevention/deterrence/mitigation perspective, there are a number of emergency action factors to be considered:

- Pre-determined system isolation or flow diversion in the event of system contamination
- Heightened system-wide contaminant testing
- Heightened levels of security to parallel Homeland Security Advisory System warnings

[11] As an example, *Greenpeace* posted a number of Risk Management Plans on the Internet well in advance of 9-11; some of these may still be accessible today.

- Indications & Warnings training and information exchange
- Interagency training and exercises

As discussed below, both the opportunity and willingness on the part of local law enforcement agencies and emergency management organizations to work to facilitate the development/refinement of viable Emergency Action Plans is valuable. Emergency Action Plans delineate specific procedures regarding how to respond to and mitigate crises and should include—at a minimum—specific guidance regarding:

- Interoperability of primary and alternate
  - Response plans and procedures (specifically terrorism and hazmat)
  - Communications
  - Command and control (to include emergency operation center roles)
  - Logistical coordination
  - Coordination and periodic exercises with local law enforcement agencies to respond to intrusion alarms
- Assets, mutual support, and crisis team participation opportunities available to the utility via interface with emergency management organizations and plans
- Crisis priorities as identified by both of the utility and the emergency management organizations (Emergency Action Plans should recognize and capitalize on priority synergy wherever possible as well as recognize and accommodate conflicting priorities).

4.2.3.5 Cooperative, Interagency, and Mutual Support

Given the opportunity for access to 800 MHz systems, utilities can be well positioned to establish a direct emergency communications interface with law enforcement agencies. Equally important, this provides an opportunity for regional utilities to organize their emergency communications to form collective "talk groups" both during times of emergency and pursue mutual support initiatives.

Mutual Support **-** Generally speaking, water purveyors stand to benefit from closer association with emergency management organizations. The converse is also true… law enforcement agencies can benefit significantly from interface with proactive utilities. The value of the latter is often underestimated and should be emphasized in every discussion with law enforcement agencies. Mutual benefits include intelligence sharing, specific roles/support during disasters, avoidance of "reinvention" or counter-productive crisis procedures, resource/cost sharing, more integrated emergency response, and "a seat at the table" in emergency planning discussions. This should be further extended to cooperation with local law enforcement and peer water organizations in the region. By interfacing more with these groups, the utility can broaden interaction to include mutual support (e.g., shared resources, joint training, and shared lessons learned).

There are a number of specific outreach and interaction activities in which the utility should become involved. Continued and broadened community outreach is perhaps the most important because an informed and proactive public represents the best first line of defense in any civic protection effort; the citizens are quite literally the eyes and ears that can become an extension of the utility and security architecture. It is also the populace whose confidence the utility must retain during times of crisis. Opportunities to meet, discuss, train, and exercise together with other organizations are of critical importance and must be aggressively sought. As in the case of law enforcement agencies, the utility should not wait for organizations to approach them.

4.2.3.6 Management

Buy-in and proactive leadership at all levels of management are key to implementing and sustaining effective security across the utility. More than mere lip service, management must be directly involved in—and proactive in improving—corporate awareness, security reviews, and training/exercises. Consistent allocation of resources (funding, personnel, and time) to the foregoing is the clearest measure of management's commitment to security. Management and labor invariably find themselves at odds over aspects of security. Key to resolving issues is demonstrating that all benefit from improved security. Often, increased security is seen as being intrusive on individuals' rights or privacy; in reality, the *greater good* principle applies. Measures taken to reasonably reduce the vulnerability of one typically enhance the security of all. Improving workplace security benefits employees, management, and shareholders alike and must be an ALL HANDS priority.

Supportive Climate **-** In addition to undertaking specific PPS and OS security initiatives, creation and maintenance of a climate supportive of security is essential to maintaining a vibrant security program. Incentives—beneficial suggestions, recognition of individuals exercising good security practices, security competitions—and other creative measures should be employed to foster awareness of and support for the utility's security program. Such efforts can and should complement programs for reporting operational/maintenance deficiencies.

Cost benefit **-** Implied throughout this assessment, evaluation of physical security options on the basis of cost-effectiveness is the bottom line. Effectiveness must be carefully considered in light of a component's role and value in an integrated security environment. As demonstrated earlier in discussions of both CCTV and fences, a poorly conceived or designed system can result in expenditures that do little or nothing to enhance overall security. If a contemplated component does not realistically contribute to the *deterrence/detection/delay/response* of a facility, it should not be included … or a lesser system that fulfills the basic need should be substituted.

Public Affairs **-** Public relations often overlooked in emergency action planning. Proper preparation of public relations entails anticipating and scripting responses to potential questions, identifying and training a qualified spokesperson, and establishing an SOP to respond quickly and effectively to media inquiries. Particularly from the standpoint of customer confidence, public relations are an important line of defense.

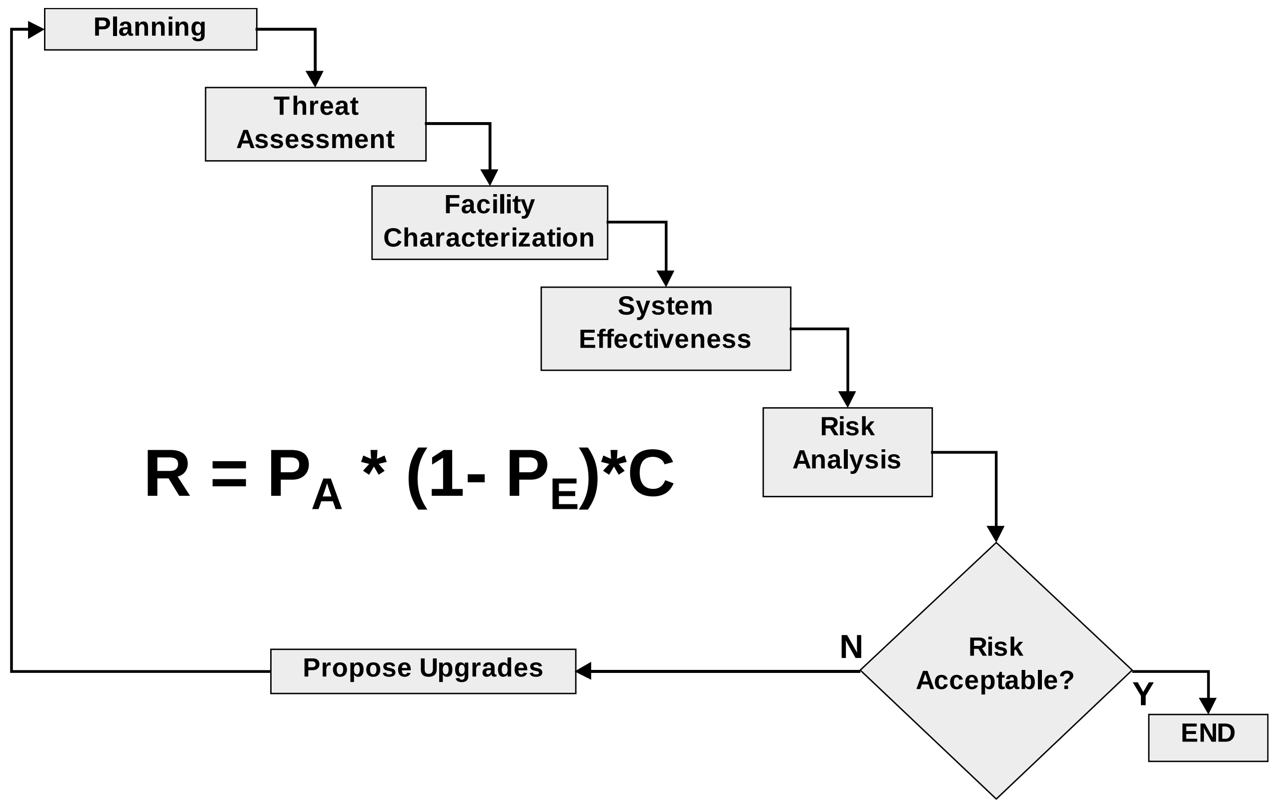

Figure 4.1 RAM-W[SM] Methodology

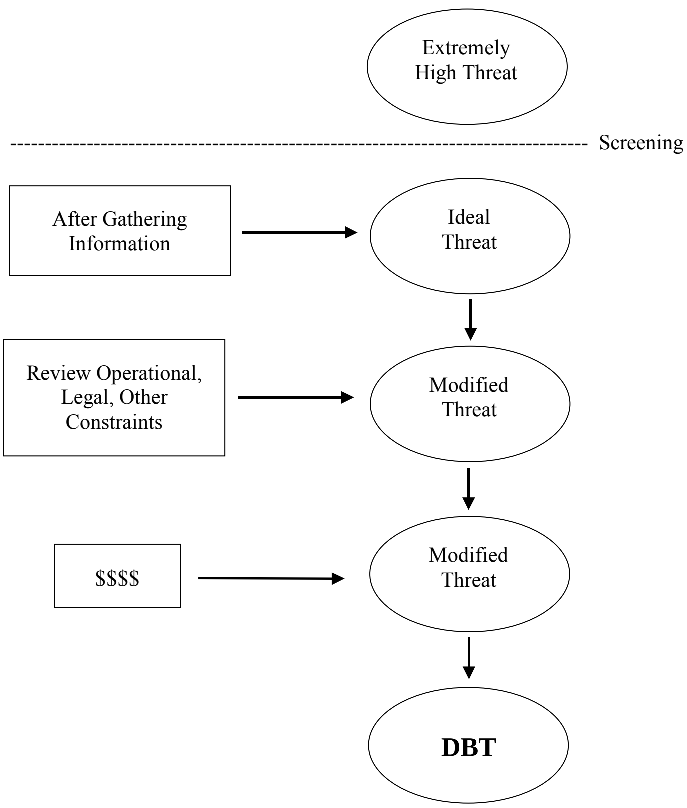

Figure 4.2 Design Basis Threat Selection

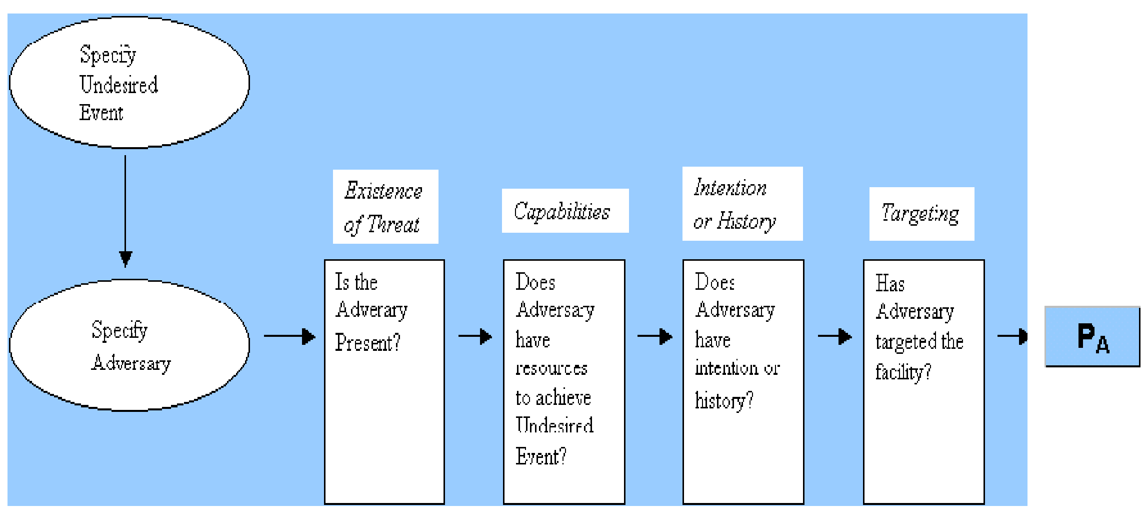

Figure4.3 Quantifying P_A

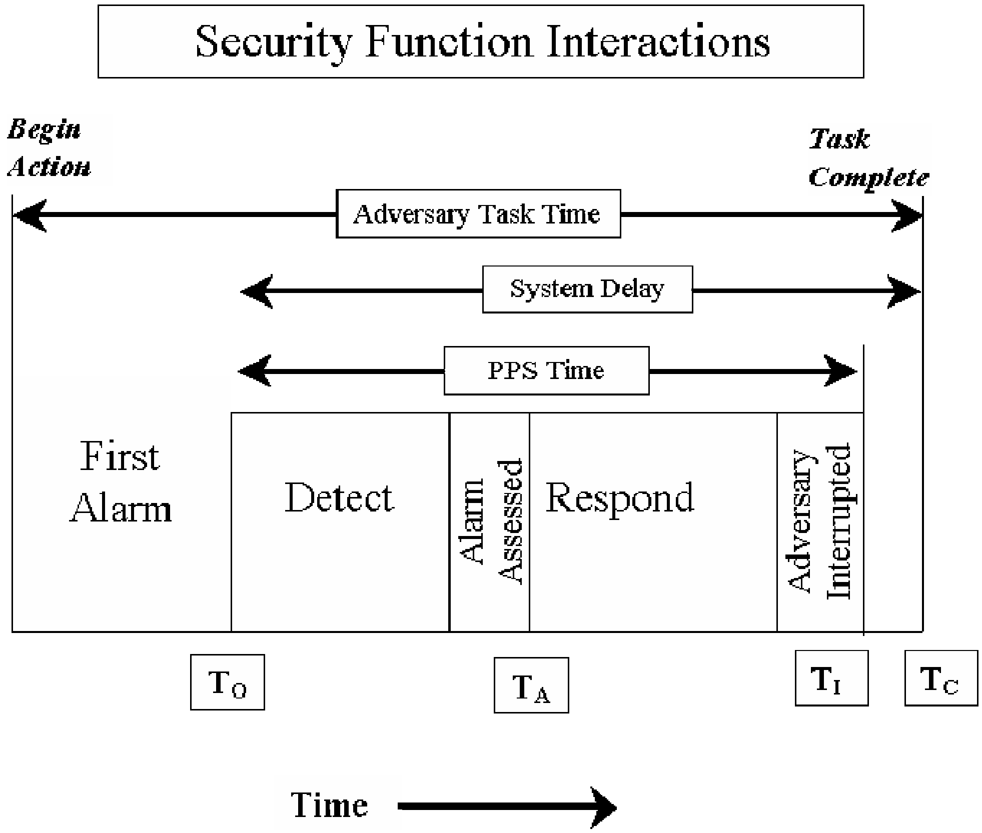

Figure 4.2 Deter, Detect, Delay and Respond

5 - Supplementary Notes on Component Vulnerability Modeling

For components subject to damage by ground movements and accelerations, preliminary, judgment-based damage functions can be constructed. This section provides supplemental information on component vulnerability modeling and discusses the use of a power function for very simplified component vulnerability modeling and how a triangular distribution may be used for simplified modeling of component fragilities.

5.1 Power Function Formulation of Vulnerability

The power function has the form

Damage (repair cost, functionality, restoration time) = Y= $A^* X^B$

in which A and B are coefficients to be determined and X is some measure of intensity for a specific natural hazard. The power function has an "S" shape if

A > 0 (as is required for components with some vulnerability)

$X \geq 0$, and

$1.0 < B < 0$.

This power function can be used to develop a deterministic component vulnerability model. If one enhances the power function with an error term, then the power function can be used in more statistically rigorous applications.

5.2 Use of a Triangular Distribution

The triangular distribution is one of the simplest of probability density functions – only the uniform distribution is simpler. The triangular distribution creates a well-behaved S-shape curve. It is a 3-parameter distribution (see Evans Hastings & Peacock, 1993). Some form of the predictive hazard parameter is used as the *x* variable (for instance, *x* may be equal to Modified Mercalli Intensity for earthquake damage).

The triangular distribution takes the form (see Figure 5.1):

$$Y = Y_{max} = \boldsymbol{f}(a, b, c, x)$$

In which:

x = *a* at the lower left corner of density function triangle; *b* at the lower right corner of triangle; *c* at the coordinate of apex of triangle

$$Y = \frac{(x-a)^2}{(b-a)(c-a)} \text{ for } x \leq c$$

$$Y \quad = \quad 1-\frac{(b-x)^2}{(b-a)(c-a)} \text{ for } x > c$$

The triangular distribution can be used to generate damage ratios for individual components or structures, where the damage ratio represents repair cost normalized by replacement value. Total damage implies a damage ratio of 1. Where damage saturates at a damage ratio less than 1, the distribution can be scaled to saturate at this lower level (Ymax < 1).

A damage function using the triangular distribution can be readily constructed from estimates of incipient damage (i.e., the x-coordinate of point a), the hazard level at the most probable failure point or highest rate of accumulation of damage (point c), the hazard level at which damage saturates (point b), and the damage ratio at damage saturation (Ymax, if less than 1).

A major challenge in the use of this functional form is the selection of the hazard parameter predicting damage, and its functional form. For example, in formulating earthquake vulnerability, some components will be vulnerable to accelerations, some to velocity, some to relative displacements (e.g., structural drifts), or permanent ground deformations. In wind, a key damage parameter would be wind velocity for exposed components. For flooding, the parameter of choice may be height of water above the base elevation of the vulnerable component. Once the damage predictor has been chosen, the functional form must then be decided. In the formulation, *x* may be a linear function of the hazard parameter, or *x* may be logarithmic or some other form.

Analytical methods using simple physical models may provide insight into the selection of the appropriate predictive hazard parameter and its functional form. Where statistical data are available, these judgment-based damage functions can serve as prior distributions in a Bayesian approach to vulnerability modeling (Der Kiureghian, 2002).

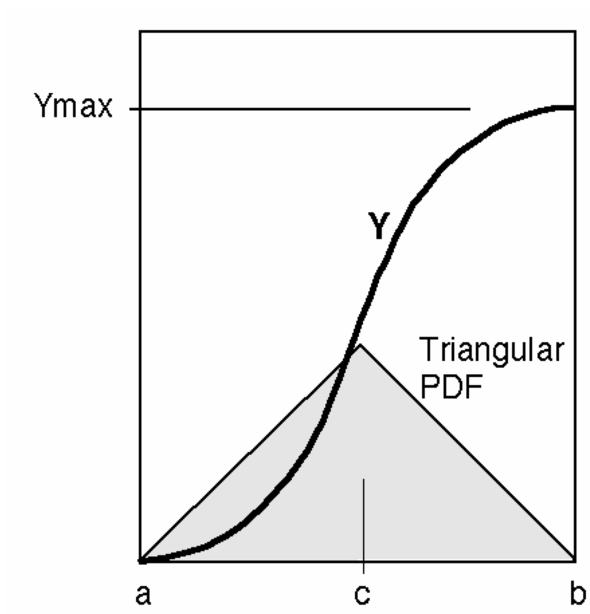

Figure 5.1 Triangular Distribution

6 - Supplementary Information on Water Systems Evaluations

This section covers some of the formalization of a connectivity evaluation used to assess the response of a networked system to under various damage states predicted by vulnerability relationships.

To begin a connectivity evaluation, one first defines the system in terms of m components, starting with sources, then links, intermediate nodes, and finally demand nodes (service zones, service connections and/or fire hydrants).

The next step is to define system states associated with a simulation of a specific hazard condition. It is the system state that defines which and how many nodes are reachable through some pathway by some source.

There may also be circumstances under which it is desirable to develop a prior sense of the operational importance of water utility components. In a system model, each component can be ‘failed’, one-by-one, and the system-wide impact evaluated. For a pipeline, a failure may mean that the water pressure must be reduced such that the hydraulic head is equal to the elevation of the break. Incomplete breaks may be modeled by introducing water demands along the pipe. Valves may fail ‘open’ or ‘closed’. Failure of a water tank may be simulated by removal of the water source.

Assessing component impact on the system requires the selection of an ‘objective function’ as the measure of system performance. Candidate objective functions may include water delivery volume (if inventory is critical), or water volume weighted to emphasize impacts on critical customers or fire flow. The time element can be considered by multiplying the reduction in water delivery rates by the time to repair the component or subsystem.

Operational importance modeling requires consideration of the water system layout. Where we have a ‘series’ subsystem, all components in the series whose failure means loss of function of the entire subsystem (or link) will have the same operational importance. This consideration helps in simplifying and reducing the number of perturbations in the system necessary to develop the operational importance matrix.

The mathematical formulation of this process is summarized below although there are many other references that utilize alternative approaches that account for the complexities of combinations of series and parallel systems. One first defines a connectivity matrix **c** such that

$\mathbf{c}_{i,j}$ = 1 if node i is immediately connected to node j and water flows from i to j and

$\mathbf{c}_{i,j}$ = 0 otherwise.

If flows are bi-directional, then

$\mathbf{c}_{i,j} = c_{i,j}$

Such an m-by-m connectivity matrix can be defined for the m components modeled for the system.

The specifics of the hazardous event and the component vulnerability models will define whether or not $\mathbf{c}_{i,j} = 1$. Binary component vulnerability models will not require any simulations.

However, if component vulnerability models yield some estimate of the probability of functionality for a component, then simulation may be needed to define specific system states. For instance, if the probability of a pipeline (a "link" in the system) failing in a specific hazard event is 0.3, then approximately 30% of the simulations for that natural hazard event should exhibit the component as failing.

A reachability matrix R is defined as having the following values:

$\mathbf{r}_{i,j}$ = 1 if directly or indirectly water can flow from node i to node j and

$\mathbf{r}_{i,j}$ = 0 if water cannot flow from node i to node j.

To derive a reachability matrix from a connectivity matrix, one defines the following Boolean function B:

$$B(x) = 0 \quad \text{if } x = 0 \text{ and}$$

$$= 1 \quad \text{if } x > 0,$$

and **r** is computed as follows:

$$\mathbf{r} = B(I + \mathbf{c} + ... + \mathbf{c}^{n-1})$$

$$= B[(I + \mathbf{c})^{n-1}]$$

in which **c** is the connectivity matrix and I is the identity matrix.

Thus, for each hazard event and for each simulation of the hazard event resulting in a system state, one could use the above formulas to define a reachability matrix and so determine whether or not a specific demand node is connected directly or indirectly to some water source. However, being reachable does not imply that adequate water supplies or water pressures will be available. For this reason, simple connectivity evaluations as given by the system state definition typically overestimate the chances that a water system will perform well after natural hazard events.

Considering that reachability may not represent adequate service, system evaluations of modest to significant complexity should be implemented with hydraulic evaluations as the level of effort to undertake connectivity evaluations can readily equals or exceed the degree of formalism in hydraulic evaluations.

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8 - Terms and Definitions

Acceleration. The rate of change of velocity. As applied to strong ground motions, the rate of change of earthquake shaking velocity of a reference point. Commonly expressed as a fraction or percentage of the acceleration due to gravity (g), wherein $g = 980\ cm/s^2$.

Active Fault. An earthquake fault that is considered to be likely to undergo renewed movement within a period of concern to humans. Faults are commonly considered to be active if they have moved one or more times in the last 10,000-11,000 years, but they may also be considered potentially active when assessing the hazard for some applications even if movement has occurred in the last 500,000 years. See **fault.**

Adverse Consequences. Those negative consequences of a particular event, including property damage, injuries, deaths, illnesses, business interruption losses, lost productivity, psychological setbacks, loss of family and group cohesion, defaults, job losses, environmental degradation, looting, and so on. Many of these negative consequences can be subjected to quantifiable measures. Typically these negative consequences are defined relative to specific stakeholders.(modified from FEMA, 1997)

Alluvium. A soil type consisting of loosely compacted gravel, sand, silt, or clay deposited by streams.

Amplification. An increase in seismic wave, wind speed or storm surge amplitude as they propagate through certain soils, tunnels, or embayments.

Annualized Loss. The loss per annum due to hazards, calculated as the probabilistic loss contribution of all events. Annualized loss is expressed as a probability distribution of loss per annum. The expected annual loss is the expectation of the probability distribution of loss per annum, and under certain assumptions may be calculated as the probability—weighted average—of loss due to all possible hazard events.

Attenuation. The rate at which seismic, wind, or water intensities decrease with distance from their sources or shoreline landing points.

Average (Expected) Annualized Loss, (AAL). See **Annualized Loss.**

Base Isolation. A structural design concept that reduces the magnitude of lateral response by preventing earthquake ground motion from being transmitted from the foundation into the building superstructure. Application is accomplished through the installation of isolator bearings at all of the connections between the structure and the foundation. The isolators are vertically stiff, capable of supporting vertical gravity loads, while being laterally flexible, capable of allowing large horizontal displacements. In effect, the ground is allowed to move back and forth under a base isolated building during an earthquake, while leaving the building to remain "stationary." In practice, the amplitudes of motion transmitted into the building are substantially reduced.

Baseline Risk. The existing risk, under current or as-is conditions.

Blizzard. A combination of heavy snowfall, high winds, extreme cold, and ice storms. (FEMA, 1997)

Business Interruption (BI) Loss. Economic loss associated with loss of function of a commercial enterprise.

Canal. A free-flowing gravity-water conduit, open to the atmosphere, and usually at grade. A canal may be lined or unlined. (ALA, 2001, modified by LeVal Lund, 9/19/01)

Coastal Erosion. A hydrologic hazard defined as the wearing away of land and loss of beach, shoreline, or dune material as a result of natural coastal processes or manmade influences. (FEMA, 1997) A hydrologic hazard defined as the eroding of land and loss of beach or shoreline as a result of natural processes or manmade influences. (9/19/01 by LeVal Lund)

Combined Event. An event consisting of the simultaneous occurrence of two or more natural hazards. (modified from ANS, 1978, p. 1)

Compaction. The uniform or differential settlement of loose soils or poorly consolidated alluvium as a result of ground shaking or applied overburden.

Component Damage Algorithm or Model. A procedure or function for estimating damage to a component subjected to a natural hazard event. (modified from ALA, 2001)

Component Downtime Model. A component vulnerability model or function relating the degree of downtime for the component as a function of its damage state. Can be combined with a component damage model to produce a model relating downtime to hazard severity.

Component Fragility Curve. A mathematical expression, represented graphically as a curve, that relates the probability of a component reaching or exceeding a particular damage state, given a specific level of a hazard. (modified from ALA, 2001)

Component Loss Algorithm or Model. A component damage algorithm or model in which component repair costs are the defined damage states.

Conduit. A free-flowing conduit can be an open channel or ditch, or may be a tunnel flowing partially full. A pressurized conduit can be a pipeline or tunnel flowing under internal pressure. An open channel can be a canal or a flume. (ALA, 2001) A free-flowing gravity water conduit, rectangular, oval, or circular in shape. A pressurized conduit is a conveyance facility flowing water under internal pressure. (LeVal Lund, 9/19/01)

Connectivity Matrix. A matrix which indicates for each node and link modeled in the water system whether or not a node and/or link is immediately connected to another node and/or link, and whether water flows from the first node/link to the second node/link. Non-functioning nodes and/or links are not connected to other nodes and/or links.

Damage. Physical disruption, such as cracking in walls or overturning of equipment (often used synonymously but erroneously with **Loss**).

Damping. The dissipation of energy in the process of viscous flow, deformation of viscoelastic materials, frictional sliding, or permanent material deformation or yielding (hysteretic damping).

Decision Under Risk. A decision in which decision-makers must take a chance on an unknown future whose chances are known with certainty (e.g., a wage on a gamble whose odds are known).

Decision Under Risk and Under Uncertainty. A decision in which decision-makers must take a chance on an unknown future whose chances are calculated, but where these calculations do not objectively incorporate the uncertainties in all pertinent parameters.

Decision Under Uncertainty. A decision in which decision-makers must take a chance on an unknown future whose chances are unknown.

Dependent Events. Event combinations for which the occurrence of one event gives information about (increases or decreases) the possibility of the occurrence of the other event. For example, the occurrence of a hazard such as an earthquake may increase the chance of headwater flooding. For another example, the occurrence of a drought may increase the chance of a subsequent wildfire. (modified from ANS, 1978, p. 1)

Deterministic-. A method of engineering and decision-making evaluation based solely on the selection of a few natural hazards events used as scenarios. For instance, a previous flood may be used as the basis for a scenario evaluation of what would happen if that flood recurred. Methods that are thoroughly deterministic are based on source models and intensity propagation methods that exclude **random effects**.

Deterministic-Based System Performance Metrics. System performance metrics based only on a deterministic evaluation of the system.

Distribution Storage Reservoir. Most water systems include various types of storage reservoirs in their distribution systems. Storage reservoirs can be either tanks or open-cut reservoirs. (ALA, 2001) A water storage reservoir used for daily or maybe weekly variation in demand and also includes capacity for fire suppression. Distribution water storage reservoirs can be either tanks or excavated basin, lined or unlined, covered or uncovered. Seasonal storage reservoirs store water for seasonal variation in demand and climatic variations in supply. (LeVal Lund, 9/19/01)

Distribution Water System. The system that delivers treated water to customers for end use from the supply. Most water distribution systems in the United States deliver treated water for drinking, sanitary, irrigation, commercial, industrial, and fire flow purposes. In some cities, separate distribution systems are built to deliver reclaimed water for irrigation or industrial purposes or ground water recharge or to supply water to fire hydrants. (ALA, 2001; modified by LeVal Lund, 9/19/01)

Ductile Detailing. Design details specifically intended to achieve an intended stable yielding mechanism in a building structure or equipment support structure. For example, special requirements for the placement of the reinforcing steel within structural elements of reinforced concrete and masonry construction necessary to achieve non-brittle, ductile behavior (**ductility**). Ductile detailing may include close spacing of transverse reinforcement to attain confinement of a concrete core or to prevent shear failures, appropriate relative dimensioning of beams and columns and 135 degree hooks on lateral reinforcement.

Earthquake. A sudden ground motion or trembling caused by an abrupt release of accumulated strain acting on the tectonic plates that comprise the Earth's crust. (FEMA, 1997) A sudden motion or trembling in the earth caused by the abrupt release of slowly accumulated strain. (Bates and Jackson, 1980)

Earthquake Hazard. The representation of an earthquake hazard can cover ground shaking, response spectra (peak spectral acceleration, peak spectral velocity, peak spectral displacement), peak ground velocity, peak ground acceleration, duration of significant shaking, time-history evaluation, and/or permanent ground deformation including fault offset. (modified from ALA, 2001)

Energy Dissipation Systems. Various structural devices that actively or passively absorb a portion structures of the intensity in order to reduce the magnitude or duration (or both) of a structure response. These devices include active mass systems, passive visco-elastic dampers, tendon devices, and **base isolation**, and may be incorporated into the building design.

Epicenter. The projection on the ground surface directly above the **hypocenter** of an earthquake.

Expansive Soils. The swelling or shrinking of soils and soft rock as a result of changes in moisture content. (FEMA, 1997)

Exposure. The number, types, qualities, and monetary values of various types of property or infrastructure, life, and environment that may be subject to an undesirable or injurious hazard event. (modified from FEMA, 1997)

Exposure Period. The period of time over which risk is to be computed; the period of time over which a facility or population at risk is subjected to a hazard.

Falls and Topples. Detachment of masses of rock or other materials from a steep slope or cliff and their descent by free fall, rolling, or bouncing. (FEMA, 1997)

Fault. A fracture along which there has been significant displacement of the two sides relative to each other parallel to the fracture. *Strike-slip faults* are predominantly vertical fractures along which rock masses have mostly shifted horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves to the left, the motion is termed left-lateral. *Dip-slip faults* are inclined fractures along which rock masses have mostly shifted vertically. If the rock mass above an inclined fault is depressed by slip, then the fault is termed *normal*, whereas if the rock above the fault is elevated by slip, then the fault is termed *thrust* (or *reverse*). *Oblique-slip faults* have significant components of both slip styles.

Fault Rupture. The differential movement of two land-masses along a fault. A concentrated, permanent deformation that occurs along the **fault trace** and caused by **slip** on the fault. (modified from AWWA, 2001)

Fault Scarp. A step-like linear land form coincident with a **fault trace** and caused by geologically recent **slip** on the fault.

Fault Trace. An intersection of a fault with the ground surface; also, the line commonly plotted on geologic maps to represent a fault.

Flooding. The accumulation of water within a water body and the overflow of excess water onto adjacent floodplain lands. (FEMA, 1997) a rising body of water (as in a stream, lake, or sea, or behind a dam) that overtops its natural or artificial confines and that covers land not normally under water; esp. any relatively high streamflow that overflows its banks in any reach of the stream, or that is measured by gage height or discharge quantity. (Bates and Jackson, 1980)

Flood-coastal. Abnormally high water on open and semi-enclosed bodies of water resulting from storm surge and tsunami, precipitation, tide, wind-wave activity, and possible flood at nearby stream. (ANS, 1978, p. 1)

Flood-lake. Abnormally high water on enclosed bodies of water resulting form high lake level, storm surge and seiche, precipitation, wind-wave activity, and possible flood of nearby stream. (ANS, 1978, p. 1)

A **Floodplain**. The land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding. (FEMA, 1997)

Flood-river. Abnormally high water on an inland stream resulting from precipitation and snowmelt runoff, possible ice blockage, wind-wave activity, and possible dam failure or stream diversion. (ANS, 1978, p. 1)

Flows. Shear strains distributed through the mass of material. Unlike slides, flows have high water content and the distribution of velocities resembles that of viscous fluids. (FEMA, 1997)

Flume. A free-flowing conduit, usually open to the atmosphere and usually elevated. A flume is typically built from wood or metal with wood or metal supports. (ALA, 2001)

Frost Heave, Frost Heaving. The uneven lifting or upward movement, and general distortion, of surface soils, rocks, vegetation, and structures such as pavements, due to subsurface freezing of water and growth of ice masses (esp. ice lenses); any upheaval of ground caused by freezing. (Bates and Jackson, 1980)

Fragility. **See** Vulnerability Model.

Frequency. **See** Probability and Frequency.

Fundamental Period. The longest period of oscillation for which a structure shows a maximum response (the reciprocal of natural frequency).

Ground Failure. A general reference to fault rupture, liquefaction, landsliding, and lateral spreading that can occur during an earthquake or other land movement causes.

Ground Shaking. The energy created by an earthquake as it radiates in waves from the earthquake source. A general term referring to the qualitative or quantitative aspects of movement of the ground surface from earthquakes. Ground shaking is produced by **seismic waves** that are generated by sudden slip on a fault and travel through the earth and along its surface. (modified from AWWA-M19, 2001)

Hazard. An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss. (FEMA, 1997) A chemical or physical condition that has the potential for causing damage to people, property, or the environment. (AWWARF, 1998)

Hazard Event Identification. The process of defining the source of a specific hazard, including its magnitude and source location. For modeling events probabilistically, expected frequency of occurrence of the initiating hazard as a function of its severity and location also needs to be modeled.

Hazard Identification. The process of defining and describing a hazard, including its physical characteristics, magnitude and severity, probability and frequency, causative factors, and locations/areas affected. (FEMA, 1997)

Hypocenter. The location within the earth of initial radiation of **seismic waves** caused by faulting action.

Intensity. A judgmental numerical index describing the severity of a hazard in terms of its effects on the ground surface and on people, structures, and the environment.

Iso-intensity. A contour line of a map bounding points of equal intensity for a particular hazard.

Landslide. The downward and outward movement of slope-forming earth materials reacting under the force of gravity. The term covers a broad category of events, including mudflows, mudslides, debris flows, rock falls, rock slides, debris avalanches, debris slides, and earth flows. When slopes lose shear strength because of a disturbance such as ground shaking. (modified from FEMA, 1997 and AWWA-M19, 2001)

Land subsidence. The loss of surface elevation owing to the removal of subsurface support. Settlement of the surface of the ground, usually occurring over a large area, sometimes precipitated by a removal of water or oil. (modified from FEMA, 1997)

Lateral Spreads. The landsliding of gentle, water-saturated slopes with rapid fluid-like flow movement caused by ground shaking and liquefaction. Large elements of distributed, lateral displacement of earth materials. (modified from FEMA, 1997)

Liquefaction. When the pressure of the pore water, water located in spaces between soil particles, exceeds particle friction forces, particularly in loose sands with high water content. The soil becomes a soil-water slurry with significantly reduced shear strength. The result can be foundation bearing failure, differential settlement, lateral spreading, or floating of underground components. A process by which water-saturated soil temporarily loses shear strength due to build-up of pore pressure and acts as a fluid. (modified from AWWA-M19, 2001)

Local Seismic Hazards. The phenomena and/or expectation of an earthquake-related agent of damage, such as vibratory ground motion (i.e., ground shaking), inundation (e.g., tsunami, seiche, dam failure), various kinds of permanent ground failure (e.g., fault rupture, liquefaction), fire or hazardous materials release.

Loss. The human or financial consequences of **damage**, such as human death or injury, cost of repairs, or disruption of social, economic, or environmental systems.

Magnitude. A unique measure of an individual earthquake's release of strain energy, measured on a variety of scales, of which the moment magnitude, M_w (derived from **seismic moment**) is often preferred. (See **Richter Scale**.)

Mean. Here, arithmetic mean, the average value in a distribution.

Median. The value in a distribution for which 50% of the distribution values are greater or less than the median value.

Mitigation. Sustained action taken to reduce or eliminate long-term costs and risks to people and property from hazards and their effects. Mitigation distinguishes actions that have a long-term impact from those that are more closely associated with preparedness for, immediate response to, and short-term recovery from a specific event. (Modified from FEMA, 1997)

Model. A representation of a physical system or process intended to enhance our ability to understand, predict, or control its behavior (AIAA G-077-1998)

Modified Mercalli Intensity (MMI) Scale. A qualitative or judgmental scale for measuring the severity of earthquake ground shaking at a site through the evaluation of the way people react to it and its effects on typical types of structures, such as chimneys and masonry buildings. The MMI scale is the most commonly used intensity scale in the United States and can be correlated with such other measures of physical intensity as peak ground accelerations, peak ground velocities, and peak ground displacements.

Mutually Exclusive. Two or more events which cannot physically occur simultaneously. (ANS, 1978, p. 1)

Natural Frequency(ies). The discrete frequency(ies) at which a particular elastic system vibrates when it is set in motion by a single impulse and not influenced by other external forces or by damping. It is the reciprocal of fundamental period.

Natural Hazard. In the context of these guidelines, a natural phenomenon which has the potential for causing damage to potable water structures, systems, or components. (adapted from ANS, 1978, p. 1)

Non-ductile Frames. Structural frames lacking **ductility** or energy-absorption capacity due to lack of **ductile detailing.** Ultimate load is sustained over a smaller deflection (relative to ductile frames) and for only a few cycles before a generally **brittle failure.**

Open Cut Reservoir. A reservoir built by creating a reservoir in the natural lie of the land, often with one side of the reservoir made up of an earthen embankment dam. Many open cut reservoirs are enclosed by adding a roof so that treated water inside is protected from contamination from outside sources. A few open cut reservoirs in treated water systems are open to the air, and water in these reservoirs usually must be treated before being delivered to customers. (ALA, 2001)

Parallel System or Sub-system. A system or sub-system in which there are multiple sources or at least multiple pathways or conduits to service connections or fire hydrants. For an antonym, see series system or sub-system.

Peak Ground Acceleration (PGA). The maximum amplitude of recorded acceleration (also termed the ZPA, or zero-period acceleration).

Performance Objectives. A range of limiting structural damage and functionality states for a facility or system, given a specific hazard. Very typically, only facility performance objectives are considered. This document emphasizes the application of system performance metrics in the light of **system performance objectives.**

Probability and Frequency. Frequency measures how often an event (including a natural hazard event, a state or condition of a component, or a state or condition of the system) occurs. One way to express expected frequency is the average time between occurrences or exceedances (non-exceedances) of an event. The mean annual rate of occurrence of a hazard parameter within a range of values is another way to express expected frequency of a hazard. Probabilities express the change of the event occurring or being exceeded (not exceeded) in a given unit of time. Whereas probabilities of occurrence cannot exceed 1.0, expected frequencies (for a given time unit) can exceed 1.0. For instance, expected frequencies of auto accidents in Washington D. C. for a given year are far in excess of 1.0 even though the probability of an auto accident within a given year can only approach very closely 1.0. (modified from FEMA, 1997; ANS, 1978, p. 2)

Probabilistic Methods. Scientific, engineering, and financial methods of calculating severities and intensities of hazard occurrences and responses of facilities that take into account the frequency of occurrence as well as the randomness and uncertainty associated with the natural phenomena and associated structural and social response.

Probability of Exceedance. A measure (expressed as a percentage or ratio) of estimation of the chance that an event will meet or exceed a specified threshold (e.g., magnitude, intensity, or loss).

Pumping Plant. A facility that boosts water pressure to a higher elevation in both transmission and distribution systems. The plant is usually composed of a building, one or more pumps, electrical and mechanical equipment, and, in some cases, backup power systems.(ALA, 2001; modified by LeVal Lund, 9/19/01)

Ranking. A process of establishing the order of priority.

Raw Water. Water as it is found in nature. This water may be in lakes , rivers or below-ground aquifers. Water is classified as raw water before treatment. Raw water is generally not used for drinking water because it does not conform to water quality requirements set by various Federal and State agencies. (ALA, 2001)

Reachability Matrix. A matrix which determines for each node and/or link in a water system whether or not there is a connection or series of connections by which water can theoretically move from the first node and/or link to the latter node and/or link. Reachability matrices are used to determine whether or not a pathway exist from water sources to demand nodes. However, reachability matrices do not determine whether or not pressures are adequate to service demand nodes either for domestic or for fire-flow purposes.

Reclaimed Water. Wastewater that has been through primary and secondary treatment, and perhaps tertiary treatment, so that it may be reused, generally for non-potable purposes. In some cities, separate distribution systems are built to deliver reclaimed water for irrigation or industrial purposes, groundwater recharge, and to supply water to fire hydrants. (LeVal Lund, 9/19/01)

Recurrence Interval. The average time span between like events (such as large hazard intensities exceeding a particular intensity) at a particular site or for a specific region (also termed return period).

Residual Risk. The remaining risk after risk management techniques have been applied.

Response Spectrum. A plot of maximum amplitudes (acceleration, velocity or displacement) of a damped, single degree of freedom oscillator (SDOF) as the natural period of the SDOF is varied across a spectrum of engineering interest (typically, for natural periods form 0.03 to 3 or more seconds, or frequencies of 0.3 to 30+ hertz). Response spectra are tabulated or plotted for specified levels of viscous damping, typically 5%.

Richter Scale. A system developed by American seismologist Charles Richter in 1935 to measure the strength (or **magnitude**) of an earthquake, indicating the energy released in an event. Owing to limitations in the instrument used (a Wood-Anderson Seismograph) and the waves it measures, this scale has been supplement by other, more comprehensive measure of earthquake size (often moment magnitude, M_w).

Risk. The chance of adverse consequences. (modified from FEMA, 1997) The combination of the expected likelihood and the consequences of incidents that could result from a particular activity. (AWWARF, 1998)

Risk Assessment. An evaluation of the risk associated with a specific hazard. Quantitative elements of this assessment are defined in terms of probabilities and/or frequencies of occurrence and severity of consequences. (modified from FEMA, 1997)

Risk-Based System Performance Metrics. System performance metrics that are based on the evaluation of how the system responds to a random suite of natural hazards events (scenarios). Financial and economic methods tend to require a risk-based evaluation in order to avoid under-estimation of the benefits of proposed risk-reduction measures..

Risk Reduction Measures. Those activities that reduce overall the costs and risks associated with specific hazards.

Risk Transference. A risk management technique to remove risk from one area to another or one party to another. Insurance transfers risk of financial loss from the insured to the insurer.

Scenario A type of event as defined by its natural hazard source parameters. That is, a scenario is defined by the source (the initiating event, e.g., the initial location and its severity expressed in such terms as magnitude or wind velocity), which may have many variable consequences dependent on random factors. A simulation is the assessment of these random factors to define specifically the consequences of the specific source event.

Scenario Loss. The loss from one scenario event (given specific values of the random values for other factors not defining the specific scenario).

Seiche. A standing wave oscillation of an enclosed water body that continues, pendulum fashion, after the cessation of the originating force, which may have been either seismic or atmospheric. (ANS, 1978, p. 2)

Seismicity. The geographic and historical distribution of past historic or future expected earthquakes.

Seismic Zonation. Geographic delineation of areas having different potentials for hazardous effects from future earthquakes. Seismic zonation can be done at any scale—national, regional, or local. For example, California has two Seismic Zones as identified in the 1997 Uniform Building Code (UBC): Zone 3 and Zone 4. Zone 3 is the less seismically active area and is located in the northern-central valley of the State extending from the northern border to Bakersfield, plus a portion of the desert area east of the San Bernadino Mountains. This is a large portion of the State and includes Sacramento. Zone 4 is the most seismically active area and is located along the western coast of the State extending from Eureka to San Diego. This is a large portion of the State and includes most of the inland area from Bakersfield to the southern border.

Series System or Sub-system. A system or sub-system that is non-redundant, lacking multiple water sources and lacking multiple pathways to the service connections or fire hydrants. For an antonym, see parallel system or sub-system.

Severe Environmental Load. A load that could infrequently be encountered during the operating life of a water system component or the water system as a whole. (modified from ANS, 1978, p. 2)

Simulation. The exercise or use of a model (AIAA G-077-1998); a simulated event based on modeling.

Site Amplification. See **Amplification.**

Slip. The relative displacement of formerly adjacent points on opposite sides of a fault, measured on the fault surface.

Slip Model. A kinematic model that describes the amount, distribution, and timing of slip associated with a real or postulated earthquake.

Slip Rate. The average rate of displacement at a point along a fault as determined from geodetic measurements, from offset man-made structures, or from offset geologic features whose age can be estimated.

A Snow Avalanche. A slope failure composed of a mass of rapidly moving, fluidized snow that slides down a mountainside. (FEMA, 1997)

Soil or Rock Slides. Downward displacement along one or more failure surfaces. (FEMA, 1997)

Soil Profile. The vertical arrangement of soil horizons down to the parent material or to bedrock. Under current building codes (e.g., the Uniform Building Code, the International Building Code) and FEMA NEHRP guidelines, the soil profile may be categorized by average shear wave velocity in the upper 30m of sediments.

Source. The geologic structure that generates a particular earthquake or class of earthquakes.

Spectrum Amplification Factor. The ratio of a response spectral parameter to the ground motion parameter (where parameter refers to **acceleration,** velocity or displacement).

Storm Surge. When the water level of a tidally influenced body of water increases above the normal astronomical high tide. (FEMA, 1997)

Strike. The approximate direction of the intersection of a fault and the surface of the earth, usually measured from North. (e.g., the fault strike is N 60 degrees W)

A Swelling Clay. A clay (a natural, earthy, fine-grained material that develops plasticity when mixed with a limited amount of water) that is capable of absorbing large quantities of water and so increasing greatly in volume. (FEMA, 1997)

System Performance Metrics. Quantitative measures by which the performance of a system may be evaluated.

System Performance Objectives. See **Performance Objectives.**

System State. A state of the overall water system or network in which water components that bear on water service from source to service connection or fire hydrant are modeled as being fully operational, partially operational, or inoperable.

System Risk Evaluation. The evaluation of the probabilities of adverse consequences to the system. A more thorough evaluation than merely the evaluation of the system at risk, the severity and likelihood of natural hazards, or the vulnerability of components to natural hazards.

System Vulnerability Evaluation. The evaluation of system performance relative to a small number of selected natural hazard states or scenarios. Generally suitable for emergency planning, but not for financial evaluations that require a Systems Risk Evaluation.

System Vulnerability Model. See Vulnerability Function or Model.

Tanks. A vessel that holds water. Water tanks are usually circular in shape, built of steel, concrete or wood—most often redwood. Tanks can be elevated by columns; built "at grade" to rest directly on the ground or on a foundation on the ground; or buried. Also, in some smaller parts of distribution systems, water can be stored in pressure tanks, which are small horizontal cylindrical pressure vessels on supports, at grade. (ALA, 2001; modified by LeVal Lund, 9/19/01)

Tornado. A rapidly rotating vortex or funnel of air extending groundward from a cumulonimbus cloud. (FEMA, 1997.) A violently rotating column of air pendent from a convective type cloud and nearly always observable as a funnel cloud or tube. Tornadoes have large rotational wind speeds, pressure gradients along their radii and translational movement. A tornado can create structural loadings. A tornado has the potential for creating missiles, the characteristics of which depend on the intensity of the tornado. (ANS, 1978, p. 2)

Water Transmission System. A system that stores "raw" water and delivers it to water treatment plants. Such a system is made up of canals, tunnels, elevated aqueducts, buried pipelines, pumping plants and reservoirs. (ALA, 2001) See also **Distribution System.**

Treated Water. Water that has been processed to meet water quality requirements set by various Federal and State agencies. Under normal conditions, water flowing out of taps in residences is treated water. (ALA, 2001)

Tropical Cyclone. A low pressure area of closed circulation winds that originates over tropical waters. Winds rotate counterclockwise in the Northern Hemisphere. (FEMA, 1997)

Tsunamis. A series of sea or lake waves produced from the displacement of water by either a local or distant submarine earthquake, volcanic eruption, submarine or coastal landslide. A tsunami may cause flooding loss, impact loads from waves or floating debris, or both, and erosion of earth foundations from structures. (modified from ANS, 1978, p. 2)

Vulnerability Function or Model.   A generic function or model relating for components the severity of adverse consequences to some measure of the severity of the hazard and for systems the severity of adverse consequences to the state of the disrupted system. If treated probabilistically, in terms of damage states for a specific component or type of component, a vulnerability function is a component fragility function. Being generic, a vulnerability function or model can also be treated deterministically as the best estimate of adverse consequences (and possibly their confidence levels) relative to a specific hazard severity. Vulnerability models can also be developed for systems, to relate the degree of system degradation or loss as a function of the operability of its individual components. (modified from ALA, 2001)

Water Wells. Used in many cities as both a primary and supplementary source of water, wells include a shaft from the ground surface to the aquifer, a pump to bring the water up to the surface, equipment used to treat the water, and a building to enclose the well and other electrical or mechanical equipment. (ALA, 2001)

Yield. The point at which a structural element or material begins to lose its ability to resist any additional applied load. The transition point between elastic and inelastic behavior. Yielding describes the continued inelastic deformation under load prior to loss of load-carrying capacity or sudden brittle failure. For ductile materials having a linear stress/strain behavior, yield can be defined as the departure of material response from this linear behavior due to permanent strain.

Appendix A: Natural Hazard Rankings by County

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Autauga	Alabama	1001	Low	Mod	Mod	Low	NOQ3	Low
Baldwin	Alabama	1003	Low	Low	High	Mod	Q3	Low
Barbour	Alabama	1005	Low	Low	Mod	Low	Q3	Low
Bibb	Alabama	1007	Mod	Mod	Mod	Low	NOQ3	Low
Blount	Alabama	1009	Mod	High	Mod	Mod	NOQ3	Mod
Bullock	Alabama	1011	Low	Low	Mod	Low	NOQ3	Low
Butler	Alabama	1013	Low	Low	Mod	Low	NOQ3	Low
Calhoun	Alabama	1015	Mod	High	Low	Low	Q3	Mod
Chambers	Alabama	1017	Mod	Low	Mod	Low	NOQ3	Mod
Cherokee	Alabama	1019	Mod	High	Low	Low	NOQ3	Mod
Chilton	Alabama	1021	Mod	Mod	Mod	Low	NOQ3	Low
Choctaw	Alabama	1023	Low	High	Mod	Low	NOQ3	Low
Clarke	Alabama	1025	Low	High	High	Low	NOQ3	Low
Clay	Alabama	1027	Mod	High	Mod	Mod	NOQ3	Low
Cleburne	Alabama	1029	Mod	High	Low	Low	NOQ3	Mod
Coffee	Alabama	1031	Low	Low	High	Mod	Q3	Low
Colbert	Alabama	1033	Mod	Mod	Mod	Mod	NOQ3	Mod
Conecuh	Alabama	1035	Low	Low	High	Low	Q3	Low
Coosa	Alabama	1037	Mod	Low	Mod	Low	NOQ3	Low
Covington	Alabama	1039	Low	Low	High	Low	Q3	Low
Crenshaw	Alabama	1041	Low	Low	Mod	Low	NOQ3	Low
Cullman	Alabama	1043	Mod	High	Mod	Mod	NOQ3	Mod
Dale	Alabama	1045	Low	Low	Mod	Mod	Q3	Low
Dallas	Alabama	1047	Low	Low	Mod	Low	Q3	Low
De Kalb	Alabama	1049	Mod	High	Mod	Mod	NOQ3	Mod
Elmore	Alabama	1051	Low	Mod	Mod	Low	NOQ3	Low
Escambia	Alabama	1053	Low	Low	High	Low	NOQ3	Low
Etowah	Alabama	1055	Mod	High	Mod	Mod	NOQ3	Mod
Fayette	Alabama	1057	Mod	High	Mod	Mod	NOQ3	Mod
Franklin	Alabama	1059	Mod	Mod	Low	Low	NOQ3	Mod
Geneva	Alabama	1061	Low	Low	High	Low	Q3	Low
Greene	Alabama	1063	Mod	Low	Mod	Low	NOQ3	Low
Hale	Alabama	1065	Mod	Mod	Mod	Low	NOQ3	Low
Henry	Alabama	1067	Low	Low	Mod	Low	Q3	Low
Houston	Alabama	1069	Low	Low	Mod	Low	Q3	Low
Jackson	Alabama	1071	Mod	High	Low	Low	NOQ3	Mod
Jefferson	Alabama	1073	Mod	Mod	Mod	Low	Q3	Low
Lamar	Alabama	1075	Mod	Mod	Low	Low	NOQ3	Mod
Lauderdale	Alabama	1077	Mod	Mod	Low	Low	NOQ3	Mod
Lawrence	Alabama	1079	Mod	High	Low	Low	NOQ3	Mod
Lee	Alabama	1081	Low	High	Mod	Low	NOQ3	Mod
Limestone	Alabama	1083	Mod	Mod	Low	Low	Q3	Mod
Lowndes	Alabama	1085	Low	Low	Mod	Low	NOQ3	Low
Macon	Alabama	1087	Low	High	Mod	Low	NOQ3	Low
Madison	Alabama	1089	Mod	Mod	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Marengo	Alabama	1091	Low	Mod	Mod	Low	NOQ3	Low
Marion	Alabama	1093	Mod	Mod	Low	Low	NOQ3	Mod
Marshall	Alabama	1095	Mod	High	Low	Low	NOQ3	Mod
Mobile	Alabama	1097	Low	Mod	High	Low	Q3	Low
Monroe	Alabama	1099	Low	Low	High	Low	NOQ3	Low
Montgomery	Alabama	1101	Low	Low	Mod	Low	Q3	Low
Morgan	Alabama	1103	Mod	Mod	Low	Low	Q3	Mod
Perry	Alabama	1105	Mod	Mod	Mod	Low	NOQ3	Low
Pickens	Alabama	1107	Mod	Mod	Mod	Low	NOQ3	Mod
Pike	Alabama	1109	Low	Low	Mod	Mod	NOQ3	Low
Randolph	Alabama	1111	Mod	Low	Mod	Low	Q3	Mod
Russell	Alabama	1113	Low	High	Mod	Low	Q3	Mod
Shelby	Alabama	1117	Mod	Mod	Mod	Low	NOQ3	Low
St Clair	Alabama	1115	Mod	High	Low	Low	Q3	Mod
Sumter	Alabama	1119	Low	Low	Mod	Low	NOQ3	Low
Talladega	Alabama	1121	Mod	High	Mod	Mod	Q3	Low
Tallapoosa	Alabama	1123	Mod	Low	Mod	Low	NOQ3	Low
Tuscaloosa	Alabama	1125	Mod	Mod	Mod	Low	Q3	Mod
Walker	Alabama	1127	Mod	High	Mod	Mod	NOQ3	Mod
Washington	Alabama	1129	Low	High	High	Low	NOQ3	Low
Wilcox	Alabama	1131	Low	Mod	Mod	Low	NOQ3	Low
Winston	Alabama	1133	Mod	High	Low	Low	NOQ3	Mod
Aleutians East	Alaska	2013	High	Low	High	Low	NOQ3	Low
Aleutians West	Alaska	2016	High	Low	High	Low	NOQ3	Low
Anchorage	Alaska	2020	High	Low	High	Low	NOQ3	Low
Bethel	Alaska	2050	Mod	Low	High	Low	NOQ3	Low
Bristol Bay	Alaska	2060	High	Low	High	Low	NOQ3	Low
Dillingham	Alaska	2070	Low	Low	High	Low	NOQ3	Low
Fairbanks North Star	Alaska	2090	Mod	Low	Low	Low	Q3	Low
Haines	Alaska	2100	Low	Low	High	Low	NOQ3	Low
Juneau	Alaska	2110	Low	Low	High	Low	NOQ3	Low
Kenai Peninsula	Alaska	2122	High	Low	High	Low	NOQ3	Low
Ketchikan Gateway	Alaska	2130	Low	Low	High	Low	NOQ3	Low
Kodiak Island	Alaska	2150	High	Low	High	Low	NOQ3	Low
Lake & Peninsula	Alaska	2164	High	Low	High	Low	NOQ3	Low
Matanuska-Susitna	Alaska	2170	Mod	Low	High	Low	NOQ3	Low
Nome	Alaska	2180	Low	Low	High	Low	NOQ3	Low
Northwest Arctic	Alaska	2188	Low	Low	High	Low	NOQ3	Low
Prince of Wales	Alaska	2201	Low	Low	High	Low	NOQ3	Low
SE Fairbanks	Alaska	2240	Mod	Low	Low	Low	NOQ3	Low
Sitka	Alaska	2220	Low	Low	High	Low	NOQ3	Low
Skagway-Yakutat-Ango	Alaska	2231	Low	Low	High	Low	NOQ3	Mod
Valdez-Cordova	Alaska	2261	High	Low	High	Low	NOQ3	Mod
Wade-Hampton	Alaska	2270	Low	Low	High	Low	NOQ3	Low
Wrangell-Petersburg	Alaska	2280	Low	Low	High	Low	NOQ3	Low
Yukon-koyukuk	Alaska	2290	Mod	Low	High	Low	NOQ3	Low
Apache	Arizona	4001	Mod	High	Low	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Cochise	Arizona	4003	Mod	High	Low	Low	Q3	Low
Coconino	Arizona	4005	Mod	High	Low	Low	Q3	Low
Gila	Arizona	4007	Mod	Mod	Low	Low	Q3	Low
Graham	Arizona	4009	Mod	Low	Low	Low	NOQ3	Low
Greenlee	Arizona	4011	Mod	Low	Low	Low	Q3	Low
La Paz	Arizona	4012	Mod	Low	Low	Low	NOQ3	Low
Maricopa	Arizona	4013	Mod	Low	Low	Low	Q3	Low
Mohave	Arizona	4015	Mod	High	Low	Low	Q3	Low
Navajo	Arizona	4017	Mod	High	Low	Low	Q3	Low
Pima	Arizona	4019	Mod	Low	Low	Low	Q3	Low
Pinal	Arizona	4021	Mod	High	Low	Low	NOQ3	Low
Santa Cruz	Arizona	4023	Mod	Mod	Low	Low	Q3	Low
Yavapai	Arizona	4025	Mod	Mod	Low	Low	Q3	Low
Yuma	Arizona	4027	Mod	Low	Low	Low	NOQ3	Low
Arkansas	Arkansas	5001	Mod	Low	Mod	Mod	NOQ3	High
Ashley	Arkansas	5003	Mod	Low	Low	Low	NOQ3	Mod
Baxter	Arkansas	5005	Mod	Low	Low	Low	Q3	High
Benton	Arkansas	5007	Low	Low	Mod	Mod	Q3	High
Boone	Arkansas	5009	Mod	Mod	Low	Low	NOQ3	High
Bradley	Arkansas	5011	Mod	Low	Low	Low	Q3	Mod
Calhoun	Arkansas	5013	Mod	Low	Low	Low	NOQ3	High
Carroll	Arkansas	5015	Mod	Mod	Low	Low	NOQ3	High
Chicot	Arkansas	5017	Mod	High	Low	Low	NOQ3	Mod
Clark	Arkansas	5019	Mod	High	Mod	Mod	NOQ3	High
Clay	Arkansas	5021	High	Low	Low	Low	NOQ3	High
Cleburne	Arkansas	5023	Mod	Mod	Mod	Mod	Q3	High
Cleveland	Arkansas	5025	Mod	Low	Low	Low	Q3	High
Columbia	Arkansas	5027	Low	Low	Mod	Mod	Q3	Mod
Conway	Arkansas	5029	Mod	Mod	Mod	Mod	NOQ3	High
Craighead	Arkansas	5031	High	Low	Mod	Mod	Q3	High
Crawford	Arkansas	5033	Low	Mod	Low	Low	NOQ3	High
Crittenden	Arkansas	5035	High	High	Low	Low	Q3	High
Cross	Arkansas	5037	High	Low	Low	Low	Q3	High
Dallas	Arkansas	5039	Mod	Low	Low	Low	Q3	High
Desha	Arkansas	5041	Mod	High	Low	Low	Q3	Mod
Drew	Arkansas	5043	Mod	Low	Low	Low	Q3	Mod
Faulkner	Arkansas	5045	Mod	Mod	Mod	Mod	Q3	High
Franklin	Arkansas	5047	Low	Mod	Low	Low	NOQ3	High
Fulton	Arkansas	5049	Mod	Low	Low	Low	NOQ3	High
Garland	Arkansas	5051	Mod	Mod	Mod	Mod	NOQ3	High
Grant	Arkansas	5053	Mod	Low	Low	Low	Q3	High
Greene	Arkansas	5055	High	Low	Mod	Mod	Q3	High
Hempstead	Arkansas	5057	Mod	High	Low	Low	NOQ3	High
Hot Spring	Arkansas	5059	Mod	High	Mod	Mod	NOQ3	High
Howard	Arkansas	5061	Low	Mod	Mod	Mod	NOQ3	High
Independence	Arkansas	5063	Mod	High	Mod	Mod	NOQ3	High
Izard	Arkansas	5065	Mod	Low	Low	Low	Q3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Jackson	Arkansas	5067	High	High	Mod	Mod	Q3	High
Jefferson	Arkansas	5069	Mod	Low	Low	Low	Q3	High
Johnson	Arkansas	5071	Mod	High	Mod	Mod	NOQ3	High
Lafayette	Arkansas	5073	Low	Low	Low	Low	Q3	Mod
Lawrence	Arkansas	5075	High	Low	Low	Low	NOQ3	High
Lee	Arkansas	5077	Mod	High	Low	Low	NOQ3	High
Lincoln	Arkansas	5079	Mod	Low	Low	Low	Q3	High
Little River	Arkansas	5081	Low	Low	Low	Low	NOQ3	High
Logan	Arkansas	5083	Mod	High	Low	Low	NOQ3	High
Lonoke	Arkansas	5085	Mod	High	Mod	Mod	Q3	High
Madison	Arkansas	5087	Mod	Mod	Low	Low	NOQ3	High
Marion	Arkansas	5089	Mod	Low	Low	Low	NOQ3	High
Miller	Arkansas	5091	Low	Low	Low	Low	NOQ3	High
Mississippi	Arkansas	5093	High	High	Mod	Mod	Q3	High
Monroe	Arkansas	5095	Mod	Low	Low	Low	Q3	High
Montgomery	Arkansas	5097	Mod	Mod	Low	Low	Q3	High
Nevada	Arkansas	5099	Mod	High	Low	Low	NOQ3	High
Newton	Arkansas	5101	Mod	High	Low	Low	NOQ3	High
Ouachita	Arkansas	5103	Mod	Low	Low	Low	Q3	High
Perry	Arkansas	5105	Mod	Mod	Low	Low	NOQ3	High
Phillips	Arkansas	5107	Mod	High	Low	Low	Q3	High
Pike	Arkansas	5109	Mod	Mod	Low	Low	NOQ3	High
Poinsett	Arkansas	5111	High	Low	Mod	Mod	Q3	High
Polk	Arkansas	5113	Low	Mod	Low	Low	NOQ3	High
Pope	Arkansas	5115	Mod	High	Low	Low	NOQ3	High
Prairie	Arkansas	5117	Mod	Low	Mod	Mod	NOQ3	High
Pulaski	Arkansas	5119	Mod	High	Mod	Mod	Q3	High
Randolph	Arkansas	5121	Mod	Low	Low	Low	NOQ3	High
Saline	Arkansas	5125	Mod	High	Low	Low	NOQ3	High
Scott	Arkansas	5127	Low	High	Low	Low	NOQ3	High
Searcy	Arkansas	5129	Mod	High	Low	Low	NOQ3	High
Sebastian	Arkansas	5131	Low	High	Mod	Mod	Q3	High
Sevier	Arkansas	5133	Low	Low	Low	Low	NOQ3	High
Sharp	Arkansas	5135	Mod	Low	Low	Low	Q3	High
St Francis	Arkansas	5123	High	High	Low	Low	Q3	High
Stone	Arkansas	5137	Mod	High	Low	Low	Q3	High
Union	Arkansas	5139	Mod	Low	Low	Low	Q3	Mod
Van Buren	Arkansas	5141	Mod	Mod	Low	Low	Q3	High
Washington	Arkansas	5143	Low	Mod	Low	Low	NOQ3	High
White	Arkansas	5145	Mod	High	Mod	Mod	NOQ3	High
Woodruff	Arkansas	5147	High	Low	Mod	Mod	NOQ3	High
Yell	Arkansas	5149	Mod	High	Low	Low	NOQ3	High
Alameda	California	6001	High	High	Low	Low	Q3	Low
Alpine	California	6003	High	Mod	Low	Low	NOQ3	Low
Amador	California	6005	Mod	Mod	Low	Low	Q3	Low
Butte	California	6007	Mod	High	Low	Low	NOQ3	Low
Calaveras	California	6009	Mod	Mod	Low	Low	Q3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Colusa	California	6011	High	High	Low	Low	Q3	Low
Contra Costa	California	6013	High	High	Low	Low	Q3	Low
Del Norte	California	6015	High	High	Low	Low	Q3	Low
El Dorado	California	6017	High	Mod	Low	Low	Q3	Low
Fresno	California	6019	High	High	Low	Low	Q3	Low
Glenn	California	6021	High	High	Low	Low	Q3	Low
Humboldt	California	6023	High	High	Low	Low	Q3	Low
Imperial	California	6025	High	Low	Low	Low	Q3	Low
Inyo	California	6027	High	High	Low	Low	Q3	Low
Kern	California	6029	High	High	Low	Low	Q3	Low
Kings	California	6031	High	High	Low	Low	Q3	Low
Lake	California	6033	High	High	Low	Low	Q3	Low
Lassen	California	6035	High	Low	Low	Low	Q3	Low
Los Angeles	California	6037	High	High	Low	Low	Q3	Low
Madera	California	6039	High	Low	Low	Low	Q3	Low
Marin	California	6041	High	High	Low	Low	Q3	Low
Mariposa	California	6043	Mod	Mod	Low	Low	Q3	Low
Mendocino	California	6045	High	High	Low	Low	Q3	Low
Merced	California	6047	High	High	Low	Low	Q3	Low
Modoc	California	6049	High	Mod	Low	Low	Q3	Low
Mono	California	6051	High	High	Low	Low	Q3	Low
Monterey	California	6053	High	High	Low	Low	Q3	Low
Napa	California	6055	High	High	Low	Low	Q3	Low
Nevada	California	6057	Mod	High	Low	Low	Q3	Low
Orange	California	6059	High	High	Mod	Mod	Q3	Low
Placer	California	6061	High	High	Low	Low	Q3	Low
Plumas	California	6063	High	Mod	Low	Low	Q3	Low
Riverside	California	6065	High	High	Low	Low	Q3	Low
Sacramento	California	6067	High	Mod	Low	Low	Q3	Low
San Benito	California	6069	High	High	Low	Low	Q3	Low
San Bernardino	California	6071	High	High	Low	Low	Q3	Low
San Diego	California	6073	High	High	Low	Low	NOQ3	Low
San Francisco	California	6075	High	Mod	Low	Low	NOQ3	Low
San Joaquin	California	6077	High	High	Low	Low	Q3	Low
San Mateo	California	6081	High	High	Low	Low	Q3	Low
Sanluis Obispo	California	6079	High	High	Low	Low	Q3	Low
Santa Barbara	California	6083	High	High	Low	Low	Q3	Low
Santa Clara	California	6085	High	High	Low	Low	Q3	Low
Santa Cruz	California	6087	High	High	Low	Low	Q3	Low
Shasta	California	6089	High	High	Low	Low	Q3	Low
Sierra	California	6091	High	Mod	Low	Low	Q3	Low
Siskiyou	California	6093	High	High	Low	Low	Q3	Low
Solano	California	6095	High	High	Low	Low	Q3	Low
Sonoma	California	6097	High	High	Low	Low	Q3	Low
Stanislaus	California	6099	High	High	Low	Low	Q3	Low
Sutter	California	6101	Mod	Low	Low	Low	Q3	Low
Tehama	California	6103	High	High	Low	Low	Q3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Trinity	California	6105	High	High	Low	Low	Q3	Low
Tulare	California	6107	Mod	Mod	Low	Low	Q3	Low
Tuolumne	California	6109	High	Mod	Low	Low	Q3	Low
Ventura	California	6111	High	High	Low	Low	Q3	Low
Yolo	California	6113	High	Mod	Low	Low	Q3	Low
Yuba	California	6115	Mod	Mod	Low	Low	Q3	Low
Adams	Colorado	8001	Low	High	Mod	Mod	Q3	Low
Alamosa	Colorado	8003	Mod	Mod	Low	Low	NOQ3	Low
Arapahoe	Colorado	8005	Low	High	Mod	Mod	Q3	Low
Archuleta	Colorado	8007	Mod	High	Low	Low	NOQ3	Low
Baca	Colorado	8009	Low	High	Low	Low	NOQ3	Mod
Bent	Colorado	8011	Low	High	Low	Low	NOQ3	Low
Boulder	Colorado	8013	Mod	High	Low	Low	Q3	Low
Chaffee	Colorado	8015	Mod	High	Low	Low	NOQ3	Low
Cheyenne	Colorado	8017	Low	Mod	Low	Low	NOQ3	Mod
Clear Creek	Colorado	8019	Mod	Mod	Low	Low	NOQ3	Low
Conejos	Colorado	8021	Mod	High	Low	Low	NOQ3	Low
Costilla	Colorado	8023	Mod	High	Low	Low	NOQ3	Low
Crowley	Colorado	8025	Low	Mod	Low	Low	NOQ3	Low
Custer	Colorado	8027	Mod	High	Low	Low	NOQ3	Low
Delta	Colorado	8029	Mod	High	Low	Low	NOQ3	Low
Denver	Colorado	8031	Mod	Mod	Mod	Mod	Q3	Low
Dolores	Colorado	8033	Mod	High	Low	Low	NOQ3	Low
Douglas	Colorado	8035	Mod	Mod	Mod	Mod	NOQ3	Low
Eagle	Colorado	8037	Mod	High	Low	Low	NOQ3	Low
El Paso	Colorado	8041	Low	High	Mod	Mod	Q3	Low
Elbert	Colorado	8039	Low	High	Mod	Mod	NOQ3	Low
Fremont	Colorado	8043	Mod	High	Low	Low	NOQ3	Low
Garfield	Colorado	8045	Mod	High	Low	Low	NOQ3	Low
Gilpin	Colorado	8047	Mod	Mod	Low	Low	NOQ3	Low
Grand	Colorado	8049	Mod	High	Low	Low	NOQ3	Low
Gunnison	Colorado	8051	Mod	High	Low	Low	NOQ3	Low
Hinsdale	Colorado	8053	Mod	High	Low	Low	NOQ3	Low
Huerfano	Colorado	8055	Mod	High	Low	Low	NOQ3	Low
Jackson	Colorado	8057	Mod	High	Low	Low	NOQ3	Low
Jefferson	Colorado	8059	Mod	Mod	Low	Low	Q3	Low
Kiowa	Colorado	8061	Low	High	Low	Low	NOQ3	Mod
Kit Carson	Colorado	8063	Low	Mod	Mod	Mod	NOQ3	Mod
La Plata	Colorado	8067	Mod	High	Low	Low	NOQ3	Low
Lake	Colorado	8065	Mod	High	Low	Low	NOQ3	Low
Larimer	Colorado	8069	Mod	High	Low	Low	Q3	Low
Las Animas	Colorado	8071	Mod	High	Low	Low	NOQ3	Low
Lincoln	Colorado	8073	Low	High	Low	Low	NOQ3	Low
Logan	Colorado	8075	Low	Low	Low	Low	NOQ3	Low
Mesa	Colorado	8077	Mod	High	Low	Low	NOQ3	Low
Mineral	Colorado	8079	Mod	High	Low	Low	NOQ3	Low
Moffat	Colorado	8081	Mod	High	Low	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Montezuma	Colorado	8083	Mod	High	Low	Low	NOQ3	Low
Montrose	Colorado	8085	Mod	High	Low	Low	NOQ3	Low
Morgan	Colorado	8087	Low	High	Mod	Mod	Q3	Low
Otero	Colorado	8089	Low	High	Low	Low	NOQ3	Low
Ouray	Colorado	8091	Mod	High	Low	Low	NOQ3	Low
Park	Colorado	8093	Mod	High	Low	Low	NOQ3	Low
Phillips	Colorado	8095	Low	Low	Mod	Mod	NOQ3	Mod
Pitkin	Colorado	8097	Mod	High	Low	Low	NOQ3	Low
Prowers	Colorado	8099	Low	High	Mod	Mod	NOQ3	Mod
Pueblo	Colorado	8101	Mod	High	Low	Low	Q3	Low
Rio Blanco	Colorado	8103	Mod	High	Low	Low	NOQ3	Low
Rio Grande	Colorado	8105	Mod	High	Low	Low	NOQ3	Low
Routt	Colorado	8107	Mod	High	Low	Low	NOQ3	Low
Saguache	Colorado	8109	Mod	High	Low	Low	NOQ3	Low
San Juan	Colorado	8111	Mod	High	Low	Low	NOQ3	Low
San Miguel	Colorado	8113	Mod	High	Low	Low	NOQ3	Low
Sedgwick	Colorado	8115	Low	Low	Mod	Mod	NOQ3	Mod
Summit	Colorado	8117	Mod	High	Low	Low	NOQ3	Low
Teller	Colorado	8119	Mod	Mod	Low	Low	NOQ3	Low
Washington	Colorado	8121	Low	High	Mod	Mod	NOQ3	Low
Weld	Colorado	8123	Mod	High	Mod	Mod	NOQ3	Low
Yuma	Colorado	8125	Low	Mod	Mod	Mod	NOQ3	Mod
Fairfield	Connecticut	9001	Mod	Mod	High	Low	Q3	Mod
Hartford	Connecticut	9003	Mod	High	Mod	Low	Q3	High
Litchfield	Connecticut	9005	Mod	Low	Mod	Low	Q3	High
Middlesex	Connecticut	9007	Mod	High	High	Low	Q3	High
New Haven	Connecticut	9009	Mod	Mod	High	Low	Q3	Mod
New London	Connecticut	9011	Mod	Low	High	Low	Q3	Mod
Tolland	Connecticut	9013	Mod	Low	Mod	Low	Q3	High
Windham	Connecticut	9015	Mod	Low	High	Low	NOQ3	High
Kent	Delaware	10001	Mod	Low	Mod	Mod	Q3	Mod
New Castle	Delaware	10003	Mod	Mod	Mod	Mod	Q3	Mod
Sussex	Delaware	10005	Low	Low	High	Low	Q3	Mod
Washington	District of C	olumbia1 1001	Low	High	Low	Low	Q3	Mod
Alachua	Florida	12001	Low	Low	Mod	Mod	Q3	Low
Baker	Florida	12003	Low	Low	Mod	Low	Q3	Low
Bay	Florida	12005	Low	Low	High	Mod	Q3	Low
Bradford	Florida	12007	Low	Low	Mod	Mod	NOQ3	Low
Brevard	Florida	12009	Low	Low	High	Mod	Q3	Low
Broward	Florida	12011	Low	Low	High	Mod	Q3	Low
Calhoun	Florida	12013	Low	Low	High	Low	Q3	Low
Charlotte	Florida	12015	Low	Low	High	Mod	Q3	Low
Citrus	Florida	12017	Low	Low	High	Mod	Q3	Low
Clay	Florida	12019	Low	Low	High	Mod	Q3	Low
Collier	Florida	12021	Low	Low	High	Low	Q3	Low
Columbia	Florida	12023	Low	Low	Mod	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Dade	Florida	12025	Low	Low	High	Mod	Q3	Low
De Soto	Florida	12027	Low	Low	High	Mod	Q3	Low
Dixie	Florida	12029	Low	Low	High	Low	Q3	Low
Duval	Florida	12031	Low	Low	High	Mod	Q3	Low
Escambia	Florida	12033	Low	Low	High	Mod	Q3	Low
Flagler	Florida	12035	Low	Low	High	Mod	Q3	Low
Franklin	Florida	12037	Low	Low	High	Mod	Q3	Low
Gadsden	Florida	12039	Low	Mod	Mod	Mod	Q3	Low
Gilchrist	Florida	12041	Low	Low	Mod	Low	Q3	Low
Glades	Florida	12043	Low	Low	High	Low	Q3	Low
Gulf	Florida	12045	Low	Low	High	Mod	Q3	Low
Hamilton	Florida	12047	Low	Low	Mod	Low	NOQ3	Low
Hardee	Florida	12049	Low	Low	Mod	Low	Q3	Low
Hendry	Florida	12051	Low	Low	High	Low	Q3	Low
Hernando	Florida	12053	Low	Low	High	Mod	Q3	Low
Highlands	Florida	12055	Low	Low	High	Mod	Q3	Low
Hillsborough	Florida	12057	Low	Low	High	Mod	Q3	Low
Holmes	Florida	12059	Low	Low	High	Low	Q3	Low
Indian River	Florida	12061	Low	Low	High	Mod	Q3	Low
Jackson	Florida	12063	Low	Low	High	Mod	Q3	Low
Jefferson	Florida	12065	Low	Low	High	Low	NOQ3	Low
Lafayette	Florida	12067	Low	Low	High	Low	NOQ3	Low
Lake	Florida	12069	Low	Low	High	Mod	Q3	Low
Lee	Florida	12071	Low	Low	High	Mod	Q3	Low
Leon	Florida	12073	Low	Mod	High	Low	Q3	Low
Levy	Florida	12075	Low	Low	High	Low	Q3	Low
Liberty	Florida	12077	Low	Mod	High	Low	Q3	Low
Madison	Florida	12079	Low	Low	Mod	Low	NOQ3	Low
Manatee	Florida	12081	Low	Low	High	Mod	Q3	Low
Marion	Florida	12083	Low	Low	Mod	Mod	Q3	Low
Martin	Florida	12085	Low	Low	High	Mod	Q3	Low
Monroe	Florida	12087	Low	Low	High	Mod	Q3	Low
Nassau	Florida	12089	Low	Low	High	Mod	Q3	Low
Okaloosa	Florida	12091	Low	Low	High	Mod	Q3	Low
Okeechobee	Florida	12093	Low	Low	High	Low	NOQ3	Low
Orange	Florida	12095	Low	Low	High	Mod	Q3	Low
Osceola	Florida	12097	Low	Low	High	Low	Q3	Low
Palm Beach	Florida	12099	Low	Low	High	Mod	Q3	Low
Pasco	Florida	12101	Low	Low	High	Mod	Q3	Low
Pinellas	Florida	12103	Low	Low	High	Hig	h Q3	Low
Polk	Florida	12105	Low	Low	High	Mod	Q3	Low
Putnam	Florida	12107	Low	Low	High	Mod	Q3	Low
Santa Rosa	Florida	12113	Low	Low	High	Mod	Q3	Low
Sarasota	Florida	12115	Low	Low	High	Mod	Q3	Low
Seminole	Florida	12117	Low	Low	High	Mod	Q3	Low
St Johns	Florida	12109	Low	Low	High	Mod	Q3	Low
St Lucie	Florida	12111	Low	Low	High	Mod	Q3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Sumter	Florida	12119	Low	Low	Mod	Low	Q3	Low
Suwannee	Florida	12121	Low	Low	Mod	Mod	Q3	Low
Taylor	Florida	12123	Low	Low	High	Low	NOQ3	Low
Union	Florida	12125	Low	Low	Mod	Low	NOQ3	Low
Volusia	Florida	12127	Low	Low	High	Mod	Q3	Low
Wakulla	Florida	12129	Low	Low	High	Low	Q3	Low
Walton	Florida	12131	Low	Low	High	Mod	Q3	Low
Washington	Florida	12133	Low	Low	High	Low	Q3	Low
Appling	Georgia	13001	Mod	Low	Mod	Low	NOQ3	Low
Atkinson	Georgia	13003	Low	Low	Mod	Low	NOQ3	Low
Bacon	Georgia	13005	Low	Low	Mod	Mod	NOQ3	Low
Baker	Georgia	13007	Low	Low	Mod	Low	Q3	Low
Baldwin	Georgia	13009	Mod	Low	Mod	Low	NOQ3	Mod
Banks	Georgia	13011	Mod	High	Low	Low	NOQ3	Mod
Barrow	Georgia	13013	Mod	High	Low	Low	NOQ3	Mod
Bartow	Georgia	13015	Mod	High	Mod	Mod	NOQ3	Mod
Ben Hill	Georgia	13017	Low	Low	Mod	Mod	NOQ3	Low
Berrien	Georgia	13019	Low	Low	Mod	Mod	NOQ3	Low
Bibb	Georgia	13021	Low	Low	Mod	Mod	Q3	Mod
Bleckley	Georgia	13023	Low	Low	Mod	Mod	NOQ3	Mod
Brantley	Georgia	13025	Low	Low	High	Low	NOQ3	Low
Brooks	Georgia	13027	Low	Low	Mod	Low	NOQ3	Low
Bryan	Georgia	13029	Mod	Low	High	Low	Q3	Low
Bulloch	Georgia	13031	Mod	Low	High	Low	NOQ3	Low
Burke	Georgia	13033	Mod	Low	Mod	Low	NOQ3	Mod
Butts	Georgia	13035	Mod	Low	Low	Low	Q3	Mod
Calhoun	Georgia	13037	Low	Low	Mod	Low	Q3	Low
Camden	Georgia	13039	Low	Low	High	Low	Q3	Low
Candler	Georgia	13043	Mod	Low	Mod	Low	NOQ3	Low
Carroll	Georgia	13045	Mod	High	Mod	Mod	Q3	Mod
Catoosa	Georgia	13047	Mod	Mod	Low	Low	NOQ3	Mod
Charlton	Georgia	13049	Low	Low	High	Low	NOQ3	Low
Chatham	Georgia	13051	Mod	Low	High	Mod	Q3	Low
Chattahoochee	Georgia	13053	Low	High	Mod	Low	NOQ3	Mod
Chattooga	Georgia	13055	Mod	Mod	Low	Low	NOQ3	Mod
Cherokee	Georgia	13057	Mod	High	Mod	Mod	Q3	Mod
Clarke	Georgia	13059	Mod	High	Mod	Mod	NOQ3	Mod
Clay	Georgia	13061	Low	Low	Mod	Low	NOQ3	Low
Clayton	Georgia	13063	Mod	Low	Mod	Mod	Q3	Mod
Clinch	Georgia	13065	Low	Low	Mod	Low	NOQ3	Low
Cobb	Georgia	13067	Mod	High	Mod	Mod	Q3	Mod
Coffee	Georgia	13069	Low	Low	Mod	Low	NOQ3	Low
Colquitt	Georgia	13071	Low	Low	Mod	Mod	NOQ3	Low
Columbia	Georgia	13073	Mod	Low	Mod	Low	NOQ3	Mod
Cook	Georgia	13075	Low	Low	Mod	Mod	NOQ3	Low
Coweta	Georgia	13077	Mod	Low	Mod	Mod	Q3	Mod
Crawford	Georgia	13079	Low	Low	Mod	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Crisp	Georgia	13081	Low	Low	Mod	Low	Q3	Low
Dade	Georgia	13083	Mod	High	Low	Low	NOQ3	Mod
Dawson	Georgia	13085	Mod	High	Mod	Mod	NOQ3	Mod
De Kalb	Georgia	13089	Mod	High	Mod	Mod	Q3	Mod
Decatur	Georgia	13087	Low	Mod	Mod	Mod	Q3	Low
Dodge	Georgia	13091	Low	Low	Mod	Low	Q3	Mod
Dooly	Georgia	13093	Low	Low	Mod	Mod	Q3	Mod
Dougherty	Georgia	13095	Low	Low	Mod	Mod	Q3	Low
Douglas	Georgia	13097	Mod	High	Mod	Mod	NOQ3	Mod
Early	Georgia	13099	Low	Low	Mod	Mod	Q3	Low
Echols	Georgia	13101	Low	Low	Mod	Low	NOQ3	Low
Effingham	Georgia	13103	Mod	Low	High	Low	NOQ3	Low
Elbert	Georgia	13105	Mod	High	Low	Low	NOQ3	Mod
Emanuel	Georgia	13107	Mod	Low	Mod	Low	NOQ3	Mod
Evans	Georgia	13109	Mod	Low	Mod	Low	NOQ3	Low
Fannin	Georgia	13111	Mod	High	Low	Low	NOQ3	Mod
Fayette	Georgia	13113	Mod	Low	Low	Low	Q3	Mod
Floyd	Georgia	13115	Mod	Mod	Mod	Mod	Q3	Mod
Forsyth	Georgia	13117	Mod	High	Low	Low	NOQ3	Mod
Franklin	Georgia	13119	Mod	High	Low	Low	NOQ3	Mod
Fulton	Georgia	13121	Mod	High	Mod	Mod	Q3	Mod
Gilmer	Georgia	13123	Mod	High	Low	Low	NOQ3	Mod
Glascock	Georgia	13125	Mod	Low	Mod	Low	NOQ3	Mod
Glynn	Georgia	13127	Low	Low	High	Mod	Q3	Low
Gordon	Georgia	13129	Mod	High	Low	Low	NOQ3	Mod
Grady	Georgia	13131	Low	Low	Mod	Mod	NOQ3	Low
Greene	Georgia	13133	Mod	Mod	Low	Low	NOQ3	Mod
Gwinnett	Georgia	13135	Mod	High	Low	Low	NOQ3	Mod
Habersham	Georgia	13137	Mod	High	Mod	Mod	NOQ3	Mod
Hall	Georgia	13139	Mod	High	Mod	Mod	NOQ3	Mod
Hancock	Georgia	13141	Mod	Low	Mod	Low	NOQ3	Mod
Haralson	Georgia	13143	Mod	High	Mod	Mod	Q3	Mod
Harris	Georgia	13145	Low	Low	Mod	Mod	NOQ3	Mod
Hart	Georgia	13147	Mod	High	Low	Low	NOQ3	Mod
Heard	Georgia	13149	Mod	Low	Mod	Low	NOQ3	Mod
Henry	Georgia	13151	Mod	Low	Low	Low	Q3	Mod
Houston	Georgia	13153	Low	Low	Mod	Mod	Q3	Mod
Irwin	Georgia	13155	Low	Low	Mod	Low	NOQ3	Low
Jackson	Georgia	13157	Mod	High	Low	Low	NOQ3	Mod
Jasper	Georgia	13159	Mod	Low	Mod	Low	NOQ3	Mod
Jeff Davis	Georgia	13161	Low	Low	Mod	Low	NOQ3	Low
Jefferson	Georgia	13163	Mod	Low	Mod	Low	NOQ3	Mod
Jenkins	Georgia	13165	Mod	Low	Mod	Low	NOQ3	Mod
Johnson	Georgia	13167	Mod	Low	Mod	Low	NOQ3	Mod
Jones	Georgia	13169	Mod	Low	Mod	Low	Q3	Mod
Lamar	Georgia	13171	Low	Low	Mod	Low	Q3	Mod
Lanier	Georgia	13173	Low	Low	Mod	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Laurens	Georgia	13175	Mod	Low	Mod	Low	NOQ3	Mod
Lee	Georgia	13177	Low	Low	Mod	Mod	Q3	Low
Liberty	Georgia	13179	Mod	Low	High	Low	Q3	Low
Lincoln	Georgia	13181	Mod	Mod	Mod	Low	NOQ3	Mod
Long	Georgia	13183	Mod	Low	High	Low	NOQ3	Low
Lowndes	Georgia	13185	Low	Low	Mod	Mod	NOQ3	Low
Lumpkin	Georgia	13187	Mod	High	Low	Low	NOQ3	Mod
Macon	Georgia	13193	Low	Low	Mod	Low	Q3	Mod
Madison	Georgia	13195	Mod	High	Low	Low	NOQ3	Mod
Marion	Georgia	13197	Low	High	Mod	Low	NOQ3	Mod
Mcduffie	Georgia	13189	Mod	Low	Mod	Low	NOQ3	Mod
Mcintosh	Georgia	13191	Mod	Low	High	Low	Q3	Low
Meriwether	Georgia	13199	Low	Low	Mod	Mod	Q3	Mod
Miller	Georgia	13201	Low	Low	Mod	Low	Q3	Low
Mitchell	Georgia	13205	Low	Low	Mod	Mod	Q3	Low
Monroe	Georgia	13207	Mod	Low	Mod	Low	Q3	Mod
Montgomery	Georgia	13209	Mod	Low	Mod	Low	Q3	Low
Morgan	Georgia	13211	Mod	Low	Low	Low	NOQ3	Mod
Murray	Georgia	13213	Mod	High	Mod	Mod	NOQ3	Mod
Muscogee	Georgia	13215	Low	High	Mod	Mod	NOQ3	Mod
Newton	Georgia	13217	Mod	High	Low	Low	Q3	Mod
Oconee	Georgia	13219	Mod	High	Mod	Mod	NOQ3	Mod
Oglethorpe	Georgia	13221	Mod	High	Low	Low	NOQ3	Mod
Paulding	Georgia	13223	Mod	High	Low	Low	NOQ3	Mod
Peach	Georgia	13225	Low	Low	Mod	Mod	Q3	Mod
Pickens	Georgia	13227	Mod	High	Mod	Mod	NOQ3	Mod
Pierce	Georgia	13229	Low	Low	Mod	Low	NOQ3	Low
Pike	Georgia	13231	Low	Low	Mod	Low	Q3	Mod
Polk	Georgia	13233	Mod	High	Low	Low	Q3	Mod
Pulaski	Georgia	13235	Low	Low	Mod	Mod	Q3	Mod
Putnam	Georgia	13237	Mod	Low	Mod	Low	NOQ3	Mod
Quitman	Georgia	13239	Low	Low	Mod	Low	Q3	Low
Rabun	Georgia	13241	Mod	High	Low	Low	NOQ3	Mod
Randolph	Georgia	13243	Low	Low	Mod	Low	NOQ3	Low
Richmond	Georgia	13245	Mod	Low	Mod	Low	Q3	Mod
Rockdale	Georgia	13247	Mod	High	Mod	Mod	Q3	Mod
Schley	Georgia	13249	Low	Low	Mod	Mod	NOQ3	Mod
Screven	Georgia	13251	Mod	Low	Mod	Low	NOQ3	Mod
Seminole	Georgia	13253	Low	Low	Mod	Low	Q3	Low
Spalding	Georgia	13255	Low	Low	Mod	Mod	Q3	Mod
Stephens	Georgia	13257	Mod	High	Mod	Mod	NOQ3	Mod
Stewart	Georgia	13259	Low	Low	Mod	Low	Q3	Mod
Sumter	Georgia	13261	Low	Low	Mod	Mod	Q3	Mod
Talbot	Georgia	13263	Low	Low	Mod	Low	Q3	Mod
Taliaferro	Georgia	13265	Mod	Mod	Mod	Low	NOQ3	Mod
Tattnall	Georgia	13267	Mod	Low	Mod	Low	NOQ3	Low
Taylor	Georgia	13269	Low	Low	Mod	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Telfair	Georgia	13271	Low	Low	Mod	Low	Q3	Low
Terrell	Georgia	13273	Low	Low	Mod	Low	Q3	Low
Thomas	Georgia	13275	Low	Low	Mod	Low	NOQ3	Low
Tift	Georgia	13277	Low	Low	Mod	Mod	NOQ3	Low
Toombs	Georgia	13279	Mod	Low	Mod	Low	Q3	Low
Towns	Georgia	13281	Mod	High	Low	Low	NOQ3	Mod
Treutlen	Georgia	13283	Mod	Low	Mod	Low	NOQ3	Mod
Troup	Georgia	13285	Low	Low	Mod	Mod	Q3	Mod
Turner	Georgia	13287	Low	Low	Mod	Low	NOQ3	Low
Twiggs	Georgia	13289	Mod	Low	Mod	Mod	NOQ3	Mod
Union	Georgia	13291	Mod	High	Low	Low	NOQ3	Mod
Upson	Georgia	13293	Low	Low	Mod	Low	Q3	Mod
Walker	Georgia	13295	Mod	Mod	Low	Low	NOQ3	Mod
Walton	Georgia	13297	Mod	High	Mod	Mod	NOQ3	Mod
Ware	Georgia	13299	Low	Low	Mod	Low	NOQ3	Low
Warren	Georgia	13301	Mod	Low	Mod	Low	NOQ3	Mod
Washington	Georgia	13303	Mod	Low	Mod	Low	NOQ3	Mod
Wayne	Georgia	13305	Mod	Low	High	Low	NOQ3	Low
Webster	Georgia	13307	Low	Low	Mod	Low	NOQ3	Mod
Wheeler	Georgia	13309	Low	Low	Mod	Low	Q3	Low
White	Georgia	13311	Mod	High	Low	Low	NOQ3	Mod
Whitfield	Georgia	13313	Mod	Mod	Low	Low	NOQ3	Mod
Wilcox	Georgia	13315	Low	Low	Mod	Low	Q3	Low
Wilkes	Georgia	13317	Mod	Mod	Mod	Low	NOQ3	Mod
Wilkinson	Georgia	13319	Mod	Low	Mod	Low	NOQ3	Mod
Worth	Georgia	13321	Low	Low	Mod	Mod	Q3	Low
Hawaii	Hawaii	15001	High	Low	High	Low	Q3	Low
Honolulu	Hawaii	15003	Mod	Low	High	Low	Q3	Low
Kauai	Hawaii	15007	Low	Low	High	Low	Q3	Low
Maui	Hawaii	15009	Mod	Low	High	Low	Q3	Low
Ada	Idaho	16001	Mod	High	Low	Low	Q3	Low
Adams	Idaho	16003	Mod	Mod	Low	Low	NOQ3	Low
Bannock	Idaho	16005	Mod	Low	Low	Low	NOQ3	Low
Bear Lake	Idaho	16007	High	Mod	Low	Low	NOQ3	Low
Benewah	Idaho	16009	Mod	Mod	Low	Low	Q3	Low
Bingham	Idaho	16011	Mod	Mod	Low	Low	Q3	Low
Blaine	Idaho	16013	Mod	High	Low	Low	Q3	Low
Boise	Idaho	16015	Mod	High	Low	Low	NOQ3	Low
Bonner	Idaho	16017	Mod	Low	Low	Low	Q3	Low
Bonneville	Idaho	16019	High	High	Low	Low	Q3	Low
Boundary	Idaho	16021	Mod	Mod	Low	Low	Q3	Low
Butte	Idaho	16023	Mod	High	Low	Low	NOQ3	Low
Camas	Idaho	16025	Mod	Mod	Low	Low	NOQ3	Low
Canyon	Idaho	16027	Mod	Mod	Low	Low	NOQ3	Low
Caribou	Idaho	16029	High	High	Low	Low	NOQ3	Low
Cassia	Idaho	16031	Mod	Mod	Low	Low	NOQ3	Low
Clark	Idaho	16033	High	High	Low	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Clearwater	Idaho	16035	Mod	Mod	Low	Low	NOQ3	Low
Custer	Idaho	16037	Mod	High	Low	Low	Q3	Low
Elmore	Idaho	16039	Mod	High	Low	Low	NOQ3	Low
Franklin	Idaho	16041	Mod	High	Low	Low	NOQ3	Low
Fremont	Idaho	16043	High	High	Low	Low	Q3	Low
Gem	Idaho	16045	Mod	Mod	Low	Low	Q3	Low
Gooding	Idaho	16047	Mod	Low	Low	Low	NOQ3	Low
Idaho	Idaho	16049	Mod	High	Low	Low	NOQ3	Low
Jefferson	Idaho	16051	Mod	Mod	Low	Low	Q3	Low
Jerome	Idaho	16053	Mod	Low	Low	Low	NOQ3	Low
Kootenai	Idaho	16055	Mod	Mod	Low	Low	Q3	Low
Latah	Idaho	16057	Mod	Low	Low	Low	NOQ3	Low
Lemhi	Idaho	16059	Mod	High	Low	Low	NOQ3	Low
Lewis	Idaho	16061	Mod	Low	Low	Low	NOQ3	Low
Lincoln	Idaho	16063	Mod	Low	Low	Low	NOQ3	Low
Madison	Idaho	16065	Mod	Mod	Low	Low	Q3	Low
Minidoka	Idaho	16067	Mod	Low	Low	Low	NOQ3	Low
Nez Perce	Idaho	16069	Mod	Low	Low	Low	NOQ3	Low
Oneida	Idaho	16071	Mod	High	Low	Low	NOQ3	Low
Owyhee	Idaho	16073	Mod	High	Low	Low	NOQ3	Low
Payette	Idaho	16075	Mod	Low	Low	Low	Q3	Low
Power	Idaho	16077	Mod	Mod	Low	Low	NOQ3	Low
Shoshone	Idaho	16079	Mod	Mod	Low	Low	Q3	Low
Teton	Idaho	16081	Mod	High	Low	Low	NOQ3	Low
Twin Falls	Idaho	16083	Mod	High	Low	Low	NOQ3	Low
Valley	Idaho	16085	Mod	High	Low	Low	NOQ3	Low
Washington	Idaho	16087	Mod	Mod	Low	Low	Q3	Low
Adams	Illinois	17001	Low	Mod	Low	Low	Q3	High
Alexander	Illinois	17003	High	High	Mod	Mod	Q3	High
Bond	Illinois	17005	Mod	Low	Low	Low	NOQ3	High
Boone	Illinois	17007	Low	Low	Low	Low	NOQ3	Mod
Brown	Illinois	17009	Low	Low	Low	Low	NOQ3	High
Bureau	Illinois	17011	Low	High	Low	Low	NOQ3	Mod
Calhoun	Illinois	17013	Mod	High	Low	Low	Q3	High
Carroll	Illinois	17015	Low	High	Low	Low	NOQ3	Mod
Cass	Illinois	17017	Low	Low	Low	Low	NOQ3	High
Champaign	Illinois	17019	Mod	Low	Mod	Mod	NOQ3	High
Christian	Illinois	17021	Mod	Low	Low	Low	NOQ3	High
Clark	Illinois	17023	Mod	Low	Low	Low	NOQ3	High
Clay	Illinois	17025	Mod	Mod	Low	Low	NOQ3	High
Clinton	Illinois	17027	Mod	Low	Low	Low	Q3	High
Coles	Illinois	17029	Mod	Mod	Mod	Mod	NOQ3	High
Cook	Illinois	17031	Mod	High	Mod	Mod	Q3	Mod
Crawford	Illinois	17033	Mod	Low	Mod	Mod	NOQ3	High
Cumberland	Illinois	17035	Mod	Low	Low	Low	NOQ3	High
De Kalb	Illinois	17037	Mod	Low	Low	Low	Q3	Mod
De Witt	Illinois	17039	Low	Low	Mod	Mod	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Douglas	Illinois	17041	Mod	Low	Mod	Mod	NOQ3	High
Du Page	Illinois	17043	Mod	Mod	Mod	Mod	Q3	Mod
Edgar	Illinois	17045	Mod	Mod	Low	Low	NOQ3	High
Edwards	Illinois	17047	Mod	Mod	Mod	Mod	NOQ3	High
Effingham	Illinois	17049	Mod	Low	Mod	Mod	NOQ3	High
Fayette	Illinois	17051	Mod	Low	Low	Low	NOQ3	High
Ford	Illinois	17053	Low	Mod	Mod	Mod	NOQ3	High
Franklin	Illinois	17055	Mod	Mod	Low	Low	NOQ3	High
Fulton	Illinois	17057	Low	High	Mod	Mod	NOQ3	High
Gallatin	Illinois	17059	Mod	Mod	Low	Low	Q3	High
Greene	Illinois	17061	Mod	High	Low	Low	NOQ3	High
Grundy	Illinois	17063	Mod	Mod	Mod	Mod	Q3	High
Hamilton	Illinois	17065	Mod	Mod	Low	Low	NOQ3	High
Hancock	Illinois	17067	Low	Low	Low	Low	NOQ3	High
Hardin	Illinois	17069	Mod	Low	Low	Low	Q3	High
Henderson	Illinois	17071	Low	High	Low	Low	NOQ3	Mod
Henry	Illinois	17073	Low	High	Mod	Mod	Q3	Mod
Iroquois	Illinois	17075	Low	Mod	Mod	Mod	NOQ3	High
Jackson	Illinois	17077	High	High	Mod	Mod	NOQ3	High
Jasper	Illinois	17079	Mod	Low	Low	Low	NOQ3	High
Jefferson	Illinois	17081	Mod	Mod	Low	Low	NOQ3	High
Jersey	Illinois	17083	Mod	High	Low	Low	Q3	High
Jo Daviess	Illinois	17085	Low	High	Low	Low	NOQ3	Mod
Johnson	Illinois	17087	High	Low	Low	Low	NOQ3	High
Kane	Illinois	17089	Mod	Low	Mod	Mod	Q3	Mod
Kankakee	Illinois	17091	Low	Mod	Mod	Mod	Q3	High
Kendall	Illinois	17093	Mod	Mod	Mod	Mod	Q3	Mod
Knox	Illinois	17095	Low	High	Mod	Mod	NOQ3	High
La Salle	Illinois	17099	Mod	High	Mod	Mod	Q3	High
Lake	Illinois	17097	Low	High	Mod	Mod	Q3	Mod
Lawrence	Illinois	17101	Mod	Mod	Low	Low	NOQ3	High
Lee	Illinois	17103	Mod	Low	Mod	Mod	NOQ3	Mod
Livingston	Illinois	17105	Low	High	Low	Low	Q3	High
Logan	Illinois	17107	Mod	Low	Mod	Mod	NOQ3	High
Macon	Illinois	17115	Mod	Low	Mod	Mod	NOQ3	High
Macoupin	Illinois	17117	Mod	High	Low	Low	NOQ3	High
Madison	Illinois	17119	Mod	High	Mod	Mod	Q3	High
Marion	Illinois	17121	Mod	Low	Low	Low	NOQ3	High
Marshall	Illinois	17123	Low	High	Low	Low	NOQ3	High
Mason	Illinois	17125	Low	High	Mod	Mod	NOQ3	High
Massac	Illinois	17127	High	Low	Low	Low	Q3	High
Mcdonough	Illinois	17109	Low	Low	Mod	Mod	NOQ3	High
Mchenry	Illinois	17111	Low	Low	Low	Low	Q3	Mod
Mclean	Illinois	17113	Low	Low	Mod	Mod	NOQ3	High
Menard	Illinois	17129	Low	Low	Low	Low	NOQ3	High
Mercer	Illinois	17131	Low	High	Low	Low	NOQ3	Mod
Monroe	Illinois	17133	Mod	High	Mod	Mod	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Montgomery	Illinois	17135	Mod	Low	Mod	Mod	NOQ3	High
Morgan	Illinois	17137	Mod	Low	Mod	Mod	NOQ3	High
Moultrie	Illinois	17139	Mod	Low	Low	Low	NOQ3	High
Ogle	Illinois	17141	Low	Low	Low	Low	Q3	Mod
Peoria	Illinois	17143	Low	High	Mod	Mod	Q3	High
Perry	Illinois	17145	Mod	Mod	Mod	Mod	NOQ3	High
Piatt	Illinois	17147	Mod	Low	Mod	Mod	NOQ3	High
Pike	Illinois	17149	Mod	High	Low	Low	Q3	High
Pope	Illinois	17151	High	Low	Low	Low	Q3	High
Pulaski	Illinois	17153	High	High	Low	Low	NOQ3	High
Putnam	Illinois	17155	Low	High	Mod	Mod	NOQ3	Mod
Randolph	Illinois	17157	Mod	High	Mod	Mod	NOQ3	High
Richland	Illinois	17159	Mod	Mod	Low	Low	NOQ3	High
Rock Island	Illinois	17161	Low	High	Mod	Mod	Q3	Mod
Saline	Illinois	17165	High	Mod	Low	Low	NOQ3	High
Sangamon	Illinois	17167	Mod	Low	Mod	Mod	NOQ3	High
Schuyler	Illinois	17169	Low	High	Mod	Mod	NOQ3	High
Scott	Illinois	17171	Mod	Low	Low	Low	NOQ3	High
Shelby	Illinois	17173	Mod	Low	Low	Low	NOQ3	High
St Clair	Illinois	17163	Mod	High	Mod	Mod	Q3	High
Stark	Illinois	17175	Low	High	Mod	Mod	NOQ3	Mod
Stephenson	Illinois	17177	Low	Mod	Low	Low	NOQ3	Mod
Tazewell	Illinois	17179	Low	High	Mod	Mod	Q3	High
Union	Illinois	17181	High	High	Low	Low	NOQ3	High
Vermilion	Illinois	17183	Mod	Mod	Mod	Mod	NOQ3	High
Wabash	Illinois	17185	Mod	Mod	Mod	Mod	NOQ3	High
Warren	Illinois	17187	Low	Low	Low	Low	NOQ3	High
Washington	Illinois	17189	Mod	Low	Mod	Mod	NOQ3	High
Wayne	Illinois	17191	Mod	Mod	Low	Low	NOQ3	High
White	Illinois	17193	Mod	Mod	Low	Low	NOQ3	High
Whiteside	Illinois	17195	Low	High	Low	Low	NOQ3	Mod
Will	Illinois	17197	Mod	Mod	Mod	Mod	Q3	High
Williamson	Illinois	17199	High	Mod	Low	Low	NOQ3	High
Winnebago	Illinois	17201	Low	Low	Low	Low	Q3	Mod
Woodford	Illinois	17203	Low	High	Mod	Mod	NOQ3	High
Adams	Indiana	18001	Mod	Low	Mod	Mod	NOQ3	High
Allen	Indiana	18003	Low	Low	Mod	Mod	Q3	High
Bartholomew	Indiana	18005	Low	Mod	Mod	Mod	Q3	Mod
Benton	Indiana	18007	Low	Low	Mod	Mod	NOQ3	High
Blackford	Indiana	18009	Low	Low	Low	Low	NOQ3	High
Boone	Indiana	18011	Low	Low	Mod	Mod	Q3	High
Brown	Indiana	18013	Mod	Mod	Low	Low	NOQ3	Mod
Carroll	Indiana	18015	Low	Low	Mod	Mod	NOQ3	High
Cass	Indiana	18017	Low	Low	Mod	Mod	NOQ3	High
Clark	Indiana	18019	Mod	Mod	Mod	Mod	Q3	Mod
Clay	Indiana	18021	Mod	Mod	Low	Low	NOQ3	High
Clinton	Indiana	18023	Low	Low	Mod	Mod	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Crawford	Indiana	18025	Mod	Mod	Low	Low	Q3	Mod
Daviess	Indiana	18027	Mod	Mod	Mod	Mod	NOQ3	Mod
De Kalb	Indiana	18033	Low	Low	Low	Low	NOQ3	High
Dearborn	Indiana	18029	Low	High	Mod	Mod	Q3	Mod
Decatur	Indiana	18031	Low	Low	Mod	Mod	NOQ3	Mod
Delaware	Indiana	18035	Low	Low	Mod	Mod	Q3	High
Dubois	Indiana	18037	Mod	Mod	Low	Low	NOQ3	Mod
Elkhart	Indiana	18039	Low	Low	Mod	Mod	Q3	High
Fayette	Indiana	18041	Low	Low	Mod	Mod	NOQ3	Mod
Floyd	Indiana	18043	Mod	Mod	Low	Low	Q3	Mod
Fountain	Indiana	18045	Mod	Low	Low	Low	NOQ3	High
Franklin	Indiana	18047	Low	High	Low	Low	Q3	Mod
Fulton	Indiana	18049	Low	Low	Mod	Mod	NOQ3	High
Gibson	Indiana	18051	Mod	Mod	Low	Low	NOQ3	High
Grant	Indiana	18053	Low	Low	Mod	Mod	NOQ3	High
Greene	Indiana	18055	Mod	Mod	Low	Low	NOQ3	High
Hamilton	Indiana	18057	Low	Low	Mod	Mod	Q3	High
Hancock	Indiana	18059	Low	Low	Mod	Mod	NOQ3	Mod
Harrison	Indiana	18061	Mod	Mod	Low	Low	Q3	Mod
Hendricks	Indiana	18063	Mod	Mod	Mod	Mod	NOQ3	High
Henry	Indiana	18065	Low	Low	Mod	Mod	NOQ3	Mod
Howard	Indiana	18067	Low	Low	Mod	Mod	NOQ3	High
Huntington	Indiana	18069	Low	Low	Mod	Mod	NOQ3	High
Jackson	Indiana	18071	Mod	Mod	Mod	Mod	Q3	Mod
Jasper	Indiana	18073	Low	Mod	Mod	Mod	NOQ3	High
Jay	Indiana	18075	Mod	Low	Low	Low	NOQ3	High
Jefferson	Indiana	18077	Low	High	Mod	Mod	Q3	Mod
Jennings	Indiana	18079	Low	Mod	Mod	Mod	NOQ3	Mod
Johnson	Indiana	18081	Low	Mod	Mod	Mod	Q3	Mod
Knox	Indiana	18083	Mod	Mod	Mod	Mod	NOQ3	High
Kosciusko	Indiana	18085	Low	Low	Mod	Mod	Q3	High
La Porte	Indiana	18091	Low	Mod	Mod	Mod	Q3	High
Lagrange	Indiana	18087	Low	Low	Mod	Mod	NOQ3	High
Lake	Indiana	18089	Low	Mod	Mod	Mod	Q3	High
Lawrence	Indiana	18093	Mod	Mod	Mod	Mod	NOQ3	Mod
Madison	Indiana	18095	Low	Low	Mod	Mod	NOQ3	High
Marion	Indiana	18097	Low	Low	Mod	Mod	Q3	High
Marshall	Indiana	18099	Low	Low	Mod	Mod	NOQ3	High
Martin	Indiana	18101	Mod	Mod	Low	Low	NOQ3	Mod
Miami	Indiana	18103	Low	Low	Mod	Mod	NOQ3	High
Monroe	Indiana	18105	Mod	Mod	Mod	Mod	NOQ3	Mod
Montgomery	Indiana	18107	Mod	Low	Mod	Mod	NOQ3	High
Morgan	Indiana	18109	Mod	Mod	Mod	Mod	NOQ3	Mod
Newton	Indiana	18111	Low	Mod	Mod	Mod	NOQ3	High
Noble	Indiana	18113	Low	Low	Mod	Mod	NOQ3	High
Ohio	Indiana	18115	Low	High	Low	Low	Q3	Mod
Orange	Indiana	18117	Mod	Mod	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Owen	Indiana	18119	Mod	Mod	Mod	Mod	NOQ3	High
Parke	Indiana	18121	Mod	Mod	Low	Low	NOQ3	High
Perry	Indiana	18123	Mod	Mod	Low	Low	Q3	Mod
Pike	Indiana	18125	Mod	Mod	Mod	Mod	NOQ3	High
Porter	Indiana	18127	Low	Mod	Mod	Mod	NOQ3	High
Posey	Indiana	18129	Mod	Mod	Low	Low	Q3	High
Pulaski	Indiana	18131	Low	Mod	Mod	Mod	NOQ3	High
Putnam	Indiana	18133	Mod	Mod	Mod	Mod	NOQ3	High
Randolph	Indiana	18135	Mod	Low	Mod	Mod	NOQ3	Mod
Ripley	Indiana	18137	Low	High	Mod	Mod	NOQ3	Mod
Rush	Indiana	18139	Low	Low	Mod	Mod	NOQ3	Mod
Scott	Indiana	18143	Mod	Mod	Mod	Mod	NOQ3	Mod
Shelby	Indiana	18145	Low	Mod	Mod	Mod	Q3	Mod
Spencer	Indiana	18147	Mod	Mod	Low	Low	Q3	Mod
St Joseph	Indiana	18141	Low	Low	Mod	Mod	NOQ3	High
Starke	Indiana	18149	Low	Low	Mod	Mod	NOQ3	High
Steuben	Indiana	18151	Low	Low	Mod	Mod	NOQ3	High
Sullivan	Indiana	18153	Mod	Mod	Low	Low	NOQ3	High
Switzerland	Indiana	18155	Low	High	Mod	Mod	Q3	Mod
Tippecanoe	Indiana	18157	Low	Low	Mod	Mod	NOQ3	High
Tipton	Indiana	18159	Low	Low	Mod	Mod	NOQ3	High
Union	Indiana	18161	Low	Low	Low	Low	NOQ3	Mod
Vanderburgh	Indiana	18163	Mod	Mod	Mod	Mod	Q3	Mod
Vermillion	Indiana	18165	Mod	Low	Mod	Mod	NOQ3	High
Vigo	Indiana	18167	Mod	Low	Mod	Mod	Q3	High
Wabash	Indiana	18169	Low	Low	Low	Low	NOQ3	High
Warren	Indiana	18171	Low	Low	Low	Low	NOQ3	High
Warrick	Indiana	18173	Mod	Mod	Low	Low	Q3	Mod
Washington	Indiana	18175	Mod	Mod	Mod	Mod	NOQ3	Mod
Wayne	Indiana	18177	Mod	Low	Mod	Mod	NOQ3	Mod
Wells	Indiana	18179	Mod	Low	Mod	Mod	NOQ3	High
White	Indiana	18181	Low	Low	Low	Low	NOQ3	High
Whitley	Indiana	18183	Low	Low	Mod	Mod	NOQ3	High
Adair	Iowa	19001	Low	Mod	Mod	Mod	NOQ3	Mod
Adams	Iowa	19003	Low	Low	Low	Low	NOQ3	Mod
Allamakee	Iowa	19005	Low	Mod	Low	Low	NOQ3	Mod
Appanoose	Iowa	19007	Low	Mod	Mod	Mod	NOQ3	Mod
Audubon	Iowa	19009	Low	Mod	Low	Low	NOQ3	Mod
Benton	Iowa	19011	Low	Low	Low	Low	NOQ3	Mod
Black Hawk	Iowa	19013	Low	Low	Mod	Mod	Q3	Mod
Boone	Iowa	19015	Low	Mod	Mod	Mod	NOQ3	Mod
Bremer	Iowa	19017	Low	Low	Mod	Mod	NOQ3	Mod
Buchanan	Iowa	19019	Low	Low	Mod	Mod	NOQ3	Mod
Buena Vista	Iowa	19021	Low	Mod	Low	Low	NOQ3	High
Butler	Iowa	19023	Low	Low	Low	Low	NOQ3	High
Calhoun	Iowa	19025	Low	Mod	Mod	Mod	NOQ3	Mod
Carroll	Iowa	19027	Low	Mod	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Cass	Iowa	19029	Low	Mod	Mod	Mod	NOQ3	Mod
Cedar	Iowa	19031	Low	Low	Mod	Mod	NOQ3	Mod
Cerro Gordo	Iowa	19033	Low	Low	Mod	Mod	NOQ3	High
Cherokee	Iowa	19035	Low	Mod	Mod	Mod	NOQ3	High
Chickasaw	Iowa	19037	Low	Low	Mod	Mod	NOQ3	High
Clarke	Iowa	19039	Low	Mod	Mod	Mod	NOQ3	Mod
Clay	Iowa	19041	Low	Low	Mod	Mod	NOQ3	High
Clayton	Iowa	19043	Low	Mod	Low	Low	NOQ3	Mod
Clinton	Iowa	19045	Low	Mod	Mod	Mod	NOQ3	Mod
Crawford	Iowa	19047	Low	Mod	Mod	Mod	NOQ3	Mod
Dallas	Iowa	19049	Low	Mod	Mod	Mod	NOQ3	Mod
Davis	Iowa	19051	Low	Mod	Mod	Mod	NOQ3	Mod
Decatur	Iowa	19053	Low	Mod	Mod	Mod	NOQ3	Mod
Delaware	Iowa	19055	Low	Mod	Mod	Mod	NOQ3	Mod
Des Moines	Iowa	19057	Low	Low	Mod	Mod	NOQ3	Mod
Dickinson	Iowa	19059	Low	Low	Mod	Mod	NOQ3	High
Dubuque	Iowa	19061	Low	Mod	Mod	Mod	NOQ3	Mod
Emmet	Iowa	19063	Low	Low	Mod	Mod	NOQ3	High
Fayette	Iowa	19065	Low	Mod	Mod	Mod	NOQ3	Mod
Floyd	Iowa	19067	Low	Low	Mod	Mod	NOQ3	High
Franklin	Iowa	19069	Low	Low	Low	Low	NOQ3	High
Fremont	Iowa	19071	Low	Mod	Mod	Mod	NOQ3	Mod
Greene	Iowa	19073	Low	Mod	Low	Low	NOQ3	Mod
Grundy	Iowa	19075	Low	Mod	Mod	Mod	NOQ3	Mod
Guthrie	Iowa	19077	Low	Mod	Low	Low	NOQ3	Mod
Hamilton	Iowa	19079	Low	Mod	Mod	Mod	NOQ3	Mod
Hancock	Iowa	19081	Low	Low	Mod	Mod	NOQ3	High
Hardin	Iowa	19083	Low	Mod	Mod	Mod	NOQ3	Mod
Harrison	Iowa	19085	Low	Mod	Low	Low	NOQ3	Mod
Henry	Iowa	19087	Low	Mod	Low	Low	NOQ3	Mod
Howard	Iowa	19089	Low	Mod	Mod	Mod	NOQ3	High
Humboldt	Iowa	19091	Low	Low	Mod	Mod	NOQ3	High
Ida	Iowa	19093	Low	Mod	Low	Low	NOQ3	Mod
Iowa	Iowa	19095	Low	Low	Mod	Mod	NOQ3	Mod
Jackson	Iowa	19097	Low	Mod	Low	Low	NOQ3	Mod
Jasper	Iowa	19099	Low	Mod	Low	Low	NOQ3	Mod
Jefferson	Iowa	19101	Low	Mod	Low	Low	NOQ3	Mod
Johnson	Iowa	19103	Low	Low	Mod	Mod	Q3	Mod
Jones	Iowa	19105	Low	Low	Mod	Mod	NOQ3	Mod
Keokuk	Iowa	19107	Low	Mod	Mod	Mod	NOQ3	Mod
Kossuth	Iowa	19109	Low	Low	Mod	Mod	NOQ3	High
Lee	Iowa	19111	Low	Mod	Mod	Mod	NOQ3	Mod
Linn	Iowa	19113	Low	Low	Mod	Mod	Q3	Mod
Louisa	Iowa	19115	Low	Mod	Mod	Mod	NOQ3	Mod
Lucas	Iowa	19117	Low	Mod	Low	Low	NOQ3	Mod
Lyon	Iowa	19119	Low	Low	Mod	Mod	NOQ3	High
Madison	Iowa	19121	Low	Mod	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Mahaska	Iowa	19123	Low	Mod	Low	Low	NOQ3	Mod
Marion	Iowa	19125	Low	Mod	Mod	Mod	NOQ3	Mod
Marshall	Iowa	19127	Low	Mod	Mod	Mod	NOQ3	Mod
Mills	Iowa	19129	Low	Mod	Low	Low	NOQ3	Mod
Mitchell	Iowa	19131	Low	Low	Low	Low	NOQ3	High
Monona	Iowa	19133	Low	Mod	Low	Low	NOQ3	Mod
Monroe	Iowa	19135	Low	Mod	Low	Low	NOQ3	Mod
Montgomery	Iowa	19137	Low	Mod	Mod	Mod	NOQ3	Mod
Muscatine	Iowa	19139	Low	High	Mod	Mod	NOQ3	Mod
Obrien	Iowa	19141	Low	Low	Mod	Mod	NOQ3	High
Osceola	Iowa	19143	Low	Low	Mod	Mod	NOQ3	High
Page	Iowa	19145	Low	Mod	Mod	Mod	NOQ3	Mod
Palo Alto	Iowa	19147	Low	Low	Mod	Mod	NOQ3	High
Plymouth	Iowa	19149	Low	Mod	Mod	Mod	NOQ3	Mod
Pocahontas	Iowa	19151	Low	Mod	Mod	Mod	NOQ3	High
Polk	Iowa	19153	Low	Mod	Mod	Mod	Q3	Mod
Pottawattamie	Iowa	19155	Low	Mod	Low	Low	Q3	Mod
Poweshiek	Iowa	19157	Low	Mod	Mod	Mod	NOQ3	Mod
Ringgold	Iowa	19159	Low	Low	Mod	Mod	NOQ3	Mod
Sac	Iowa	19161	Low	Mod	Low	Low	NOQ3	Mod
Scott	Iowa	19163	Low	High	Mod	Mod	Q3	Mod
Shelby	Iowa	19165	Low	Mod	Mod	Mod	NOQ3	Mod
Sioux	Iowa	19167	Low	Low	Low	Low	NOQ3	High
Story	Iowa	19169	Low	Mod	Mod	Mod	Q3	Mod
Tama	Iowa	19171	Low	Low	Mod	Mod	NOQ3	Mod
Taylor	Iowa	19173	Low	Low	Mod	Mod	NOQ3	Mod
Union	Iowa	19175	Low	Low	Mod	Mod	NOQ3	Mod
Van Buren	Iowa	19177	Low	Mod	Mod	Mod	NOQ3	Mod
Wapello	Iowa	19179	Low	Mod	Mod	Mod	NOQ3	Mod
Warren	Iowa	19181	Low	Mod	Mod	Mod	NOQ3	Mod
Washington	Iowa	19183	Low	Mod	Low	Low	NOQ3	Mod
Wayne	Iowa	19185	Low	Mod	Mod	Mod	NOQ3	Mod
Webster	Iowa	19187	Low	Mod	Mod	Mod	NOQ3	Mod
Winnebago	Iowa	19189	Low	Low	Mod	Mod	NOQ3	High
Winneshiek	Iowa	19191	Low	Mod	Mod	Mod	NOQ3	High
Woodbury	Iowa	19193	Low	Mod	Mod	Mod	Q3	Mod
Worth	Iowa	19195	Low	Low	Mod	Mod	NOQ3	High
Wright	Iowa	19197	Low	Low	Mod	Mod	NOQ3	High
Allen	Kansas	20001	Low	Low	Mod	Mod	NOQ3	High
Anderson	Kansas	20003	Low	Low	Low	Low	NOQ3	High
Atchison	Kansas	20005	Low	Mod	Mod	Mod	NOQ3	Mod
Barber	Kansas	20007	Low	Low	Low	Low	NOQ3	Mod
Barton	Kansas	20009	Low	Mod	Mod	Mod	Q3	Mod
Bourbon	Kansas	20011	Low	Low	Low	Low	NOQ3	High
Brown	Kansas	20013	Low	Mod	Mod	Mod	NOQ3	Mod
Butler	Kansas	20015	Low	Low	Mod	Mod	Q3	Mod
Chase	Kansas	20017	Low	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Chautauqua	Kansas	20019	Low	Mod	Low	Low	NOQ3	High
Cherokee	Kansas	20021	Low	Low	Mod	Mod	NOQ3	High
Cheyenne	Kansas	20023	Low	Mod	Low	Low	NOQ3	Mod
Clark	Kansas	20025	Low	Low	Low	Low	NOQ3	Mod
Clay	Kansas	20027	Low	Mod	Mod	Mod	NOQ3	Mod
Cloud	Kansas	20029	Low	Mod	Mod	Mod	NOQ3	Mod
Coffey	Kansas	20031	Low	Low	Mod	Mod	NOQ3	High
Comanche	Kansas	20033	Low	Low	Low	Low	NOQ3	Mod
Cowley	Kansas	20035	Low	Low	Mod	Mod	NOQ3	High
Crawford	Kansas	20037	Low	Low	Mod	Mod	NOQ3	High
Decatur	Kansas	20039	Low	Low	Mod	Mod	NOQ3	Mod
Dickinson	Kansas	20041	Low	Mod	Mod	Mod	NOQ3	Mod
Doniphan	Kansas	20043	Low	Mod	Mod	Mod	NOQ3	Mod
Douglas	Kansas	20045	Low	Mod	Mod	Mod	Q3	Mod
Edwards	Kansas	20047	Low	Mod	Mod	Mod	NOQ3	Mod
Elk	Kansas	20049	Low	Low	Mod	Mod	NOQ3	High
Ellis	Kansas	20051	Low	Mod	Mod	Mod	NOQ3	Mod
Ellsworth	Kansas	20053	Low	Mod	Mod	Mod	NOQ3	Mod
Finney	Kansas	20055	Low	Low	Mod	Mod	NOQ3	Mod
Ford	Kansas	20057	Low	Mod	Mod	Mod	NOQ3	Mod
Franklin	Kansas	20059	Low	Low	Mod	Mod	NOQ3	High
Geary	Kansas	20061	Mod	Low	Low	Low	NOQ3	Mod
Gove	Kansas	20063	Low	Low	Low	Low	NOQ3	Mod
Graham	Kansas	20065	Low	Low	Mod	Mod	NOQ3	Mod
Grant	Kansas	20067	Low	Low	Low	Low	NOQ3	Mod
Gray	Kansas	20069	Low	Low	Low	Low	NOQ3	Mod
Greeley	Kansas	20071	Low	Low	Low	Low	NOQ3	Mod
Greenwood	Kansas	20073	Low	Low	Mod	Mod	NOQ3	High
Hamilton	Kansas	20075	Low	High	Low	Low	NOQ3	Mod
Harper	Kansas	20077	Low	Low	Mod	Mod	NOQ3	Mod
Harvey	Kansas	20079	Low	Low	Mod	Mod	NOQ3	Mod
Haskell	Kansas	20081	Low	Low	Mod	Mod	NOQ3	Mod
Hodgeman	Kansas	20083	Low	Mod	Mod	Mod	NOQ3	Mod
Jackson	Kansas	20085	Mod	Low	Mod	Mod	NOQ3	Mod
Jefferson	Kansas	20087	Low	Mod	Mod	Mod	NOQ3	Mod
Jewell	Kansas	20089	Low	Mod	Mod	Mod	NOQ3	Mod
Johnson	Kansas	20091	Low	Mod	Mod	Mod	Q3	High
Kearny	Kansas	20093	Low	Low	Mod	Mod	NOQ3	Mod
Kingman	Kansas	20095	Low	Low	Mod	Mod	NOQ3	Mod
Kiowa	Kansas	20097	Low	Low	Low	Low	NOQ3	Mod
Labette	Kansas	20099	Low	Low	Low	Low	NOQ3	High
Lane	Kansas	20101	Low	Low	Mod	Mod	NOQ3	Mod
Leavenworth	Kansas	20103	Low	Mod	Mod	Mod	NOQ3	Mod
Lincoln	Kansas	20105	Low	Mod	Low	Low	NOQ3	Mod
Linn	Kansas	20107	Low	Low	Low	Low	NOQ3	High
Logan	Kansas	20109	Low	Low	Low	Low	NOQ3	Mod
Lyon	Kansas	20111	Low	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Marion	Kansas	20115	Low	Mod	Mod	Mod	NOQ3	Mod
Marshall	Kansas	20117	Mod	Mod	Mod	Mod	NOQ3	Mod
Mcpherson	Kansas	20113	Low	Mod	Mod	Mod	NOQ3	Mod
Meade	Kansas	20119	Low	Low	Mod	Mod	NOQ3	Mod
Miami	Kansas	20121	Low	Low	Mod	Mod	NOQ3	High
Mitchell	Kansas	20123	Low	Mod	Mod	Mod	NOQ3	Mod
Montgomery	Kansas	20125	Low	Low	Mod	Mod	NOQ3	High
Morris	Kansas	20127	Mod	Low	Mod	Mod	NOQ3	Mod
Morton	Kansas	20129	Low	Low	Low	Low	NOQ3	Mod
Nemaha	Kansas	20131	Mod	Low	Low	Low	NOQ3	Mod
Neosho	Kansas	20133	Low	Low	Mod	Mod	NOQ3	High
Ness	Kansas	20135	Low	Low	Mod	Mod	NOQ3	Mod
Norton	Kansas	20137	Low	Low	Low	Low	NOQ3	Mod
Osage	Kansas	20139	Low	Low	Mod	Mod	NOQ3	Mod
Osborne	Kansas	20141	Low	Mod	Mod	Mod	NOQ3	Mod
Ottawa	Kansas	20143	Low	Mod	Low	Low	NOQ3	Mod
Pawnee	Kansas	20145	Low	Mod	Mod	Mod	NOQ3	Mod
Phillips	Kansas	20147	Low	Low	Mod	Mod	NOQ3	Mod
Pottawatomie	Kansas	20149	Mod	Low	Mod	Mod	NOQ3	Mod
Pratt	Kansas	20151	Low	Low	Mod	Mod	NOQ3	Mod
Rawlins	Kansas	20153	Low	Low	Mod	Mod	NOQ3	Mod
Reno	Kansas	20155	Low	Low	Mod	Mod	Q3	Mod
Republic	Kansas	20157	Low	Mod	Mod	Mod	NOQ3	Mod
Rice	Kansas	20159	Low	Mod	Mod	Mod	NOQ3	Mod
Riley	Kansas	20161	Mod	Low	Mod	Mod	NOQ3	Mod
Rooks	Kansas	20163	Low	Mod	Mod	Mod	NOQ3	Mod
Rush	Kansas	20165	Low	Mod	Mod	Mod	NOQ3	Mod
Russell	Kansas	20167	Low	Mod	Mod	Mod	NOQ3	Mod
Saline	Kansas	20169	Low	Mod	Mod	Mod	Q3	Mod
Scott	Kansas	20171	Low	Low	Mod	Mod	NOQ3	Mod
Sedgwick	Kansas	20173	Low	Low	Mod	Mod	Q3	Mod
Seward	Kansas	20175	Low	Low	Mod	Mod	NOQ3	Mod
Shawnee	Kansas	20177	Mod	Low	Mod	Mod	Q3	Mod
Sheridan	Kansas	20179	Low	Low	Low	Low	NOQ3	Mod
Sherman	Kansas	20181	Low	Low	Mod	Mod	NOQ3	Mod
Smith	Kansas	20183	Low	Low	Mod	Mod	NOQ3	Mod
Stafford	Kansas	20185	Low	Low	Mod	Mod	NOQ3	Mod
Stanton	Kansas	20187	Low	Low	Mod	Mod	NOQ3	Mod
Stevens	Kansas	20189	Low	Low	Low	Low	NOQ3	Mod
Sumner	Kansas	20191	Low	Low	Mod	Mod	NOQ3	Mod
Thomas	Kansas	20193	Low	Low	Mod	Mod	NOQ3	Mod
Trego	Kansas	20195	Low	Low	Mod	Mod	NOQ3	Mod
Wabaunsee	Kansas	20197	Mod	Low	Mod	Mod	NOQ3	Mod
Wallace	Kansas	20199	Low	Low	Low	Low	NOQ3	Mod
Washington	Kansas	20201	Low	Mod	Low	Low	NOQ3	Mod
Wichita	Kansas	20203	Low	Low	Mod	Mod	NOQ3	Mod
Wilson	Kansas	20205	Low	Low	Low	Low	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Woodson	Kansas	20207	Low	Low	Low	Low	NOQ3	High
Wyandotte	Kansas	20209	Low	Mod	Mod	Mod	NOQ3	Mod
Adair	Kentucky	21001	Low	Mod	Low	Low	NOQ3	Mod
Allen	Kentucky	21003	Mod	Low	Low	Low	NOQ3	Mod
Anderson	Kentucky	21005	Mod	Low	Mod	Mod	Q3	Mod
Ballard	Kentucky	21007	High	High	Low	Low	Q3	High
Barren	Kentucky	21009	Mod	Low	Low	Low	Q3	Mod
Bath	Kentucky	21011	Mod	High	Low	Low	Q3	Mod
Bell	Kentucky	21013	Mod	High	Low	Low	Q3	Mod
Boone	Kentucky	21015	Low	High	Mod	Mod	Q3	Mod
Bourbon	Kentucky	21017	Mod	Low	Low	Low	Q3	Mod
Boyd	Kentucky	21019	Mod	High	Low	Low	Q3	Mod
Boyle	Kentucky	21021	Low	Mod	Mod	Mod	Q3	Mod
Bracken	Kentucky	21023	Mod	High	Low	Low	Q3	Mod
Breathitt	Kentucky	21025	Mod	High	Low	Low	Q3	Mod
Breckinridge	Kentucky	21027	Mod	Mod	Low	Low	Q3	Mod
Bullitt	Kentucky	21029	Mod	Mod	Low	Low	Q3	Mod
Butler	Kentucky	21031	Mod	Low	Low	Low	Q3	Mod
Caldwell	Kentucky	21033	Mod	Low	Low	Low	Q3	Mod
Calloway	Kentucky	21035	High	Low	Mod	Mod	Q3	High
Campbell	Kentucky	21037	Low	High	Low	Low	Q3	Mod
Carlisle	Kentucky	21039	High	High	Low	Low	Q3	High
Carroll	Kentucky	21041	Low	High	Mod	Mod	Q3	Mod
Carter	Kentucky	21043	Mod	High	Low	Low	Q3	Mod
Casey	Kentucky	21045	Low	Mod	Low	Low	Q3	Mod
Christian	Kentucky	21047	Mod	Low	Low	Low	Q3	Mod
Clark	Kentucky	21049	Mod	Low	Low	Low	Q3	Mod
Clay	Kentucky	21051	Mod	High	Low	Low	Q3	Mod
Clinton	Kentucky	21053	Mod	High	Low	Low	NOQ3	Mod
Crittenden	Kentucky	21055	Mod	Low	Low	Low	Q3	High
Cumberland	Kentucky	21057	Low	Mod	Low	Low	NOQ3	Mod
Daviess	Kentucky	21059	Mod	Mod	Low	Low	Q3	Mod
Edmonson	Kentucky	21061	Mod	Low	Low	Low	Q3	Mod
Elliott	Kentucky	21063	Mod	High	Low	Low	NOQ3	Mod
Estill	Kentucky	21065	Mod	High	Low	Low	Q3	Mod
Fayette	Kentucky	21067	Mod	Low	Mod	Mod	Q3	Mod
Fleming	Kentucky	21069	Mod	High	Low	Low	Q3	Mod
Floyd	Kentucky	21071	Mod	High	Low	Low	Q3	Mod
Franklin	Kentucky	21073	Mod	Low	Mod	Mod	Q3	Mod
Fulton	Kentucky	21075	High	High	Low	Low	Q3	High
Gallatin	Kentucky	21077	Low	High	Low	Low	Q3	Mod
Garrard	Kentucky	21079	Mod	High	Low	Low	NOQ3	Mod
Grant	Kentucky	21081	Mod	Low	Low	Low	NOQ3	Mod
Graves	Kentucky	21083	High	Low	Low	Low	Q3	High
Grayson	Kentucky	21085	Mod	Low	Low	Low	Q3	Mod
Green	Kentucky	21087	Low	Low	Low	Low	Q3	Mod
Greenup	Kentucky	21089	Mod	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Hancock	Kentucky	21091	Mod	Mod	Mod	Mod	Q3	Mod
Hardin	Kentucky	21093	Mod	Mod	Low	Low	Q3	Mod
Harlan	Kentucky	21095	Mod	High	Low	Low	Q3	Mod
Harrison	Kentucky	21097	Mod	Low	Low	Low	Q3	Mod
Hart	Kentucky	21099	Mod	Low	Low	Low	Q3	Mod
Henderson	Kentucky	21101	Mod	Mod	Low	Low	Q3	High
Henry	Kentucky	21103	Low	Low	Mod	Mod	Q3	Mod
Hickman	Kentucky	21105	High	High	Low	Low	Q3	High
Hopkins	Kentucky	21107	Mod	Mod	Low	Low	Q3	Mod
Jackson	Kentucky	21109	Mod	High	Low	Low	NOQ3	Mod
Jefferson	Kentucky	21111	Mod	Mod	Low	Low	Q3	Mod
Jessamine	Kentucky	21113	Mod	Low	Low	Low	Q3	Mod
Johnson	Kentucky	21115	Mod	High	Low	Low	Q3	Mod
Kenton	Kentucky	21117	Low	High	Mod	Mod	Q3	Mod
Knott	Kentucky	21119	Mod	High	Low	Low	Q3	Mod
Knox	Kentucky	21121	Mod	High	Low	Low	NOQ3	Mod
Larue	Kentucky	21123	Mod	Mod	Low	Low	Q3	Mod
Laurel	Kentucky	21125	Mod	High	Mod	Mod	NOQ3	Mod
Lawrence	Kentucky	21127	Mod	High	Low	Low	Q3	Mod
Lee	Kentucky	21129	Mod	High	Low	Low	Q3	Mod
Leslie	Kentucky	21131	Mod	High	Low	Low	Q3	Mod
Letcher	Kentucky	21133	Mod	High	Low	Low	Q3	Mod
Lewis	Kentucky	21135	Mod	High	Low	Low	Q3	Mod
Lincoln	Kentucky	21137	Mod	High	Low	Low	NOQ3	Mod
Livingston	Kentucky	21139	High	Low	Low	Low	Q3	High
Logan	Kentucky	21141	Mod	Low	Low	Low	Q3	Mod
Lyon	Kentucky	21143	Mod	Low	Low	Low	NOQ3	High
Madison	Kentucky	21151	Mod	High	Low	Low	NOQ3	Mod
Magoffin	Kentucky	21153	Mod	High	Low	Low	Q3	Mod
Marion	Kentucky	21155	Low	Mod	Low	Low	Q3	Mod
Marshall	Kentucky	21157	High	Low	Mod	Mod	Q3	High
Martin	Kentucky	21159	Mod	High	Low	Low	Q3	Mod
Mason	Kentucky	21161	Mod	High	Low	Low	Q3	Mod
McCracken	Kentucky	21145	High	Low	Low	Low	Q3	High
McCreary	Kentucky	21147	Mod	High	Low	Low	NOQ3	Mod
McLean	Kentucky	21149	Mod	Mod	Low	Low	Q3	Mod
Meade	Kentucky	21163	Mod	Mod	Low	Low	Q3	Mod
Menifee	Kentucky	21165	Mod	High	Low	Low	NOQ3	Mod
Mercer	Kentucky	21167	Mod	Mod	Mod	Mod	Q3	Mod
Metcalfe	Kentucky	21169	Low	Low	Low	Low	Q3	Mod
Monroe	Kentucky	21171	Mod	Mod	Low	Low	NOQ3	Mod
Montgomery	Kentucky	21173	Mod	Mod	Low	Low	Q3	Mod
Morgan	Kentucky	21175	Mod	High	Low	Low	Q3	Mod
Muhlenberg	Kentucky	21177	Mod	Mod	Low	Low	Q3	Mod
Nelson	Kentucky	21179	Low	Mod	Low	Low	Q3	Mod
Nicholas	Kentucky	21181	Mod	Low	Low	Low	Q3	Mod
Ohio	Kentucky	21183	Mod	Mod	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Oldham	Kentucky	21185	Low	Low	Mod	Mod	Q3	Mod
Owen	Kentucky	21187	Mod	Low	Low	Low	Q3	Mod
Owsley	Kentucky	21189	Mod	High	Low	Low	NOQ3	Mod
Pendleton	Kentucky	21191	Mod	High	Low	Low	Q3	Mod
Perry	Kentucky	21193	Mod	High	Low	Low	Q3	Mod
Pike	Kentucky	21195	Mod	High	Low	Low	Q3	Mod
Powell	Kentucky	21197	Mod	High	Low	Low	Q3	Mod
Pulaski	Kentucky	21199	Mod	High	Low	Low	NOQ3	Mod
Robertson	Kentucky	21201	Mod	Low	Low	Low	Q3	Mod
Rockcastle	Kentucky	21203	Mod	High	Low	Low	NOQ3	Mod
Rowan	Kentucky	21205	Mod	High	Low	Low	Q3	Mod
Russell	Kentucky	21207	Low	Mod	Low	Low	Q3	Mod
Scott	Kentucky	21209	Mod	Low	Mod	Mod	Q3	Mod
Shelby	Kentucky	21211	Low	Low	Mod	Mod	Q3	Mod
Simpson	Kentucky	21213	Mod	Low	Mod	Mod	Q3	Mod
Spencer	Kentucky	21215	Low	Mod	Low	Low	Q3	Mod
Taylor	Kentucky	21217	Low	Mod	Low	Low	Q3	Mod
Todd	Kentucky	21219	Mod	Low	Low	Low	Q3	Mod
Trigg	Kentucky	21221	Mod	Low	Low	Low	Q3	High
Trimble	Kentucky	21223	Low	Low	Mod	Mod	Q3	Mod
Union	Kentucky	21225	Mod	Mod	Low	Low	Q3	High
Warren	Kentucky	21227	Mod	Low	Mod	Mod	Q3	Mod
Washington	Kentucky	21229	Low	Low	Low	Low	Q3	Mod
Wayne	Kentucky	21231	Mod	High	Low	Low	NOQ3	Mod
Webster	Kentucky	21233	Mod	Mod	Low	Low	Q3	Mod
Whitley	Kentucky	21235	Mod	High	Low	Low	NOQ3	Mod
Wolfe	Kentucky	21237	Mod	High	Low	Low	NOQ3	Mod
Woodford	Kentucky	21239	Mod	Low	Low	Low	Q3	Mod
Acadia	Louisiana	22001	Low	Low	High	Mod	Q3	Mod
Allen	Louisiana	22003	Low	Low	Mod	Low	Q3	Mod
Ascension	Louisiana	22005	Low	High	High	Mod	Q3	Low
Assumption	Louisiana	22007	Low	High	High	Mod	Q3	Low
Avoyelles	Louisiana	22009	Low	High	Mod	Mod	Q3	Mod
Beauregard	Louisiana	22011	Low	Low	Mod	Low	NOQ3	Mod
Bienville	Louisiana	22013	Low	Low	Mod	Mod	NOQ3	Mod
Bossier	Louisiana	22015	Low	Low	Mod	Mod	Q3	Mod
Caddo	Louisiana	22017	Low	Low	Mod	Mod	NOQ3	Mod
Calcasieu	Louisiana	22019	Low	Low	High	Mod	Q3	Mod
Caldwell	Louisiana	22021	Low	Mod	Low	Low	NOQ3	Mod
Cameron	Louisiana	22023	Low	Mod	High	Low	Q3	Mod
Catahoula	Louisiana	22025	Low	High	Mod	Low	Q3	Mod
Claiborne	Louisiana	22027	Low	Low	Low	Low	NOQ3	Mod
Concordia	Louisiana	22029	Low	High	Mod	Mod	Q3	Mod
De Soto	Louisiana	22031	Low	Low	Mod	Mod	NOQ3	Mod
East Baton Rouge	Louisiana	22033	Low	High	Mod	Mod	Q3	Low
East Carroll	Louisiana	22035	Mod	High	Mod	Mod	NOQ3	Mod
East Feliciana	Louisiana	22037	Low	High	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Evangeline	Louisiana	22039	Low	Low	Mod	Low	NOQ3	Mod
Franklin	Louisiana	22041	Low	High	Mod	Mod	Q3	Mod
Grant	Louisiana	22043	Low	Low	Mod	Low	Q3	Mod
Iberia	Louisiana	22045	Low	Mod	High	Mod	Q3	Mod
Iberville	Louisiana	22047	Low	High	High	Low	Q3	Mod
Jackson	Louisiana	22049	Low	Low	Mod	Mod	NOQ3	Mod
Jefferson	Louisiana	22051	Low	Mod	High	Mod	Q3	Low
Jefferson Davis	Louisiana	22053	Low	Low	High	Mod	NOQ3	Mod
La Salle	Louisiana	22059	Low	Low	Mod	Low	NOQ3	Mod
Lafayette	Louisiana	22055	Low	Low	High	Mod	Q3	Mod
LaFourche	Louisiana	22057	Low	Mod	High	Low	Q3	Low
Lincoln	Louisiana	22061	Low	Low	Mod	Mod	NOQ3	Mod
Livingston	Louisiana	22063	Low	Mod	High	Mod	Q3	Low
Madison	Louisiana	22065	Low	High	Mod	Mod	Q3	Mod
Morehouse	Louisiana	22067	Mod	Low	Mod	Mod	NOQ3	Mod
Natchitoches	Louisiana	22069	Low	Low	Mod	Low	Q3	Mod
Orleans	Louisiana	22071	Low	Mod	High	Mod	Q3	Low
Ouachita	Louisiana	22073	Low	Mod	Mod	Mod	Q3	Mod
Plaquemines	Louisiana	22075	Low	Mod	High	Low	Q3	Low
Pointe Coupee	Louisiana	22077	Low	High	Mod	Low	Q3	Mod
Rapides	Louisiana	22079	Low	Low	Mod	Mod	Q3	Mod
Red River	Louisiana	22081	Low	Low	Low	Low	NOQ3	Mod
Richland	Louisiana	22083	Low	Low	Mod	Mod	NOQ3	Mod
Sabine	Louisiana	22085	Low	Low	Mod	Low	NOQ3	Mod
St. Bernard	Louisiana	22087	Low	Mod	High	Low	Q3	Low
St. Charles	Louisiana	22089	Low	Mod	High	Low	Q3	Low
St. Helena	Louisiana	22091	Low	Mod	Mod	Mod	NOQ3	Low
St. James	Louisiana	22093	Low	High	High	Low	Q3	Low
St. John the Baptist	Louisiana	22095	Low	Mod	High	Mod	Q3	Low
St. Landry	Louisiana	22097	Low	High	Mod	Mod	Q3	Mod
St. Martin	Louisiana	22099	Low	High	High	Low	Q3	Mod
St. Mary	Louisiana	22101	Low	Mod	High	Low	Q3	Low
St. Tammany	Louisiana	22103	Low	Mod	High	Low	Q3	Low
Tangipahoa	Louisiana	22105	Low	Mod	High	Mod	Q3	Low
Tensas	Louisiana	22107	Low	High	Mod	Mod	NOQ3	Mod
Terrebonne	Louisiana	22109	Low	Mod	High	Low	Q3	Low
Union	Louisiana	22111	Low	Low	Mod	Mod	NOQ3	Mod
Vermilion	Louisiana	22113	Low	Low	High	Mod	Q3	Mod
Vernon	Louisiana	22115	Low	Low	Mod	Low	NOQ3	Mod
Washington	Louisiana	22121	Low	High	Mod	Mod	NOQ3	Low
Webster	Louisiana	22117	Low	Mod	High	Low	NOQ3	Mod
West Baton Rouge	Louisiana	22119	Low	Low	Mod	Mod	NOQ3	Low
West Carroll	Louisiana	22123	Mod	Low	Mod	Mod	NOQ3	Mod
West Feliciana	Louisiana	22125	Low	High	Mod	Low	NOQ3	Mod
Winn	Louisiana	22127	Low	Low	Low	Low	NOQ3	Mod
Androscoggin	Maine	23001	Mod	Mod	Mod	Low	NOQ3	High
Aroostook	Maine	23003	Mod	Low	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Cumberland	Maine	23005	Mod	High	Mod	Low	Q3	High
Franklin	Maine	23007	Mod	High	Low	Low	NOQ3	High
Hancock	Maine	23009	Mod	Mod	Mod	Low	Q3	High
Kennebec	Maine	23011	Mod	Mod	Mod	Low	Q3	High
Knox	Maine	23013	Mod	Mod	Mod	Low	NOQ3	High
Lincoln	Maine	23015	Mod	Mod	High	Low	NOQ3	High
Oxford	Maine	23017	Mod	High	Low	Low	Q3	High
Penobscot	Maine	23019	Mod	High	Mod	Low	Q3	High
Piscataquis	Maine	23021	Mod	High	Low	Low	NOQ3	Mod
Sagadahoc	Maine	23023	Mod	Mod	Mod	Low	Q3	High
Somerset	Maine	23025	Mod	High	Low	Low	NOQ3	High
Waldo	Maine	23027	Mod	Mod	Mod	Low	Q3	High
Washington	Maine	23029	Mod	Mod	Mod	Low	Q3	High
York	Maine	23031	Mod	High	Mod	Low	Q3	High
Allegany	Maryland	24001	Low	High	Low	Low	Q3	Mod
Anne Arundel	Maryland	24003	Low	High	Mod	Mod	Q3	Mod
Baltimore	Maryland	24005	Mod	High	Low	Low	Q3	Mod
Baltimore City	Maryland	24510	Low	High	Low	Low	Q3	Mod
Calvert	Maryland	24009	Low	Mod	Mod	Mod	Q3	Mod
Caroline	Maryland	24011	Low	Low	Mod	Low	NOQ3	Mod
Carroll	Maryland	24013	Mod	High	Low	Low	Q3	Mod
Cecil	Maryland	24015	Mod	Mod	Mod	Mod	Q3	Mod
Charles	Maryland	24017	Low	High	Low	Low	NOQ3	Mod
Dorchester	Maryland	24019	Low	Low	High	Low	Q3	Mod
Frederick	Maryland	24021	Low	High	Mod	Mod	Q3	Mod
Garrett	Maryland	24023	Low	High	Low	Low	NOQ3	Mod
Harford	Maryland	24025	Mod	Mod	Mod	Mod	Q3	Mod
Howard	Maryland	24027	Low	High	Low	Low	NOQ3	Mod
Kent	Maryland	24029	Mod	Mod	Low	Low	Q3	Mod
Montgomery	Maryland	24031	Low	Low	Low	Low	NOQ3	Mod
Prince Georges	Maryland	24033	Low	High	Low	Low	Q3	Mod
Queen Annes	Maryland	24035	Mod	Low	Mod	Low	Q3	Mod
Somerset	Maryland	24039	Low	Low	High	Low	Q3	Mod
St. Marys	Maryland	24037	Low	Low	Mod	Mod	Q3	Mod
Talbot	Maryland	24041	Low	Low	Mod	Low	Q3	Mod
Washington	Maryland	24043	Low	High	Low	Low	Q3	Mod
Wicomico	Maryland	24045	Low	Low	High	Low	Q3	Mod
Worcester	Maryland	24047	Low	Low	High	Low	Q3	Mod
Barnstable	Massachusetts	25001	Mod	Low	High	Low	Q3	Mod
Berkshire	Massachusetts	25003	Mod	High	Mod	Low	Q3	Mod
Bristol	Massachusetts	25005	Mod	Mod	High	Low	Q3	Mod
Dukes	Massachusetts	25007	Mod	High	High	Low	Q3	Mod
Essex	Massachusetts	25009	Mod	High	High	Mod	Q3	High
Franklin	Massachusetts	25011	Mod	High	Mod	Mod	NOQ3	High
Hampden	Massachusetts	25013	Mod	High	Mod	Mod	Q3	High
Hampshire	Massachusetts	25015	Mod	High	Mod	Low	Q3	High
Middlesex	Massachusetts	25017	Mod	Mod	Mod	Low	Q3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Nantucket	Massachusetts	25019	Low	Mod	High	Low	Q3	Mod
Norfolk	Massachusetts	25021	Mod	Mod	High	Low	Q3	Mod
Plymouth	Massachusetts	25023	Mod	Mod	High	Low	Q3	Mod
Suffolk	Massachusetts	25025	Mod	Mod	High	Low	Q3	High
Worcester	Massachusetts	25027	Mod	Mod	Mod	Low	Q3	High
Alcona	Michigan	26001	Low	Mod	Low	Low	NOQ3	Mod
Alger	Michigan	26003	Low	Mod	Low	Low	NOQ3	Mod
Allegan	Michigan	26005	Low	Mod	Mod	Mod	NOQ3	Mod
Alpena	Michigan	26007	Low	Low	Low	Low	Q3	Mod
Antrim	Michigan	26009	Low	Mod	Low	Low	NOQ3	Mod
Arenac	Michigan	26011	Low	Mod	Low	Low	Q3	Mod
Baraga	Michigan	26013	Low	High	Low	Low	NOQ3	Mod
Barry	Michigan	26015	Low	Low	Mod	Mod	NOQ3	Mod
Bay	Michigan	26017	Low	Mod	Low	Low	Q3	Mod
Benzie	Michigan	26019	Low	Mod	Low	Low	NOQ3	Mod
Berrien	Michigan	26021	Low	Mod	Mod	Mod	Q3	Mod
Branch	Michigan	26023	Low	Low	Mod	Mod	NOQ3	High
Calhoun	Michigan	26025	Low	Low	Low	Low	Q3	Mod
Cass	Michigan	26027	Low	Low	Low	Low	NOQ3	Mod
Charlevoix	Michigan	26029	Low	Low	Low	Low	NOQ3	Mod
Cheboygan	Michigan	26031	Low	Mod	Low	Low	NOQ3	Mod
Chippewa	Michigan	26033	Low	High	Low	Low	Q3	Mod
Clare	Michigan	26035	Low	Low	Low	Low	Q3	Mod
Clinton	Michigan	26037	Low	Low	Mod	Mod	Q3	Mod
Crawford	Michigan	26039	Low	Low	Low	Low	NOQ3	Mod
Delta	Michigan	26041	Low	Mod	Low	Low	Q3	Mod
Dickinson	Michigan	26043	Low	Low	Low	Low	NOQ3	Mod
Eaton	Michigan	26045	Low	Low	Mod	Mod	NOQ3	Mod
Emmet	Michigan	26047	Low	Mod	Low	Low	NOQ3	Mod
Genesee	Michigan	26049	Low	Mod	Mod	Mod	Q3	Mod
Gladwin	Michigan	26051	Low	Mod	Low	Low	NOQ3	Mod
Gogebic	Michigan	26053	Low	High	Low	Low	NOQ3	Mod
Grand Traverse	Michigan	26055	Low	Mod	Low	Low	NOQ3	Mod
Gratiot	Michigan	26057	Low	Low	Low	Low	NOQ3	Mod
Hillsdale	Michigan	26059	Low	Low	Mod	Mod	NOQ3	High
Houghton	Michigan	26061	Low	High	Low	Low	NOQ3	Mod
Huron	Michigan	26063	Low	Mod	Low	Low	Q3	Mod
Ingham	Michigan	26065	Low	Low	Mod	Mod	Q3	Mod
Ionia	Michigan	26067	Low	Low	Mod	Mod	NOQ3	Mod
Iosco	Michigan	26069	Low	Mod	Low	Low	Q3	Mod
Iron	Michigan	26071	Low	Low	Low	Low	NOQ3	Mod
Isabella	Michigan	26073	Low	Low	Low	Low	Q3	Mod
Jackson	Michigan	26075	Low	Low	Low	Low	NOQ3	High
Kalamazoo	Michigan	26077	Low	Low	Mod	Mod	NOQ3	Mod
Kalkaska	Michigan	26079	Low	Mod	Low	Low	NOQ3	Mod
Kent	Michigan	26081	Low	Low	Mod	Mod	Q3	Mod
Keweenaw	Michigan	26083	Low	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Lake	Michigan	26085	Low	Low	Low	Low	NOQ3	Mod
Lapeer	Michigan	26087	Low	Low	Low	Low	NOQ3	Mod
Leelanau	Michigan	26089	Low	Mod	Low	Low	NOQ3	Mod
Lenawee	Michigan	26091	Low	Low	Mod	Mod	NOQ3	High
Livingston	Michigan	26093	Low	Low	Mod	Mod	Q3	High
Luce	Michigan	26095	Low	Mod	Low	Low	NOQ3	Mod
Mackinac	Michigan	26097	Low	High	Low	Low	Q3	Mod
Macomb	Michigan	26099	Low	Mod	Mod	Mod	Q3	High
Manistee	Michigan	26101	Low	Mod	Low	Low	Q3	Mod
Marquette	Michigan	26103	Low	High	Low	Low	NOQ3	Mod
Mason	Michigan	26105	Low	Mod	Low	Low	NOQ3	Mod
Mecosta	Michigan	26107	Low	Low	Low	Low	NOQ3	Mod
Menominee	Michigan	26109	Low	Low	Low	Low	Q3	Mod
Midland	Michigan	26111	Low	Mod	Low	Low	Q3	Mod
Missaukee	Michigan	26113	Low	Low	Low	Low	NOQ3	Mod
Monroe	Michigan	26115	Low	Mod	Mod	Mod	Q3	High
Montcalm	Michigan	26117	Low	Low	Low	Low	NOQ3	Mod
Montmorency	Michigan	26119	Low	Low	Low	Low	NOQ3	Mod
Muskegon	Michigan	26121	Low	Mod	Low	Low	Q3	Mod
Newaygo	Michigan	26123	Low	Low	Low	Low	NOQ3	Mod
Oakland	Michigan	26125	Low	Mod	Mod	Mod	Q3	High
Oceana	Michigan	26127	Low	Mod	Low	Low	NOQ3	Mod
Ogemaw	Michigan	26129	Low	Low	Low	Low	NOQ3	Mod
Ontonagon	Michigan	26131	Low	High	Low	Low	NOQ3	Mod
Osceola	Michigan	26133	Low	Low	Low	Low	NOQ3	Mod
Oscoda	Michigan	26135	Low	Low	Low	Low	NOQ3	Mod
Otsego	Michigan	26137	Low	Low	Low	Low	NOQ3	Mod
Ottawa	Michigan	26139	Low	Mod	Mod	Mod	NOQ3	Mod
Presque Isle	Michigan	26141	Low	Mod	Low	Low	NOQ3	Mod
Roscommon	Michigan	26143	Low	Low	Low	Low	NOQ3	Mod
Saginaw	Michigan	26145	Low	Mod	Low	Low	Q3	Mod
Sanilac	Michigan	26151	Low	Mod	Low	Low	NOQ3	Mod
Schoolcraft	Michigan	26153	Low	Mod	Low	Low	NOQ3	Mod
Shiawassee	Michigan	26155	Low	Low	Mod	Mod	NOQ3	Mod
St. Clair	Michigan	26147	Low	Mod	Low	Low	Q3	High
St. Joseph	Michigan	26149	Low	Low	Low	Low	NOQ3	Mod
Tuscola	Michigan	26157	Low	Mod	Low	Low	NOQ3	Mod
Van Buren	Michigan	26159	Low	Mod	Mod	Mod	NOQ3	Mod
Washtenaw	Michigan	26161	Low	Mod	Mod	Mod	Q3	High
Wayne	Michigan	26163	Low	Mod	Mod	Mod	Q3	High
Wexford	Michigan	26165	Low	Low	Low	Low	NOQ3	Mod
Aitkin	Minnesota	27001	Low	Low	Low	Low	Q3	Mod
Anoka	Minnesota	27003	Low	Low	Mod	Mod	Q3	Mod
Becker	Minnesota	27005	Low	Low	Low	Low	Q3	Mod
Beltrami	Minnesota	27007	Low	Low	Low	Low	Q3	Mod
Benton	Minnesota	27009	Low	Low	Low	Low	Q3	Mod
Big Stone	Minnesota	27011	Low	Low	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Blue Earth	Minnesota	27013	Low	Mod	Mod	Mod	Q3	High
Brown	Minnesota	27015	Low	Mod	Low	Low	Q3	High
Carlton	Minnesota	27017	Low	High	Low	Low	NOQ3	High
Carver	Minnesota	27019	Low	Mod	Mod	Mod	Q3	Mod
Cass	Minnesota	27021	Low	Low	Low	Low	Q3	Mod
Chippewa	Minnesota	27023	Low	Low	Low	Low	Q3	Mod
Chisago	Minnesota	27025	Low	Low	Low	Low	NOQ3	Mod
Clay	Minnesota	27027	Low	Low	Low	Low	Q3	Mod
Clearwater	Minnesota	27029	Low	Low	Low	Low	NOQ3	Mod
Cook	Minnesota	27031	Low	Low	Low	Low	NOQ3	High
Cottonwood	Minnesota	27033	Low	Low	Low	Low	NOQ3	High
Crow Wing	Minnesota	27035	Low	Low	Low	Low	NOQ3	Mod
Dakota	Minnesota	27037	Low	Mod	Low	Low	Q3	Mod
Dodge	Minnesota	27039	Low	Low	Low	Low	NOQ3	High
Douglas	Minnesota	27041	Low	Low	Low	Low	Q3	Mod
Faribault	Minnesota	27043	Low	Mod	Low	Low	NOQ3	High
Fillmore	Minnesota	27045	Low	Mod	Low	Low	NOQ3	High
Freeborn	Minnesota	27047	Low	Low	Mod	Mod	NOQ3	High
Goodhue	Minnesota	27049	Low	Mod	Low	Low	Q3	High
Grant	Minnesota	27051	Low	Low	Low	Low	Q3	Mod
Hennepin	Minnesota	27053	Low	Mod	Mod	Mod	Q3	Mod
Houston	Minnesota	27055	Low	Mod	Low	Low	Q3	Mod
Hubbard	Minnesota	27057	Low	Low	Low	Low	NOQ3	Mod
Isanti	Minnesota	27059	Low	Low	Low	Low	NOQ3	Mod
Itasca	Minnesota	27061	Low	Low	Low	Low	Q3	Mod
Jackson	Minnesota	27063	Low	Low	Low	Low	NOQ3	High
Kanabec	Minnesota	27065	Low	Low	Low	Low	NOQ3	Mod
Kandiyohi	Minnesota	27067	Low	Low	Low	Low	Q3	Mod
Kittson	Minnesota	27069	Low	Low	Low	Low	Q3	Mod
Koochiching	Minnesota	27071	Low	Low	Low	Low	NOQ3	Mod
Lac Qui Parle	Minnesota	27073	Low	Low	Low	Low	Q3	Mod
Lake	Minnesota	27075	Low	Low	Low	Low	NOQ3	High
Lake of the Woods	Minnesota	27077	Low	Low	Low	Low	Q3	Mod
Le Sueur	Minnesota	27079	Low	Mod	Low	Low	Q3	High
Lincoln	Minnesota	27081	Low	Low	Low	Low	Q3	Mod
Lyon	Minnesota	27083	Low	Low	Mod	Mod	Q3	Mod
Mahnomen	Minnesota	27087	Low	Low	Low	Low	Q3	Mod
Marshall	Minnesota	27089	Low	Low	Low	Low	Q3	Mod
Martin	Minnesota	27091	Low	Low	Low	Low	NOQ3	High
McLeod	Minnesota	27085	Low	Low	Low	Low	Q3	Mod
Meeker	Minnesota	27093	Low	Low	Low	Low	NOQ3	Mod
Mille Lacs	Minnesota	27095	Low	Low	Low	Low	NOQ3	Mod
Morrison	Minnesota	27097	Low	Low	Low	Low	Q3	Mod
Mower	Minnesota	27099	Low	Low	Mod	Mod	Q3	High
Murray	Minnesota	27101	Low	Low	Mod	Mod	Q3	High
Nicollet	Minnesota	27103	Low	Mod	Low	Low	Q3	High
Nobles	Minnesota	27105	Low	Low	Low	Low	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Norman	Minnesota	27107	Low	Low	Low	Low	Q3	Mod
Olmsted	Minnesota	27109	Low	Mod	Mod	Mod	Q3	High
Otter Tail	Minnesota	27111	Low	Low	Low	Low	Q3	Mod
Pennington	Minnesota	27113	Low	Low	Low	Low	Q3	Mod
Pine	Minnesota	27115	Low	Low	Low	Low	NOQ3	Mod
Pipestone	Minnesota	27117	Low	Low	Low	Low	NOQ3	High
Polk	Minnesota	27119	Low	Low	Low	Low	Q3	Mod
Pope	Minnesota	27121	Low	Low	Low	Low	Q3	Mod
Ramsey	Minnesota	27123	Low	Low	Mod	Mod	Q3	Mod
Red Lake	Minnesota	27125	Low	Low	Low	Low	Q3	Mod
Redwood	Minnesota	27127	Low	Mod	Low	Low	Q3	High
Renville	Minnesota	27129	Low	Mod	Low	Low	Q3	Mod
Rice	Minnesota	27131	Low	Low	Low	Low	Q3	High
Rock	Minnesota	27133	Low	Low	Low	Low	NOQ3	High
Roseau	Minnesota	27135	Low	Low	Low	Low	Q3	Mod
Scott	Minnesota	27139	Low	Mod	Low	Low	Q3	Mod
Sherburne	Minnesota	27141	Low	Low	Low	Low	Q3	Mod
Sibley	Minnesota	27143	Low	Mod	Mod	Mod	Q3	Mod
St. Louis	Minnesota	27137	Low	High	Low	Low	Q3	High
Stearns	Minnesota	27145	Low	Low	Low	Low	Q3	Mod
Steele	Minnesota	27147	Low	Low	Mod	Mod	NOQ3	High
Stevens	Minnesota	27149	Low	Low	Low	Low	Q3	Mod
Swift	Minnesota	27151	Low	Low	Low	Low	Q3	Mod
Todd	Minnesota	27153	Low	Low	Low	Low	Q3	Mod
Traverse	Minnesota	27155	Low	Low	Low	Low	Q3	Mod
Wabasha	Minnesota	27157	Low	Mod	Low	Low	Q3	High
Wadena	Minnesota	27159	Low	Low	Low	Low	Q3	Mod
Waseca	Minnesota	27161	Low	Mod	Mod	Mod	NOQ3	High
Washington	Minnesota	27163	Low	Low	Low	Low	Q3	Mod
Watonwan	Minnesota	27165	Low	Low	Mod	Mod	NOQ3	High
Wilkin	Minnesota	27167	Low	Low	Low	Low	Q3	Mod
Winona	Minnesota	27169	Low	Mod	Low	Low	Q3	High
Wright	Minnesota	27171	Low	Low	Low	Low	Q3	Mod
Yellow Medicine	Minnesota	27173	Low	Low	Low	Low	Q3	Mod
Adams	Mississippi	28001	Low	High	Mod	Low	NOQ3	Mod
Alcorn	Mississippi	28003	Mod	Low	Mod	Mod	NOQ3	Mod
Amite	Mississippi	28005	Low	High	Mod	Low	NOQ3	Mod
Attala	Mississippi	28007	Mod	Low	Mod	Mod	NOQ3	Mod
Benton	Mississippi	28009	Mod	Low	Low	Low	NOQ3	Mod
Bolivar	Mississippi	28011	Mod	High	Mod	Mod	Q3	Mod
Calhoun	Mississippi	28013	Mod	Low	Low	Low	NOQ3	Mod
Carroll	Mississippi	28015	Mod	High	Low	Low	NOQ3	Mod
Chickasaw	Mississippi	28017	Mod	Low	Mod	Mod	NOQ3	Mod
Choctaw	Mississippi	28019	Mod	Low	Mod	Low	NOQ3	Mod
Claiborne	Mississippi	28021	Low	High	Mod	Mod	Q3	Mod
Clarke	Mississippi	28023	Low	High	Mod	Mod	NOQ3	Low
Clay	Mississippi	28025	Mod	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Coahoma	Mississippi	28027	Mod	High	Mod	Mod	NOQ3	High
Copiah	Mississippi	28029	Low	Mod	Mod	Mod	NOQ3	Mod
Covington	Mississippi	28031	Low	Mod	Mod	Mod	NOQ3	Low
De Soto	Mississippi	28033	High	High	Mod	Mod	Q3	High
Forrest	Mississippi	28035	Low	Mod	High	Mod	Q3	Low
Franklin	Mississippi	28037	Low	High	Mod	Low	NOQ3	Mod
George	Mississippi	28039	Low	Mod	High	Low	NOQ3	Low
Greene	Mississippi	28041	Low	Mod	High	Low	NOQ3	Low
Grenada	Mississippi	28043	Mod	High	Mod	Mod	NOQ3	Mod
Hancock	Mississippi	28045	Low	Low	High	Mod	Q3	Low
Harrison	Mississippi	28047	Low	Low	High	Mod	Q3	Low
Hinds	Mississippi	28049	Low	High	Mod	Mod	Q3	Mod
Holmes	Mississippi	28051	Mod	High	Low	Low	NOQ3	Mod
Humphreys	Mississippi	28053	Mod	Low	Mod	Mod	NOQ3	Mod
Issaquena	Mississippi	28055	Mod	High	Mod	Mod	NOQ3	Mod
Itawamba	Mississippi	28057	Mod	Mod	Low	Low	Q3	Mod
Jackson	Mississippi	28059	Low	Low	High	Mod	Q3	Low
Jasper	Mississippi	28061	Low	High	Mod	Mod	NOQ3	Low
Jefferson	Mississippi	28063	Low	High	Mod	Low	NOQ3	Mod
Jefferson Davis	Mississippi	28065	Low	Mod	Mod	Mod	NOQ3	Low
Jones	Mississippi	28067	Low	Mod	Mod	Mod	NOQ3	Low
Kemper	Mississippi	28069	Low	Low	Mod	Low	NOQ3	Mod
Lafayette	Mississippi	28071	Mod	Low	Low	Low	NOQ3	Mod
Lamar	Mississippi	28073	Low	Mod	High	Mod	NOQ3	Low
Lauderdale	Mississippi	28075	Low	Low	Mod	Mod	Q3	Low
Lawrence	Mississippi	28077	Low	Mod	Mod	Mod	NOQ3	Low
Leake	Mississippi	28079	Low	Low	Mod	Mod	NOQ3	Mod
Lee	Mississippi	28081	Mod	Low	Mod	Mod	Q3	Mod
Leflore	Mississippi	28083	Mod	Low	Mod	Mod	Q3	Mod
Lincoln	Mississippi	28085	Low	Mod	Mod	Mod	NOQ3	Mod
Lowndes	Mississippi	28087	Mod	Low	Mod	Mod	Q3	Mod
Madison	Mississippi	28089	Low	High	Mod	Mod	Q3	Mod
Marion	Mississippi	28091	Low	Mod	Mod	Mod	NOQ3	Low
Marshall	Mississippi	28093	Mod	Low	Low	Low	NOQ3	High
Monroe	Mississippi	28095	Mod	Low	Mod	Mod	NOQ3	Mod
Montgomery	Mississippi	28097	Mod	Low	Mod	Mod	NOQ3	Mod
Neshoba	Mississippi	28099	Low	Low	Mod	Mod	NOQ3	Mod
Newton	Mississippi	28101	Low	High	Mod	Mod	NOQ3	Low
Noxubee	Mississippi	28103	Low	Low	Mod	Low	NOQ3	Mod
Oktibbeha	Mississippi	28105	Mod	Low	Mod	Low	NOQ3	Mod
Panola	Mississippi	28107	Mod	High	Low	Low	NOQ3	High
Pearl River	Mississippi	28109	Low	Mod	High	Mod	Q3	Low
Perry	Mississippi	28111	Low	Mod	High	Low	NOQ3	Low
Pike	Mississippi	28113	Low	Mod	Mod	Mod	NOQ3	Low
Pontotoc	Mississippi	28115	Mod	Low	Mod	Mod	NOQ3	Mod
Prentiss	Mississippi	28117	Mod	Low	Mod	Mod	Q3	Mod
Quitman	Mississippi	28119	Mod	Low	Low	Low	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Rankin	Mississippi	28121	Low	High	Mod	Mod	Q3	Mod
Scott	Mississippi	28123	Low	High	Mod	Mod	NOQ3	Mod
Sharkey	Mississippi	28125	Mod	Low	Mod	Mod	NOQ3	Mod
Simpson	Mississippi	28127	Low	Mod	Mod	Mod	NOQ3	Mod
Smith	Mississippi	28129	Low	High	Mod	Mod	NOQ3	Low
Stone	Mississippi	28131	Low	Mod	High	Mod	NOQ3	Low
Sunflower	Mississippi	28133	Mod	Low	Low	Low	NOQ3	Mod
Tallahatchie	Mississippi	28135	Mod	High	Mod	Mod	NOQ3	Mod
Tate	Mississippi	28137	Mod	High	Low	Low	NOQ3	High
Tippah	Mississippi	28139	Mod	Low	Mod	Mod	NOQ3	Mod
Tishomingo	Mississippi	28141	Mod	Mod	Mod	Mod	NOQ3	Mod
Tunica	Mississippi	28143	Mod	High	Low	Low	Q3	High
Union	Mississippi	28145	Mod	Low	Mod	Mod	NOQ3	Mod
Walthall	Mississippi	28147	Low	Mod	Mod	Mod	NOQ3	Low
Warren	Mississippi	28149	Low	High	Mod	Mod	Q3	Mod
Washington	Mississippi	28151	Mod	High	Mod	Mod	Q3	Mod
Wayne	Mississippi	28153	Low	High	Mod	Low	NOQ3	Low
Webster	Mississippi	28155	Mod	Low	Low	Low	NOQ3	Mod
Wilkinson	Mississippi	28157	Low	High	Mod	Low	NOQ3	Mod
Winston	Mississippi	28159	Low	Low	Mod	Low	NOQ3	Mod
Yalobusha	Mississippi	28161	Mod	High	Low	Low	NOQ3	Mod
Yazoo	Mississippi	28163	Mod	High	Mod	Mod	Q3	Mod
Adair	Missouri	29001	Low	Mod	Low	Low	NOQ3	Mod
Andrew	Missouri	29003	Low	Mod	Mod	Mod	NOQ3	Mod
Atchison	Missouri	29005	Low	Mod	Low	Low	NOQ3	Mod
Audrain	Missouri	29007	Low	Mod	Low	Low	NOQ3	High
Barry	Missouri	29009	Low	Low	Low	Low	NOQ3	High
Barton	Missouri	29011	Low	Low	Mod	Mod	NOQ3	High
Bates	Missouri	29013	Low	Low	Low	Low	NOQ3	High
Benton	Missouri	29015	Low	Low	Mod	Mod	NOQ3	High
Bollinger	Missouri	29017	High	Low	Low	Low	NOQ3	High
Boone	Missouri	29019	Low	Mod	Mod	Mod	Q3	High
Buchanan	Missouri	29021	Low	Mod	Mod	Mod	Q3	Mod
Butler	Missouri	29023	High	Low	Low	Low	NOQ3	High
Caldwell	Missouri	29025	Low	Mod	Low	Low	NOQ3	Mod
Callaway	Missouri	29027	Mod	Low	Mod	Mod	NOQ3	High
Camden	Missouri	29029	Low	Low	Low	Low	NOQ3	High
Cape Girardeau	Missouri	29031	High	Low	Mod	Mod	Q3	High
Carroll	Missouri	29033	Low	Mod	Low	Low	NOQ3	High
Carter	Missouri	29035	Mod	Low	Low	Low	NOQ3	High
Cass	Missouri	29037	Low	Mod	Mod	Mod	NOQ3	High
Cedar	Missouri	29039	Low	Low	Low	Low	NOQ3	High
Chariton	Missouri	29041	Low	Mod	Low	Low	NOQ3	High
Christian	Missouri	29043	Mod	Low	Mod	Mod	NOQ3	High
Clark	Missouri	29045	Low	Low	Low	Low	NOQ3	High
Clay	Missouri	29047	Low	Mod	Mod	Mod	Q3	Mod
Clinton	Missouri	29049	Low	Mod	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Cole	Missouri	29051	Low	Mod	Low	Low	Q3	High
Cooper	Missouri	29053	Low	Mod	Low	Low	NOQ3	High
Crawford	Missouri	29055	Mod	Low	Low	Low	NOQ3	High
Dade	Missouri	29057	Low	Low	Low	Low	NOQ3	High
Dallas	Missouri	29059	Low	Low	Low	Low	NOQ3	High
Daviess	Missouri	29061	Low	Mod	Low	Low	NOQ3	Mod
De Kalb	Missouri	29063	Low	Mod	Mod	Mod	NOQ3	Mod
Dent	Missouri	29065	Mod	Low	Low	Low	NOQ3	High
Douglas	Missouri	29067	Mod	Low	Low	Low	NOQ3	High
Dunklin	Missouri	29069	High	Low	Mod	Mod	NOQ3	High
Franklin	Missouri	29071	Mod	Mod	Low	Low	Q3	High
Gasconade	Missouri	29073	Mod	Low	Low	Low	NOQ3	High
Gentry	Missouri	29075	Low	Mod	Low	Low	NOQ3	Mod
Greene	Missouri	29077	Low	Low	Mod	Mod	Q3	High
Grundy	Missouri	29079	Low	Mod	Low	Low	NOQ3	Mod
Harrison	Missouri	29081	Low	Mod	Low	Low	NOQ3	Mod
Henry	Missouri	29083	Low	Low	Low	Low	NOQ3	High
Hickory	Missouri	29085	Low	Low	Low	Low	NOQ3	High
Holt	Missouri	29087	Low	Mod	Low	Low	NOQ3	Mod
Howard	Missouri	29089	Low	Mod	Low	Low	NOQ3	High
Howell	Missouri	29091	Mod	Low	Mod	Mod	NOQ3	High
Iron	Missouri	29093	Mod	Low	Low	Low	NOQ3	High
Jackson	Missouri	29095	Low	Mod	Mod	Mod	Q3	High
Jasper	Missouri	29097	Low	Low	Mod	Mod	NOQ3	High
Jefferson	Missouri	29099	Mod	Mod	Mod	Mod	Q3	High
Johnson	Missouri	29101	Low	Low	Low	Low	NOQ3	High
Knox	Missouri	29103	Low	Mod	Low	Low	NOQ3	High
Laclede	Missouri	29105	Mod	Low	Low	Low	NOQ3	High
Lafayette	Missouri	29107	Low	Mod	Low	Low	NOQ3	High
Lawrence	Missouri	29109	Low	Low	Low	Low	NOQ3	High
Lewis	Missouri	29111	Low	Mod	Low	Low	NOQ3	High
Lincoln	Missouri	29113	Mod	High	Low	Low	NOQ3	High
Linn	Missouri	29115	Low	Mod	Low	Low	NOQ3	High
Livingston	Missouri	29117	Low	Low	Low	Low	NOQ3	High
Macon	Missouri	29121	Low	Mod	Low	Low	NOQ3	High
Madison	Missouri	29123	Mod	Low	Low	Low	NOQ3	High
Maries	Missouri	29125	Mod	Low	Low	Low	NOQ3	High
Marion	Missouri	29127	Low	Mod	Low	Low	NOQ3	High
McDonald	Missouri	29119	Low	Low	Low	Low	NOQ3	High
Mercer	Missouri	29129	Low	Mod	Low	Low	NOQ3	Mod
Miller	Missouri	29131	Mod	Low	Mod	Mod	NOQ3	High
Mississippi	Missouri	29133	High	High	Mod	Mod	NOQ3	High
Moniteau	Missouri	29135	Low	Mod	Mod	Mod	NOQ3	High
Monroe	Missouri	29137	Low	Mod	Low	Low	NOQ3	High
Montgomery	Missouri	29139	Mod	Low	Low	Low	NOQ3	High
Morgan	Missouri	29141	Low	Low	Mod	Mod	NOQ3	High
New Madrid	Missouri	29143	High	High	Low	Low	NOQ3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Newton	Missouri	29145	Low	Low	Mod	Mod	NOQ3	High
Nodaway	Missouri	29147	Low	Mod	Mod	Mod	NOQ3	Mod
Oregon	Missouri	29149	Mod	Low	Low	Low	NOQ3	High
Osage	Missouri	29151	Mod	Low	Low	Low	NOQ3	High
Ozark	Missouri	29153	Mod	Low	Mod	Mod	NOQ3	High
Pemiscot	Missouri	29155	High	High	Mod	Mod	NOQ3	High
Perry	Missouri	29157	High	Low	Mod	Mod	NOQ3	High
Pettis	Missouri	29159	Low	Low	Mod	Mod	NOQ3	High
Phelps	Missouri	29161	Mod	Low	Low	Low	NOQ3	High
Pike	Missouri	29163	Mod	High	Low	Low	NOQ3	High
Platte	Missouri	29165	Low	Mod	Mod	Mod	Q3	Mod
Polk	Missouri	29167	Low	Low	Low	Low	NOQ3	High
Pulaski	Missouri	29169	Mod	Low	Low	Low	NOQ3	High
Putnam	Missouri	29171	Low	Mod	Low	Low	NOQ3	Mod
Ralls	Missouri	29173	Low	High	Low	Low	NOQ3	High
Randolph	Missouri	29175	Low	Mod	Low	Low	NOQ3	High
Ray	Missouri	29177	Low	Mod	Mod	Mod	NOQ3	High
Reynolds	Missouri	29179	Mod	Low	Low	Low	NOQ3	High
Ripley	Missouri	29181	Mod	Low	Low	Low	NOQ3	High
Saline	Missouri	29195	Low	Mod	Low	Low	NOQ3	High
Schuyler	Missouri	29197	Low	Mod	Low	Low	NOQ3	Mod
Scotland	Missouri	29199	Low	Mod	Low	Low	NOQ3	Mod
Scott	Missouri	29201	High	High	Mod	Mod	NOQ3	High
Shannon	Missouri	29203	Mod	Low	Low	Low	NOQ3	High
Shelby	Missouri	29205	Low	Mod	Low	Low	NOQ3	High
St. Charles	Missouri	29183	Mod	High	Mod	Mod	Q3	High
St. Clair	Missouri	29185	Low	Low	Low	Low	NOQ3	High
St. Francois	Missouri	29187	Mod	Low	Mod	Mod	NOQ3	High
St. Louis	Missouri	29510	Mod	Mod	Mod	Mod	Q3	High
St. Louis City	Missouri	29189	Mod	Mod	Mod	Mod	Q3	High
Ste. Genevieve	Missouri	29186	Mod	Low	Low	Low	NOQ3	High
Stoddard	Missouri	29207	High	Low	Low	Low	NOQ3	High
Stone	Missouri	29209	Low	Low	Low	Low	NOQ3	High
Sullivan	Missouri	29211	Low	Mod	Low	Low	NOQ3	Mod
Taney	Missouri	29213	Mod	Low	Low	Low	NOQ3	High
Texas	Missouri	29215	Mod	Low	Low	Low	NOQ3	High
Vernon	Missouri	29217	Low	Low	Low	Low	NOQ3	High
Warren	Missouri	29219	Mod	Mod	Low	Low	NOQ3	High
Washington	Missouri	29221	Mod	Low	Low	Low	NOQ3	High
Wayne	Missouri	29223	High	Low	Low	Low	NOQ3	High
Webster	Missouri	29225	Mod	Low	Low	Low	NOQ3	High
Worth	Missouri	29227	Low	Low	Mod	Mod	NOQ3	Mod
Wright	Missouri	29229	Mod	Low	Low	Low	NOQ3	High
Beaverhead	Montana	30001	High	High	Low	Low	NOQ3	Low
Big Horn	Montana	30003	Mod	High	Low	Low	NOQ3	Low
Blaine	Montana	30005	Low	High	Low	Low	NOQ3	Low
Broadwater	Montana	30007	Mod	High	Low	Low	Q3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Carbon	Montana	30009	Mod	High	Low	Low	Q3	Low
Carter	Montana	30011	Low	High	Low	Low	NOQ3	Low
Cascade	Montana	30013	Mod	High	Low	Low	Q3	Low
Chouteau	Montana	30015	Mod	High	Low	Low	NOQ3	Low
Custer	Montana	30017	Low	Low	Low	Low	Q3	Low
Daniels	Montana	30019	Mod	Low	Low	Low	NOQ3	Low
Dawson	Montana	30021	Low	High	Low	Low	Q3	Low
Deer Lodge	Montana	30023	Mod	Mod	Low	Low	Q3	Low
Fallon	Montana	30025	Low	High	Low	Low	NOQ3	Low
Fergus	Montana	30027	Low	High	Low	Low	NOQ3	Low
Flathead	Montana	30029	Mod	High	Low	Low	Q3	Low
Gallatin	Montana	30031	High	High	Low	Low	NOQ3	Low
Garfield	Montana	30033	Mod	High	Low	Low	NOQ3	Low
Glacier	Montana	30035	Mod	High	Low	Low	NOQ3	Low
Golden Valley	Montana	30037	Low	High	Low	Low	NOQ3	Low
Granite	Montana	30039	Mod	Mod	Low	Low	NOQ3	Low
Hill	Montana	30041	Low	High	Low	Low	NOQ3	Low
Jefferson	Montana	30043	Mod	High	Low	Low	NOQ3	Low
Judith Basin	Montana	30045	Mod	High	Low	Low	NOQ3	Low
Lake	Montana	30047	High	Low	Low	Low	NOQ3	Low
Lewis and Clark	Montana	30049	Mod	High	Low	Low	NOQ3	Low
Liberty	Montana	30051	Mod	High	Low	Low	NOQ3	Low
Lincoln	Montana	30053	Mod	Low	Low	Low	Q3	Low
Madison	Montana	30057	High	High	Low	Low	NOQ3	Low
McCone	Montana	30055	Mod	High	Low	Low	NOQ3	Low
Meagher	Montana	30059	Mod	High	Low	Low	Q3	Low
Mineral	Montana	30061	Mod	Mod	Low	Low	NOQ3	Low
Missoula	Montana	30063	Mod	Mod	Low	Low	NOQ3	Low
Musselshell	Montana	30065	Low	High	Low	Low	Q3	Low
Park	Montana	30067	Mod	High	Low	Low	Q3	Low
Petroleum	Montana	30069	Low	High	Low	Low	NOQ3	Low
Phillips	Montana	30071	Low	High	Low	Low	NOQ3	Low
Pondera	Montana	30073	Mod	High	Low	Low	NOQ3	Low
Powder River	Montana	30075	Mod	High	Low	Low	NOQ3	Low
Powell	Montana	30077	Mod	High	Low	Low	NOQ3	Low
Prairie	Montana	30079	Low	High	Low	Low	NOQ3	Low
Ravalli	Montana	30081	Mod	Mod	Low	Low	Q3	Low
Richland	Montana	30083	Low	High	Low	Low	Q3	Mod
Roosevelt	Montana	30085	Mod	High	Low	Low	NOQ3	Mod
Rosebud	Montana	30087	Mod	High	Low	Low	NOQ3	Low
Sanders	Montana	30089	Mod	Mod	Low	Low	Q3	Low
Sheridan	Montana	30091	Mod	Low	Low	Low	NOQ3	Mod
Silver Bow	Montana	30093	Mod	Mod	Low	Low	NOQ3	Low
Stillwater	Montana	30095	Mod	High	Low	Low	NOQ3	Low
Sweet Grass	Montana	30097	Mod	High	Low	Low	Q3	Low
Teton	Montana	30099	Mod	High	Low	Low	NOQ3	Low
Toole	Montana	30101	Mod	High	Low	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Treasure	Montana	30103	Low	High	Low	Low	Q3	Low
Valley	Montana	30105	Mod	High	Low	Low	NOQ3	Low
Wheatland	Montana	30107	Mod	High	Low	Low	Q3	Low
Wibaux	Montana	30109	Low	High	Low	Low	NOQ3	Mod
Yellowstone	Montana	30111	Low	High	Low	Low	Q3	Low
Yellowstone National Park	Montana	30113	High	High	Low	Low	NOQ3	Low
Adams	Nebraska	31001	Low	Low	Mod	Mod	NOQ3	Mod
Antelope	Nebraska	31003	Low	Low	Mod	Mod	NOQ3	Mod
Arthur	Nebraska	31005	Low	Low	Low	Low	NOQ3	Mod
Banner	Nebraska	31007	Low	Low	Low	Low	NOQ3	Low
Blaine	Nebraska	31009	Low	Low	Low	Low	NOQ3	Mod
Boone	Nebraska	31011	Low	Low	Mod	Mod	NOQ3	Mod
Box Butte	Nebraska	31013	Low	Low	Mod	Mod	NOQ3	Low
Boyd	Nebraska	31015	Low	High	Low	Low	NOQ3	Mod
Brown	Nebraska	31017	Low	High	Low	Low	NOQ3	Mod
Buffalo	Nebraska	31019	Low	Low	Mod	Mod	NOQ3	Mod
Burt	Nebraska	31021	Low	Low	Mod	Mod	NOQ3	Mod
Butler	Nebraska	31023	Low	Low	Mod	Mod	NOQ3	Mod
Cass	Nebraska	31025	Low	Mod	Mod	Mod	Q3	Mod
Cedar	Nebraska	31027	Low	High	Low	Low	NOQ3	Mod
Chase	Nebraska	31029	Low	Low	Low	Low	NOQ3	Mod
Cherry	Nebraska	31031	Low	Low	Low	Low	NOQ3	Mod
Cheyenne	Nebraska	31033	Low	Low	Mod	Mod	NOQ3	Low
Clay	Nebraska	31035	Low	Low	Mod	Mod	NOQ3	Mod
Colfax	Nebraska	31037	Low	Low	Mod	Mod	NOQ3	Mod
Cuming	Nebraska	31039	Low	Low	Mod	Mod	NOQ3	Mod
Custer	Nebraska	31041	Low	Low	Low	Low	NOQ3	Mod
Dakota	Nebraska	31043	Low	Low	Low	Low	NOQ3	Mod
Dawes	Nebraska	31045	Low	High	Low	Low	NOQ3	Low
Dawson	Nebraska	31047	Low	Low	Mod	Mod	NOQ3	Mod
Deuel	Nebraska	31049	Low	Low	Mod	Mod	NOQ3	Mod
Dixon	Nebraska	31051	Low	Low	Mod	Mod	NOQ3	Mod
Dodge	Nebraska	31053	Low	Low	Mod	Mod	Q3	Mod
Douglas	Nebraska	31055	Low	Low	Mod	Mod	Q3	Mod
Dundy	Nebraska	31057	Low	Mod	Low	Low	NOQ3	Mod
Fillmore	Nebraska	31059	Low	Low	Mod	Mod	NOQ3	Mod
Franklin	Nebraska	31061	Low	Low	Mod	Mod	NOQ3	Mod
Frontier	Nebraska	31063	Low	Low	Low	Low	NOQ3	Mod
Furnas	Nebraska	31065	Low	Low	Mod	Mod	NOQ3	Mod
Gage	Nebraska	31067	Low	Mod	Mod	Mod	NOQ3	Mod
Garden	Nebraska	31069	Low	Low	Low	Low	NOQ3	Mod
Garfield	Nebraska	31071	Low	Low	Low	Low	NOQ3	Mod
Gosper	Nebraska	31073	Low	Low	Mod	Mod	NOQ3	Mod
Grant	Nebraska	31075	Low	Low	Low	Low	NOQ3	Mod
Greeley	Nebraska	31077	Low	Low	Mod	Mod	NOQ3	Mod
Hall	Nebraska	31079	Low	Low	High	Hig	h Q3	Mod
Hamilton	Nebraska	31081	Low	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Harlan	Nebraska	31083	Low	Low	Low	Low	NOQ3	Mod
Hayes	Nebraska	31085	Low	Low	Low	Low	NOQ3	Mod
Hitchcock	Nebraska	31087	Low	Low	Mod	Mod	NOQ3	Mod
Holt	Nebraska	31089	Low	High	Low	Low	NOQ3	Mod
Hooker	Nebraska	31091	Low	Low	Low	Low	NOQ3	Mod
Howard	Nebraska	31093	Low	Low	Mod	Mod	NOQ3	Mod
Jefferson	Nebraska	31095	Low	Mod	Mod	Mod	NOQ3	Mod
Johnson	Nebraska	31097	Low	Low	Mod	Mod	NOQ3	Mod
Kearney	Nebraska	31099	Low	Low	Mod	Mod	NOQ3	Mod
Keith	Nebraska	31101	Low	Low	Mod	Mod	NOQ3	Mod
Keya Paha	Nebraska	31103	Low	High	Low	Low	NOQ3	Mod
Kimball	Nebraska	31105	Low	Low	Mod	Mod	NOQ3	Low
Knox	Nebraska	31107	Low	High	Mod	Mod	NOQ3	Mod
Lancaster	Nebraska	31109	Low	Low	Mod	Mod	Q3	Mod
Lincoln	Nebraska	31111	Low	Low	Low	Low	NOQ3	Mod
Logan	Nebraska	31113	Low	Low	Low	Low	NOQ3	Mod
Loup	Nebraska	31115	Low	Low	Low	Low	NOQ3	Mod
Madison	Nebraska	31119	Low	Low	Mod	Mod	NOQ3	Mod
McPherson	Nebraska	31117	Low	Low	Low	Low	NOQ3	Mod
Merrick	Nebraska	31121	Low	Low	Mod	Mod	NOQ3	Mod
Morrill	Nebraska	31123	Low	Low	Mod	Mod	NOQ3	Low
Nance	Nebraska	31125	Low	Low	Mod	Mod	NOQ3	Mod
Nemaha	Nebraska	31127	Low	Mod	Mod	Mod	NOQ3	Mod
Nuckolls	Nebraska	31129	Low	Low	Mod	Mod	NOQ3	Mod
Otoe	Nebraska	31131	Low	Mod	Mod	Mod	NOQ3	Mod
Pawnee	Nebraska	31133	Low	Low	Mod	Mod	NOQ3	Mod
Perkins	Nebraska	31135	Low	Low	Mod	Mod	NOQ3	Mod
Phelps	Nebraska	31137	Low	Low	Mod	Mod	NOQ3	Mod
Pierce	Nebraska	31139	Low	High	Mod	Mod	NOQ3	Mod
Platte	Nebraska	31141	Low	Low	Mod	Mod	Q3	Mod
Polk	Nebraska	31143	Low	Low	Mod	Mod	NOQ3	Mod
Red Willow	Nebraska	31145	Low	Low	Mod	Mod	NOQ3	Mod
Richardson	Nebraska	31147	Low	Mod	Low	Low	NOQ3	Mod
Rock	Nebraska	31149	Low	High	Low	Low	NOQ3	Mod
Saline	Nebraska	31151	Low	Low	Mod	Mod	NOQ3	Mod
Sarpy	Nebraska	31153	Low	Low	Mod	Mod	Q3	Mod
Saunders	Nebraska	31155	Low	Low	Mod	Mod	Q3	Mod
Scotts Bluff	Nebraska	31157	Low	Low	Mod	Mod	NOQ3	Low
Seward	Nebraska	31159	Low	Low	Mod	Mod	NOQ3	Mod
Sheridan	Nebraska	31161	Low	High	Low	Low	NOQ3	Mod
Sherman	Nebraska	31163	Low	Low	Mod	Mod	NOQ3	Mod
Sioux	Nebraska	31165	Low	High	Low	Low	NOQ3	Low
Stanton	Nebraska	31167	Low	Low	Mod	Mod	NOQ3	Mod
Thayer	Nebraska	31169	Low	Mod	Mod	Mod	NOQ3	Mod
Thomas	Nebraska	31171	Low	Low	Low	Low	NOQ3	Mod
Thurston	Nebraska	31173	Low	Low	Mod	Mod	NOQ3	Mod
Valley	Nebraska	31175	Low	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Washington	Nebraska	31177	Low	Low	Mod	Mod	NOQ3	Mod
Wayne	Nebraska	31179	Low	Low	Mod	Mod	NOQ3	Mod
Webster	Nebraska	31181	Low	Low	Mod	Mod	NOQ3	Mod
Wheeler	Nebraska	31183	Low	Low	Low	Low	NOQ3	Mod
York	Nebraska	31185	Low	Low	Mod	Mod	NOQ3	Mod
Carson City	Nevada	32510	High	High	Low	Low	Q3	Low
Churchill	Nevada	32001	Mod	High	Low	Low	NOQ3	Low
Clark	Nevada	32003	Mod	Mod	Low	Low	Q3	Low
Douglas	Nevada	32005	High	Mod	Low	Low	NOQ3	Low
Elko	Nevada	32007	Mod	High	Low	Low	NOQ3	Low
Esmeralda	Nevada	32009	High	High	Low	Low	NOQ3	Low
Eureka	Nevada	32011	Mod	High	Low	Low	NOQ3	Low
Humboldt	Nevada	32013	Mod	High	Low	Low	NOQ3	Low
Lander	Nevada	32015	Mod	High	Low	Low	NOQ3	Low
Lincoln	Nevada	32017	Mod	Mod	Low	Low	NOQ3	Low
Lyon	Nevada	32019	High	Mod	Low	Low	NOQ3	Low
Mineral	Nevada	32021	High	High	Low	Low	NOQ3	Low
Nye	Nevada	32023	High	High	Low	Low	NOQ3	Low
Pershing	Nevada	32027	Mod	High	Low	Low	NOQ3	Low
Storey	Nevada	32029	High	Mod	Low	Low	NOQ3	Low
Washoe	Nevada	32031	High	High	Low	Low	Q3	Low
White Pine	Nevada	32033	Mod	High	Low	Low	NOQ3	Low
Belknap	New Hampshire	33001	Mod	High	Mod	Low	NOQ3	High
Carroll	New Hampshire	33003	Mod	High	Mod	Low	NOQ3	High
Cheshire	New Hampshire	33005	Mod	High	Mod	Low	Q3	High
Coos	New Hampshire	33007	Mod	High	Low	Low	NOQ3	Mod
Grafton	New Hampshire	33009	Mod	High	Low	Low	NOQ3	Mod
Hillsborough	New Hampshire	33011	Mod	Low	Mod	Low	Q3	High
Merrimack	New Hampshire	33013	Mod	Mod	Mod	Low	NOQ3	High
Rockingham	New Hampshire	33015	Mod	High	Mod	Low	Q3	High
Strafford	New Hampshire	33017	Mod	High	Mod	Low	NOQ3	High
Sullivan	New Hampshire	33019	Mod	High	Low	Low	NOQ3	High
Atlantic	New Jersey	34001	Mod	Low	High	Low	Q3	Mod
Bergen	New Jersey	34003	Mod	High	Mod	Mod	Q3	Mod
Burlington	New Jersey	34005	Mod	Mod	High	Low	Q3	Mod
Camden	New Jersey	34007	Mod	Mod	Mod	Low	Q3	Mod
Cape May	New Jersey	34009	Low	Low	High	Mod	Q3	Mod
Cumberland	New Jersey	34011	Mod	Low	High	Low	Q3	Mod
Essex	New Jersey	34013	Mod	High	Mod	Low	Q3	Mod
Gloucester	New Jersey	34015	Mod	Mod	Mod	Mod	Q3	Mod
Hudson	New Jersey	34017	Mod	Low	Mod	Low	Q3	Mod
Hunterdon	New Jersey	34019	Mod	Low	Low	Low	Q3	High
Mercer	New Jersey	34021	Mod	Mod	Mod	Mod	Q3	High
Middlesex	New Jersey	34023	Mod	High	Mod	Low	Q3	High
Monmouth	New Jersey	34025	Mod	High	High	Low	Q3	Mod
Morris	New Jersey	34027	Mod	High	Mod	Low	Q3	High
Ocean	New Jersey	34029	Mod	Low	High	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Passaic	New Jersey	34031	Mod	High	Mod	Low	Q3	Mod
Salem	New Jersey	34033	Mod	Mod	Mod	Low	Q3	Mod
Somerset	New Jersey	34035	Mod	High	Mod	Low	Q3	High
Sussex	New Jersey	34037	Mod	High	Low	Low	Q3	Mod
Union	New Jersey	34039	Mod	High	Mod	Mod	Q3	High
Warren	New Jersey	34041	Mod	Low	Low	Low	Q3	High
Bernalillo	New Mexico	35001	Mod	High	Low	Low	NOQ3	Low
Catron	New Mexico	35003	Mod	High	Low	Low	NOQ3	Low
Chaves	New Mexico	35005	Mod	Mod	Low	Low	NOQ3	Low
Cibola	New Mexico	35006	Mod	High	Low	Low	NOQ3	Low
Colfax	New Mexico	35007	Mod	High	Low	Low	NOQ3	Low
Curry	New Mexico	35009	Low	Mod	Mod	Mod	Q3	Low
De Baca	New Mexico	35011	Low	Mod	Low	Low	NOQ3	Low
Dona Ana	New Mexico	35013	Mod	Mod	Low	Low	Q3	Low
Eddy	New Mexico	35015	Mod	Low	Low	Low	NOQ3	Low
Grant	New Mexico	35017	Mod	High	Low	Low	NOQ3	Low
Guadalupe	New Mexico	35019	Mod	Mod	Low	Low	NOQ3	Low
Harding	New Mexico	35021	Low	Mod	Low	Low	NOQ3	Low
Hidalgo	New Mexico	35023	Mod	Low	Low	Low	NOQ3	Low
Lea	New Mexico	35025	Mod	Low	Low	Low	NOQ3	Low
Lincoln	New Mexico	35027	Mod	High	Low	Low	NOQ3	Low
Los Alamos	New Mexico	35028	Mod	High	Low	Low	NOQ3	Low
Luna	New Mexico	35029	Mod	Low	Low	Low	NOQ3	Low
McKinley	New Mexico	35031	Mod	High	Low	Low	NOQ3	Low
Mora	New Mexico	35033	Mod	High	Low	Low	NOQ3	Low
Otero	New Mexico	35035	Mod	High	Low	Low	Q3	Low
Quay	New Mexico	35037	Low	Mod	Low	Low	NOQ3	Low
Rio Arriba	New Mexico	35039	Mod	High	Low	Low	NOQ3	Low
Roosevelt	New Mexico	35041	Low	Mod	Low	Low	NOQ3	Low
San Juan	New Mexico	35045	Mod	High	Low	Low	NOQ3	Low
San Miguel	New Mexico	35047	Mod	High	Low	Low	NOQ3	Low
Sandoval	New Mexico	35043	Mod	High	Low	Low	NOQ3	Low
Santa Fe	New Mexico	35049	Mod	High	Low	Low	NOQ3	Low
Sierra	New Mexico	35051	Mod	High	Low	Low	NOQ3	Low
Socorro	New Mexico	35053	Mod	High	Low	Low	NOQ3	Low
Taos	New Mexico	35055	Mod	High	Low	Low	NOQ3	Low
Torrance	New Mexico	35057	Mod	Mod	Low	Low	NOQ3	Low
Union	New Mexico	35059	Low	High	Low	Low	NOQ3	Low
Valencia	New Mexico	35061	Mod	High	Low	Low	NOQ3	Low
Albany	New York	36001	Mod	High	Low	Low	Q3	Mod
Allegany	New York	36003	Mod	Mod	Low	Low	Q3	Mod
Bronx	New York	36005	Mod	Low	Mod	Low	Q3	Mod
Broome	New York	36007	Low	Mod	Low	Low	Q3	Mod
Cattaraugus	New York	36009	Mod	Mod	Low	Low	Q3	Mod
Cayuga	New York	36011	Low	Mod	Low	Low	Q3	High
Chautauqua	New York	36013	Mod	Mod	Low	Low	Q3	Mod
Chemung	New York	36015	Low	Low	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Chenango	New York	36017	Low	Mod	Low	Low	Q3	Mod
Clinton	New York	36019	Mod	High	Low	Low	NOQ3	High
Columbia	New York	36021	Mod	High	Low	Low	Q3	Mod
Cortland	New York	36023	Low	Mod	Low	Low	Q3	Mod
Delaware	New York	36025	Mod	High	Low	Low	Q3	Mod
Dutchess	New York	36027	Mod	High	Mod	Low	Q3	Mod
Erie	New York	36029	Mod	Mod	Low	Low	Q3	High
Essex	New York	36031	Mod	High	Low	Low	NOQ3	Mod
Franklin	New York	36033	Mod	High	Low	Low	NOQ3	High
Fulton	New York	36035	Mod	Low	Low	Low	Q3	Mod
Genesee	New York	36037	Mod	Mod	Low	Low	Q3	High
Greene	New York	36039	Mod	High	Low	Low	NOQ3	Mod
Hamilton	New York	36041	Mod	High	Low	Low	NOQ3	Mod
Herkimer	New York	36043	Mod	Low	Low	Low	Q3	High
Jefferson	New York	36045	Mod	Mod	Low	Low	Q3	High
Kings	New York	36047	Mod	Low	High	Low	Q3	Mod
Lewis	New York	36049	Mod	Low	Low	Low	NOQ3	High
Livingston	New York	36051	Mod	Mod	Low	Low	Q3	High
Madison	New York	36053	Low	Mod	Low	Low	Q3	High
Monroe	New York	36055	Mod	Mod	Low	Low	Q3	High
Montgomery	New York	36057	Mod	Low	Low	Low	NOQ3	Mod
Nassau	New York	36059	Mod	High	High	Low	Q3	Mod
New York	New York	36061	Mod	Low	Mod	Low	Q3	Mod
Niagara	New York	36063	Mod	High	Low	Low	Q3	High
Oneida	New York	36065	Mod	Mod	Low	Low	Q3	High
Onondaga	New York	36067	Low	Mod	Low	Low	Q3	High
Ontario	New York	36069	Mod	Mod	Low	Low	Q3	High
Orange	New York	36071	Mod	High	Low	Low	Q3	Mod
Orleans	New York	36073	Mod	Mod	Low	Low	NOQ3	High
Oswego	New York	36075	Mod	Mod	Low	Low	Q3	High
Otsego	New York	36077	Mod	Low	Low	Low	NOQ3	Mod
Putnam	New York	36079	Mod	High	Mod	Low	NOQ3	Mod
Queens	New York	36081	Mod	Low	High	Low	Q3	Mod
Rensselaer	New York	36083	Mod	High	Low	Low	Q3	Mod
Richmond	New York	36085	Mod	Low	Mod	Mod	Q3	Mod
Rockland	New York	36087	Mod	High	Mod	Low	Q3	Mod
Saratoga	New York	36091	Mod	High	Low	Low	Q3	Mod
Schenectady	New York	36093	Mod	High	Low	Low	NOQ3	Mod
Schoharie	New York	36095	Mod	Low	Low	Low	NOQ3	Mod
Schuyler	New York	36097	Low	Mod	Low	Low	NOQ3	Mod
Seneca	New York	36099	Low	Mod	Low	Low	Q3	High
St. Lawrence	New York	36089	Mod	High	Low	Low	NOQ3	High
Steuben	New York	36101	Mod	Mod	Low	Low	Q3	Mod
Suffolk	New York	36103	Mod	High	High	Low	Q3	Mod
Sullivan	New York	36105	Mod	High	Low	Low	Q3	Mod
Tioga	New York	36107	Low	Mod	Low	Low	Q3	Mod
Tompkins	New York	36109	Low	Mod	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Ulster	New York	36111	Mod	High	Low	Low	Q3	Mod
Warren	New York	36113	Mod	High	Low	Low	NOQ3	Mod
Washington	New York	36115	Mod	High	Low	Low	NOQ3	Mod
Wayne	New York	36117	Mod	Mod	Low	Low	Q3	High
Westchester	New York	36119	Mod	High	Mod	Low	Q3	Mod
Wyoming	New York	36121	Mod	Low	Low	Low	NOQ3	High
Yates	New York	36123	Mod	Mod	Low	Low	Q3	High
Alamance	North Carolina	37001	Low	Mod	Low	Low	Q3	Mod
Alexander	North Carolina	37003	Mod	High	Low	Low	NOQ3	Mod
Alleghany	North Carolina	37005	Mod	High	Low	Low	NOQ3	Mod
Anson	North Carolina	37007	Mod	High	Mod	Low	NOQ3	Mod
Ashe	North Carolina	37009	Mod	High	Low	Low	NOQ3	Mod
Avery	North Carolina	37011	Mod	High	Low	Low	NOQ3	Mod
Beaufort	North Carolina	37013	Low	Low	High	Low	Q3	Mod
Bertie	North Carolina	37015	Low	Low	Mod	Low	Q3	Mod
Bladen	North Carolina	37017	Mod	Low	High	Low	Q3	Mod
Brunswick	North Carolina	37019	Mod	Low	High	Low	Q3	Low
Buncombe	North Carolina	37021	Mod	High	Low	Low	Q3	Mod
Burke	North Carolina	37023	Mod	High	Low	Low	NOQ3	Mod
Cabarrus	North Carolina	37025	Mod	High	Mod	Mod	Q3	Mod
Caldwell	North Carolina	37027	Mod	High	Low	Low	NOQ3	Mod
Camden	North Carolina	37029	Low	Low	High	Low	Q3	Mod
Carteret	North Carolina	37031	Low	Low	High	Mod	Q3	Low
Caswell	North Carolina	37033	Low	Mod	Low	Low	NOQ3	Mod
Catawba	North Carolina	37035	Mod	High	Mod	Mod	NOQ3	Mod
Chatham	North Carolina	37037	Mod	Mod	Mod	Low	NOQ3	Mod
Cherokee	North Carolina	37039	Mod	High	Low	Low	NOQ3	Mod
Chowan	North Carolina	37041	Low	Low	Mod	Mod	NOQ3	Mod
Clay	North Carolina	37043	Mod	High	Low	Low	NOQ3	Mod
Cleveland	North Carolina	37045	Mod	High	Low	Low	NOQ3	Mod
Columbus	North Carolina	37047	Mod	Low	High	Low	Q3	Mod
Craven	North Carolina	37049	Low	Low	High	Low	Q3	Mod
Cumberland	North Carolina	37051	Mod	Low	Mod	Mod	Q3	Mod
Currituck	North Carolina	37053	Low	Low	High	Low	Q3	Mod
Dare	North Carolina	37055	Low	Low	High	Mod	Q3	Low
Davidson	North Carolina	37057	Mod	Mod	Low	Low	Q3	Mod
Davie	North Carolina	37059	Mod	Mod	Low	Low	NOQ3	Mod
Duplin	North Carolina	37061	Mod	Low	High	Low	Q3	Mod
Durham	North Carolina	37063	Low	Mod	Mod	Low	Q3	Mod
Edgecombe	North Carolina	37065	Low	Low	Mod	Low	Q3	Mod
Forsyth	North Carolina	37067	Mod	Mod	Mod	Mod	Q3	Mod
Franklin	North Carolina	37069	Low	Low	Mod	Low	Q3	Mod
Gaston	North Carolina	37071	Mod	High	Low	Low	NOQ3	Mod
Gates	North Carolina	37073	Low	Low	Mod	Low	NOQ3	Mod
Graham	North Carolina	37075	Mod	High	Low	Low	NOQ3	Mod
Granville	North Carolina	37077	Low	Mod	Mod	Low	Q3	Mod
Greene	North Carolina	37079	Low	Low	Mod	Mod	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Guilford	North Carolina	37081	Mod	Mod	Low	Low	Q3	Mod
Halifax	North Carolina	37083	Low	Low	Mod	Low	Q3	Mod
Harnett	North Carolina	37085	Mod	Low	Mod	Mod	Q3	Mod
Haywood	North Carolina	37087	Mod	High	Low	Low	NOQ3	Mod
Henderson	North Carolina	37089	Mod	High	Low	Low	Q3	Mod
Hertford	North Carolina	37091	Low	Low	Mod	Low	NOQ3	Mod
Hoke	North Carolina	37093	Mod	Low	Mod	Low	Q3	Mod
Hyde	North Carolina	37095	Low	Low	High	Low	Q3	Mod
Iredell	North Carolina	37097	Mod	High	Low	Low	NOQ3	Mod
Jackson	North Carolina	37099	Mod	High	Low	Low	NOQ3	Mod
Johnston	North Carolina	37101	Mod	Low	Mod	Low	Q3	Mod
Jones	North Carolina	37103	Low	Low	High	Low	Q3	Mod
Lee	North Carolina	37105	Mod	Mod	Mod	Low	NOQ3	Mod
Lenoir	North Carolina	37107	Low	Low	High	Mod	Q3	Mod
Lincoln	North Carolina	37109	Mod	High	Low	Low	NOQ3	Mod
Macon	North Carolina	37113	Mod	High	Low	Low	NOQ3	Mod
Madison	North Carolina	37115	Mod	High	Low	Low	NOQ3	Mod
Martin	North Carolina	37117	Low	Low	Mod	Low	NOQ3	Mod
McDowell	North Carolina	37111	Mod	High	Low	Low	NOQ3	Mod
Mecklenburg	North Carolina	37119	Mod	High	Mod	Mod	Q3	Mod
Mitchell	North Carolina	37121	Mod	High	Low	Low	NOQ3	Mod
Montgomery	North Carolina	37123	Mod	High	Mod	Low	NOQ3	Mod
Moore	North Carolina	37125	Mod	Mod	Mod	Low	Q3	Mod
Nash	North Carolina	37127	Low	Low	Mod	Low	Q3	Mod
New Hanover	North Carolina	37129	Mod	Low	High	Mod	Q3	Low
Northampton	North Carolina	37131	Low	Low	Mod	Low	NOQ3	Mod
Onslow	North Carolina	37133	Mod	Low	High	Mod	Q3	Mod
Orange	North Carolina	37135	Low	Mod	Low	Low	Q3	Mod
Pamlico	North Carolina	37137	Low	Low	High	Low	Q3	Low
Pasquotank	North Carolina	37139	Low	Low	High	Mod	Q3	Mod
Pender	North Carolina	37141	Mod	Low	High	Low	Q3	Mod
Perquimans	North Carolina	37143	Low	Low	Mod	Low	NOQ3	Mod
Person	North Carolina	37145	Low	Mod	Low	Low	Q3	Mod
Pitt	North Carolina	37147	Low	Low	Mod	Low	Q3	Mod
Polk	North Carolina	37149	Mod	High	Low	Low	NOQ3	Mod
Randolph	North Carolina	37151	Mod	Mod	Mod	Low	Q3	Mod
Richmond	North Carolina	37153	Mod	Mod	Mod	Low	NOQ3	Mod
Robeson	North Carolina	37155	Mod	Low	Mod	Low	Q3	Mod
Rockingham	North Carolina	37157	Mod	High	Low	Low	NOQ3	Mod
Rowan	North Carolina	37159	Mod	Mod	Low	Low	Q3	Mod
Rutherford	North Carolina	37161	Mod	High	Low	Low	Q3	Mod
Sampson	North Carolina	37163	Mod	Low	High	Low	Q3	Mod
Scotland	North Carolina	37165	Mod	Low	Mod	Mod	Q3	Mod
Stanly	North Carolina	37167	Mod	High	Mod	Mod	NOQ3	Mod
Stokes	North Carolina	37169	Mod	High	Low	Low	Q3	Mod
Surry	North Carolina	37171	Mod	High	Low	Low	NOQ3	Mod
Swain	North Carolina	37173	Mod	High	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Transylvania	North Carolina	37175	Mod	High	Low	Low	NOQ3	Mod
Tyrrell	North Carolina	37177	Low	Low	High	Low	NOQ3	Low
Union	North Carolina	37179	Mod	Mod	Mod	Mod	NOQ3	Mod
Vance	North Carolina	37181	Low	Mod	Low	Low	Q3	Mod
Wake	North Carolina	37183	Low	Mod	Mod	Mod	Q3	Mod
Warren	North Carolina	37185	Low	Low	Mod	Low	Q3	Mod
Washington	North Carolina	37187	Low	Low	High	Low	NOQ3	Mod
Watauga	North Carolina	37189	Mod	High	Low	Low	Q3	Mod
Wayne	North Carolina	37191	Low	Low	Mod	Mod	Q3	Mod
Wilkes	North Carolina	37193	Mod	High	Low	Low	NOQ3	Mod
Wilson	North Carolina	37195	Low	Low	Mod	Low	Q3	Mod
Yadkin	North Carolina	37197	Mod	High	Low	Low	NOQ3	Mod
Yancey	North Carolina	37199	Mod	High	Low	Low	NOQ3	Mod
Adams	North Dakota	38001	Low	Mod	Low	Low	Q3	Mod
Barnes	North Dakota	38003	Low	Low	Low	Low	Q3	Mod
Benson	North Dakota	38005	Low	Low	Low	Low	NOQ3	Mod
Billings	North Dakota	38007	Low	Mod	Low	Low	Q3	Mod
Bottineau	North Dakota	38009	Low	Mod	Low	Low	Q3	Mod
Bowman	North Dakota	38011	Low	High	Low	Low	Q3	Mod
Burke	North Dakota	38013	Low	High	Low	Low	Q3	Mod
Burleigh	North Dakota	38015	Low	Mod	Low	Low	Q3	Mod
Cass	North Dakota	38017	Low	Low	Mod	Mod	Q3	Mod
Cavalier	North Dakota	38019	Low	Low	Low	Low	Q3	Mod
Dickey	North Dakota	38021	Low	Low	Low	Low	NOQ3	Mod
Divide	North Dakota	38023	Mod	Low	Low	Low	Q3	Mod
Dunn	North Dakota	38025	Low	Mod	Low	Low	Q3	Mod
Eddy	North Dakota	38027	Low	Low	Low	Low	Q3	Mod
Emmons	North Dakota	38029	Low	High	Low	Low	Q3	Mod
Foster	North Dakota	38031	Low	Low	Low	Low	NOQ3	Mod
Golden Valley	North Dakota	38033	Low	Mod	Low	Low	Q3	Mod
Grand Forks	North Dakota	38035	Low	Low	Low	Low	Q3	Mod
Grant	North Dakota	38037	Low	Mod	Low	Low	NOQ3	Mod
Griggs	North Dakota	38039	Low	Low	Mod	Mod	Q3	Mod
Hettinger	North Dakota	38041	Low	Mod	Low	Low	Q3	Mod
Kidder	North Dakota	38043	Low	Mod	Low	Low	Q3	Mod
La Moure	North Dakota	38045	Low	Low	Low	Low	Q3	Mod
Logan	North Dakota	38047	Low	Mod	Low	Low	Q3	Mod
McHenry	North Dakota	38049	Low	Low	Low	Low	Q3	Mod
McIntosh	North Dakota	38051	Low	Mod	Low	Low	Q3	Mod
McKenzie	North Dakota	38053	Low	Mod	Low	Low	Q3	Mod
McLean	North Dakota	38055	Low	Mod	Low	Low	NOQ3	Mod
Mercer	North Dakota	38057	Low	Mod	Low	Low	Q3	Mod
Morton	North Dakota	38059	Low	High	Low	Low	Q3	Mod
Mountrial	North Dakota	38061	Low	Mod	Low	Low	Q3	Mod
Nelson	North Dakota	38063	Low	Low	Low	Low	Q3	Mod
Oliver	North Dakota	38065	Low	Mod	Low	Low	Q3	Mod
Pembina	North Dakota	38067	Low	Low	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Pierce	North Dakota	38069	Low	Low	Low	Low	Q3	Mod
Ramsey	North Dakota	38071	Low	Low	Mod	Mod	Q3	Mod
Ransom	North Dakota	38073	Low	Low	Low	Low	Q3	Mod
Renville	North Dakota	38075	Low	High	Low	Low	Q3	Mod
Richland	North Dakota	38077	Low	Low	Low	Low	Q3	Mod
Rolette	North Dakota	38079	Low	Mod	Low	Low	Q3	Mod
Sargent	North Dakota	38081	Low	Low	Low	Low	NOQ3	Mod
Sheridan	North Dakota	38083	Low	Low	Low	Low	NOQ3	Mod
Sioux	North Dakota	38085	Low	High	Low	Low	Q3	Mod
Slope	North Dakota	38087	Low	High	Low	Low	Q3	Mod
Stark	North Dakota	38089	Low	Mod	Low	Low	Q3	Mod
Steele	North Dakota	38091	Low	Low	Mod	Mod	NOQ3	Mod
Stutsman	North Dakota	38093	Low	Low	Low	Low	Q3	Mod
Towner	North Dakota	38095	Low	Mod	Low	Low	NOQ3	Mod
Traill	North Dakota	38097	Low	Low	Low	Low	Q3	Mod
Walsh	North Dakota	38099	Low	Low	Low	Low	Q3	Mod
Ward	North Dakota	38101	Low	High	Low	Low	Q3	Mod
Wells	North Dakota	38103	Low	Low	Low	Low	Q3	Mod
Williams	North Dakota	38105	Mod	Mod	Low	Low	Q3	Mod
Adams	Ohio	39001	Mod	High	Low	Low	Q3	Mod
Allen	Ohio	39003	Mod	Mod	Mod	Mod	Q3	Mod
Ashland	Ohio	39005	Low	Low	Mod	Mod	NOQ3	Mod
Ashtabula	Ohio	39007	Mod	High	Low	Low	NOQ3	Mod
Athens	Ohio	39009	Low	High	Low	Low	Q3	Mod
Auglaize	Ohio	39011	Mod	Mod	Low	Low	NOQ3	Mod
Belmont	Ohio	39013	Low	High	Low	Low	Q3	Mod
Brown	Ohio	39015	Mod	High	Low	Low	Q3	Mod
Butler	Ohio	39017	Low	High	Mod	Mod	Q3	Mod
Carroll	Ohio	39019	Low	High	Low	Low	Q3	Mod
Champaign	Ohio	39021	Mod	Low	Low	Low	NOQ3	Mod
Clark	Ohio	39023	Mod	Low	Mod	Mod	NOQ3	Mod
Clermont	Ohio	39025	Mod	High	Low	Low	Q3	Mod
Clinton	Ohio	39027	Low	Mod	Mod	Mod	NOQ3	Mod
Columbiana	Ohio	39029	Low	High	Mod	Mod	Q3	Mod
Coshocton	Ohio	39031	Low	High	Low	Low	NOQ3	Mod
Crawford	Ohio	39033	Low	Mod	Mod	Mod	Q3	Mod
Cuyahoga	Ohio	39035	Mod	High	Mod	Mod	Q3	Mod
Darke	Ohio	39037	Mod	Mod	Mod	Mod	NOQ3	Mod
Defiance	Ohio	39039	Low	Mod	Low	Low	NOQ3	High
Delaware	Ohio	39041	Low	Mod	Low	Low	Q3	Mod
Erie	Ohio	39043	Low	Mod	Mod	Mod	Q3	Mod
Fairfield	Ohio	39045	Low	High	Low	Low	Q3	Mod
Fayette	Ohio	39047	Low	Low	Low	Low	NOQ3	Mod
Franklin	Ohio	39049	Low	Mod	Mod	Mod	Q3	Mod
Fulton	Ohio	39051	Low	Mod	Mod	Mod	NOQ3	High
Gallia	Ohio	39053	Low	High	Low	Low	Q3	Mod
Geauga	Ohio	39055	Mod	Mod	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Greene	Ohio	39057	Mod	Low	Mod	Mod	Q3	Mod
Guernsey	Ohio	39059	Low	High	Low	Low	NOQ3	Mod
Hamilton	Ohio	39061	Low	High	Mod	Mod	Q3	Mod
Hancock	Ohio	39063	Mod	Low	Low	Low	Q3	High
Hardin	Ohio	39065	Mod	Mod	Low	Low	NOQ3	Mod
Harrison	Ohio	39067	Low	High	Low	Low	NOQ3	Mod
Henry	Ohio	39069	Low	Mod	Low	Low	NOQ3	High
Highland	Ohio	39071	Low	Low	Mod	Mod	NOQ3	Mod
Hocking	Ohio	39073	Low	High	Low	Low	Q3	Mod
Holmes	Ohio	39075	Low	Low	Low	Low	NOQ3	Mod
Huron	Ohio	39077	Low	Low	Mod	Mod	Q3	Mod
Jackson	Ohio	39079	Low	High	Low	Low	Q3	Mod
Jefferson	Ohio	39081	Low	High	Low	Low	Q3	Mod
Knox	Ohio	39083	Low	Low	Low	Low	NOQ3	Mod
Lake	Ohio	39085	Mod	Mod	Low	Low	Q3	Mod
Lawrence	Ohio	39087	Mod	High	Low	Low	Q3	Mod
Licking	Ohio	39089	Low	High	Low	Low	Q3	Mod
Logan	Ohio	39091	Mod	Low	Low	Low	NOQ3	Mod
Lorain	Ohio	39093	Low	Mod	Mod	Mod	Q3	Mod
Lucas	Ohio	39095	Low	High	Low	Low	Q3	High
Madison	Ohio	39097	Mod	Low	Low	Low	NOQ3	Mod
Mahoning	Ohio	39099	Low	High	Mod	Mod	Q3	Mod
Marion	Ohio	39101	Mod	Low	Mod	Mod	NOQ3	Mod
Medina	Ohio	39103	Mod	Low	Mod	Mod	Q3	Mod
Meigs	Ohio	39105	Low	High	Low	Low	Q3	Mod
Mercer	Ohio	39107	Mod	Mod	Mod	Mod	NOQ3	High
Miami	Ohio	39109	Mod	Low	Mod	Mod	NOQ3	Mod
Monroe	Ohio	39111	Low	High	Low	Low	Q3	Mod
Montgomery	Ohio	39113	Mod	Low	Low	Low	Q3	Mod
Morgan	Ohio	39115	Low	High	Low	Low	Q3	Mod
Morrow	Ohio	39117	Low	Low	Mod	Mod	NOQ3	Mod
Muskingum	Ohio	39119	Low	High	Low	Low	NOQ3	Mod
Noble	Ohio	39121	Low	High	Low	Low	NOQ3	Mod
Ottawa	Ohio	39123	Low	Mod	Low	Low	Q3	High
Paulding	Ohio	39125	Mod	Mod	Low	Low	NOQ3	High
Perry	Ohio	39127	Low	High	Low	Low	NOQ3	Mod
Pickaway	Ohio	39129	Low	Mod	Mod	Mod	NOQ3	Mod
Pike	Ohio	39131	Low	Mod	Low	Low	Q3	Mod
Portage	Ohio	39133	Mod	Mod	Low	Low	NOQ3	Mod
Preble	Ohio	39135	Mod	Low	Low	Low	NOQ3	Mod
Putnam	Ohio	39137	Mod	Mod	Mod	Mod	NOQ3	High
Richland	Ohio	39139	Low	Mod	Mod	Mod	Q3	Mod
Ross	Ohio	39141	Low	Mod	Low	Low	Q3	Mod
Sandusky	Ohio	39143	Low	Mod	Low	Low	NOQ3	High
Scioto	Ohio	39145	Mod	Mod	Low	Low	Q3	Mod
Seneca	Ohio	39147	Low	Low	Mod	Mod	Q3	Mod
Shelby	Ohio	39149	Mod	Low	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Stark	Ohio	39151	Low	High	Low	Low	Q3	Mod
Summit	Ohio	39153	Mod	High	Low	Low	Q3	Mod
Trumbull	Ohio	39155	Mod	High	Low	Low	Q3	Mod
Tuscarawas	Ohio	39157	Low	High	Low	Low	NOQ3	Mod
Union	Ohio	39159	Mod	Low	Low	Low	NOQ3	Mod
Van Wert	Ohio	39161	Mod	Low	Low	Low	NOQ3	High
Vinton	Ohio	39163	Low	High	Low	Low	Q3	Mod
Warren	Ohio	39165	Low	High	Mod	Mod	Q3	Mod
Washington	Ohio	39167	Low	High	Low	Low	Q3	Mod
Wayne	Ohio	39169	Low	Low	Low	Low	Q3	Mod
Williams	Ohio	39171	Low	Mod	Low	Low	NOQ3	High
Wood	Ohio	39173	Low	High	Low	Low	Q3	High
Wyandot	Ohio	39175	Mod	Low	Mod	Mod	NOQ3	Mod
Adair	Oklahoma	40001	Low	Mod	Low	Low	NOQ3	High
Alfalfa	Oklahoma	40003	Low	Low	Mod	Mod	NOQ3	Mod
Atoka	Oklahoma	40005	Mod	High	Mod	Mod	NOQ3	High
Beaver	Oklahoma	40007	Low	Low	Low	Low	NOQ3	Mod
Beckham	Oklahoma	40009	Mod	Low	Mod	Mod	NOQ3	Mod
Blaine	Oklahoma	40011	Mod	Low	Mod	Mod	NOQ3	Mod
Bryan	Oklahoma	40013	Mod	Mod	Mod	Mod	NOQ3	Mod
Caddo	Oklahoma	40015	Mod	Low	Mod	Mod	NOQ3	Mod
Canadian	Oklahoma	40017	Mod	Low	Mod	Mod	Q3	Mod
Carter	Oklahoma	40019	Mod	Low	Mod	Mod	NOQ3	Mod
Cherokee	Oklahoma	40021	Low	Mod	Low	Low	NOQ3	High
Choctaw	Oklahoma	40023	Low	Mod	Low	Low	NOQ3	High
Cimarron	Oklahoma	40025	Low	High	Low	Low	NOQ3	Mod
Cleveland	Oklahoma	40027	Mod	Low	Mod	Mod	Q3	Mod
Coal	Oklahoma	40029	Mod	High	Mod	Mod	NOQ3	High
Comanche	Oklahoma	40031	Mod	Low	Mod	Mod	Q3	Mod
Cotton	Oklahoma	40033	Mod	Low	Mod	Mod	NOQ3	Mod
Craig	Oklahoma	40035	Low	Low	Mod	Mod	NOQ3	High
Creek	Oklahoma	40037	Low	Mod	Mod	Mod	Q3	High
Custer	Oklahoma	40039	Mod	Low	Mod	Mod	NOQ3	Mod
Delaware	Oklahoma	40041	Low	Low	Mod	Mod	NOQ3	High
Dewey	Oklahoma	40043	Mod	Low	Mod	Mod	NOQ3	Mod
Ellis	Oklahoma	40045	Low	Low	Mod	Mod	NOQ3	Mod
Garfield	Oklahoma	40047	Mod	Low	Mod	Mod	Q3	Mod
Garvin	Oklahoma	40049	Mod	Low	Mod	Mod	NOQ3	Mod
Grady	Oklahoma	40051	Mod	Low	Mod	Mod	Q3	Mod
Grant	Oklahoma	40053	Low	Low	Mod	Mod	NOQ3	Mod
Greer	Oklahoma	40055	Mod	Low	Mod	Mod	NOQ3	Mod
Harmon	Oklahoma	40057	Low	Low	Mod	Mod	NOQ3	Mod
Harper	Oklahoma	40059	Low	Low	Low	Low	NOQ3	Mod
Haskell	Oklahoma	40061	Low	High	Low	Low	NOQ3	High
Hughes	Oklahoma	40063	Mod	Low	Mod	Mod	NOQ3	High
Jackson	Oklahoma	40065	Mod	Low	Mod	Mod	NOQ3	Mod
Jefferson	Oklahoma	40067	Mod	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Johnston	Oklahoma	40069	Mod	Mod	Mod	Mod	NOQ3	Mod
Kay	Oklahoma	40071	Low	Low	Mod	Mod	Q3	Mod
Kingfisher	Oklahoma	40073	Mod	Low	Mod	Mod	NOQ3	Mod
Kiowa	Oklahoma	40075	Mod	Low	Mod	Mod	NOQ3	Mod
Latimer	Oklahoma	40077	Low	High	Low	Low	NOQ3	High
Le Flore	Oklahoma	40079	Low	High	Low	Low	NOQ3	High
Lincoln	Oklahoma	40081	Mod	Low	Mod	Mod	NOQ3	High
Logan	Oklahoma	40083	Mod	Low	Mod	Mod	NOQ3	Mod
Love	Oklahoma	40085	Mod	Mod	Mod	Mod	NOQ3	Mod
Major	Oklahoma	40093	Mod	Low	Mod	Mod	NOQ3	Mod
Marshall	Oklahoma	40095	Mod	Mod	Mod	Mod	NOQ3	Mod
Mayes	Oklahoma	40097	Low	Mod	Mod	Mod	NOQ3	High
McClain	Oklahoma	40087	Mod	Low	Mod	Mod	NOQ3	Mod
McCurtain	Oklahoma	40089	Low	Mod	Low	Low	NOQ3	High
McIntosh	Oklahoma	40091	Low	High	Mod	Mod	NOQ3	High
Murray	Oklahoma	40099	Mod	Low	Mod	Mod	NOQ3	Mod
Muskogee	Oklahoma	40101	Low	High	Mod	Mod	NOQ3	High
Noble	Oklahoma	40103	Mod	Low	Mod	Mod	NOQ3	Mod
Nowata	Oklahoma	40105	Low	Low	Mod	Mod	NOQ3	High
Okfuskee	Oklahoma	40107	Mod	Low	Mod	Mod	NOQ3	High
Oklahoma	Oklahoma	40109	Mod	Low	Mod	Mod	Q3	Mod
Okmulgee	Oklahoma	40111	Low	Low	Mod	Mod	NOQ3	High
Osage	Oklahoma	40113	Low	High	Low	Low	Q3	High
Ottawa	Oklahoma	40115	Low	Low	Mod	Mod	Q3	High
Pawnee	Oklahoma	40117	Low	Mod	Mod	Mod	NOQ3	High
Payne	Oklahoma	40119	Mod	Low	Mod	Mod	Q3	High
Pittsburg	Oklahoma	40121	Mod	High	Mod	Mod	NOQ3	High
Pontotoc	Oklahoma	40123	Mod	Low	Mod	Mod	NOQ3	High
Pottawatomie	Oklahoma	40125	Mod	Low	Mod	Mod	NOQ3	High
Pushmataha	Oklahoma	40127	Low	Mod	Low	Low	NOQ3	High
Roger Mills	Oklahoma	40129	Low	Low	Mod	Mod	NOQ3	Mod
Rogers	Oklahoma	40131	Low	Low	Mod	Mod	NOQ3	High
Seminole	Oklahoma	40133	Mod	Low	Mod	Mod	NOQ3	High
Sequoyah	Oklahoma	40135	Low	Mod	Mod	Mod	NOQ3	High
Stephens	Oklahoma	40137	Mod	Low	Mod	Mod	NOQ3	Mod
Texas	Oklahoma	40139	Low	Low	Low	Low	NOQ3	Mod
Tillman	Oklahoma	40141	Mod	Low	Mod	Mod	NOQ3	Mod
Tulsa	Oklahoma	40143	Low	High	Mod	Mod	Q3	High
Wagoner	Oklahoma	40145	Low	High	Mod	Mod	NOQ3	High
Washington	Oklahoma	40147	Low	Mod	Mod	Mod	NOQ3	High
Washita	Oklahoma	40149	Mod	Low	Mod	Mod	NOQ3	Mod
Woods	Oklahoma	40151	Low	Low	Mod	Mod	NOQ3	Mod
Woodward	Oklahoma	40153	Low	Low	Mod	Mod	NOQ3	Mod
Baker	Oregon	41001	Mod	High	Low	Low	NOQ3	Low
Benton	Oregon	41003	High	Mod	Low	Low	Q3	Mod
Clackamas	Oregon	41005	Mod	High	Low	Low	Q3	High
Clatsop	Oregon	41007	High	High	Low	Low	Q3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Columbia	Oregon	41009	Mod	High	Low	Low	Q3	Mod
Coos	Oregon	41011	High	High	Low	Low	Q3	Low
Crook	Oregon	41013	Mod	High	Low	Low	NOQ3	Low
Curry	Oregon	41015	High	High	Low	Low	NOQ3	Low
Deschutes	Oregon	41017	Mod	High	Low	Low	Q3	Low
Douglas	Oregon	41019	High	High	Low	Low	Q3	Low
Gilliam	Oregon	41021	Mod	High	Low	Low	Q3	Low
Grant	Oregon	41023	Mod	High	Low	Low	NOQ3	Low
Harney	Oregon	41025	Mod	High	Low	Low	NOQ3	Low
Hood River	Oregon	41027	Mod	Mod	Low	Low	Q3	High
Jackson	Oregon	41029	Mod	High	Low	Low	Q3	Low
Jefferson	Oregon	41031	Mod	High	Low	Low	Q3	Low
Josephine	Oregon	41033	High	High	Low	Low	Q3	Low
Klamath	Oregon	41035	High	Mod	Low	Low	NOQ3	Low
Lake	Oregon	41037	Mod	High	Low	Low	NOQ3	Low
Lane	Oregon	41039	High	High	Low	Low	Q3	Mod
Lincoln	Oregon	41041	High	High	Low	Low	Q3	Low
Linn	Oregon	41043	Mod	High	Low	Low	Q3	Mod
Malheur	Oregon	41045	Mod	High	Low	Low	NOQ3	Low
Marion	Oregon	41047	Mod	High	Low	Low	Q3	Mod
Morrow	Oregon	41049	Mod	High	Low	Low	Q3	Low
Multnomah	Oregon	41051	Mod	High	Low	Low	Q3	High
Polk	Oregon	41053	Mod	Mod	Low	Low	Q3	Mod
Sherman	Oregon	41055	Mod	Low	Low	Low	Q3	Low
Tillamook	Oregon	41057	High	High	Low	Low	Q3	Low
Umatilla	Oregon	41059	Mod	Low	Low	Low	Q3	Low
Union	Oregon	41061	Mod	High	Low	Low	Q3	Low
Wallowa	Oregon	41063	Mod	High	Low	Low	Q3	Low
Wasco	Oregon	41065	Mod	High	Low	Low	Q3	Mod
Washington	Oregon	41067	Mod	High	Low	Low	Q3	High
Wheeler	Oregon	41069	Mod	High	Low	Low	Q3	Low
Yamhill	Oregon	41071	High	Mod	Low	Low	Q3	Mod
Adams	Pennsylvania	42001	Low	High	Low	Low	Q3	Mod
Allegheny	Pennsylvania	42003	Low	High	Low	Low	Q3	Mod
Armstrong	Pennsylvania	42005	Low	High	Low	Low	Q3	Mod
Beaver	Pennsylvania	42007	Low	High	Mod	Mod	Q3	Mod
Bedford	Pennsylvania	42009	Low	High	Low	Low	Q3	Mod
Berks	Pennsylvania	42011	Mod	High	Low	Low	Q3	High
Blair	Pennsylvania	42013	Low	High	Low	Low	Q3	Mod
Bradford	Pennsylvania	42015	Low	Mod	Low	Low	Q3	Mod
Bucks	Pennsylvania	42017	Mod	Mod	Mod	Mod	Q3	High
Butler	Pennsylvania	42019	Low	High	Low	Low	Q3	Mod
Cambria	Pennsylvania	42021	Low	High	Low	Low	Q3	Mod
Cameron	Pennsylvania	42023	Low	High	Low	Low	NOQ3	Mod
Carbon	Pennsylvania	42025	Mod	High	Low	Low	Q3	Mod
Centre	Pennsylvania	42027	Low	High	Low	Low	NOQ3	Mod
Chester	Pennsylvania	42029	Mod	Low	Mod	Mod	Q3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Clarion	Pennsylvania	42031	Low	High	Low	Low	Q3	Mod
Clearfield	Pennsylvania	42033	Low	High	Low	Low	Q3	Mod
Clinton	Pennsylvania	42035	Low	High	Low	Low	Q3	Mod
Columbia	Pennsylvania	42037	Mod	High	Low	Low	Q3	Mod
Crawford	Pennsylvania	42039	Low	Low	Low	Low	Q3	Mod
Cumberland	Pennsylvania	42041	Mod	High	Low	Low	Q3	Mod
Dauphin	Pennsylvania	42043	Mod	High	Low	Low	Q3	Mod
Delaware	Pennsylvania	42045	Mod	Mod	Low	Low	Q3	High
Elk	Pennsylvania	42047	Low	High	Low	Low	NOQ3	Mod
Erie	Pennsylvania	42049	Low	Mod	Low	Low	Q3	Mod
Fayette	Pennsylvania	42051	Low	High	Low	Low	Q3	Mod
Forest	Pennsylvania	42053	Low	High	Low	Low	NOQ3	Mod
Franklin	Pennsylvania	42055	Low	High	Low	Low	Q3	Mod
Fulton	Pennsylvania	42057	Low	High	Low	Low	NOQ3	Mod
Greene	Pennsylvania	42059	Low	High	Low	Low	NOQ3	Mod
Huntingdon	Pennsylvania	42061	Low	High	Low	Low	NOQ3	Mod
Indiana	Pennsylvania	42063	Low	High	Low	Low	Q3	Mod
Jefferson	Pennsylvania	42065	Low	High	Low	Low	NOQ3	Mod
Juniata	Pennsylvania	42067	Low	High	Low	Low	NOQ3	Mod
Lackawanna	Pennsylvania	42069	Mod	High	Low	Low	Q3	Mod
Lancaster	Pennsylvania	42071	Mod	Low	Low	Low	Q3	High
Lawrence	Pennsylvania	42073	Low	High	Mod	Mod	Q3	Mod
Lebanon	Pennsylvania	42075	Mod	High	Mod	Mod	Q3	High
Lehigh	Pennsylvania	42077	Mod	High	Mod	Mod	Q3	High
Luzerne	Pennsylvania	42079	Mod	High	Low	Low	Q3	Mod
Lycoming	Pennsylvania	42081	Low	High	Low	Low	Q3	Mod
McKean	Pennsylvania	42083	Low	High	Low	Low	NOQ3	Mod
Mercer	Pennsylvania	42085	Low	High	Low	Low	NOQ3	Mod
Mifflin	Pennsylvania	42087	Low	High	Low	Low	Q3	Mod
Monroe	Pennsylvania	42089	Mod	High	Low	Low	NOQ3	Mod
Montgomery	Pennsylvania	42091	Mod	Low	Mod	Mod	Q3	High
Montour	Pennsylvania	42093	Low	High	Low	Low	NOQ3	Mod
Northampton	Pennsylvania	42095	Mod	High	Mod	Mod	Q3	High
Northumberland	Pennsylvania	42097	Mod	High	Low	Low	Q3	Mod
Perry	Pennsylvania	42099	Low	High	Low	Low	Q3	Mod
Philadelphia	Pennsylvania	42101	Mod	Mod	Mod	Mod	Q3	High
Pike	Pennsylvania	42103	Mod	High	Low	Low	NOQ3	Mod
Potter	Pennsylvania	42105	Low	Mod	Low	Low	NOQ3	Mod
Schuylkill	Pennsylvania	42107	Mod	High	Low	Low	Q3	Mod
Snyder	Pennsylvania	42109	Low	High	Low	Low	Q3	Mod
Somerset	Pennsylvania	42111	Low	High	Low	Low	Q3	Mod
Sullivan	Pennsylvania	42113	Low	Mod	Low	Low	NOQ3	Mod
Susquehanna	Pennsylvania	42115	Low	High	Low	Low	NOQ3	Mod
Tioga	Pennsylvania	42117	Low	Mod	Low	Low	NOQ3	Mod
Union	Pennsylvania	42119	Low	High	Low	Low	Q3	Mod
Venango	Pennsylvania	42121	Low	High	Low	Low	NOQ3	Mod
Warren	Pennsylvania	42123	Low	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Washington	Pennsylvania	42125	Low	High	Low	Low	Q3	Mod
Wayne	Pennsylvania	42127	Mod	High	Low	Low	NOQ3	Mod
Westmoreland	Pennsylvania	42129	Low	High	Mod	Mod	Q3	Mod
Wyoming	Pennsylvania	42131	Mod	Mod	Low	Low	Q3	Mod
York	Pennsylvania	42133	Mod	High	Low	Low	Q3	Mod
Bristol	Rhode Island	44001	Mod	Low	High	Mod	Q3	Mod
Kent	Rhode Island	44003	Mod	Low	High	Low	Q3	Mod
Newport	Rhode Island	44005	Mod	Low	High	Low	Q3	Mod
Providence	Rhode Island	44007	Mod	Low	High	Low	Q3	Mod
Washington	Rhode Island	44009	Mod	Low	High	Low	Q3	Mod
Abbeville	South Carolina	45001	Mod	Mod	Low	Low	NOQ3	Mod
Aiken	South Carolina	45003	Mod	Low	Mod	Low	NOQ3	Mod
Allendale	South Carolina	45005	Mod	Low	Mod	Low	NOQ3	Mod
Anderson	South Carolina	45007	Mod	High	Low	Low	NOQ3	Mod
Bamberg	South Carolina	45009	Mod	Low	Mod	Low	NOQ3	Mod
Barnwell	South Carolina	45011	Mod	Low	Mod	Low	NOQ3	Mod
Beaufort	South Carolina	45013	Mod	Low	High	Low	Q3	Low
Berkeley	South Carolina	45015	High	Low	High	Low	Q3	Mod
Calhoun	South Carolina	45017	Mod	Low	Mod	Low	NOQ3	Mod
Charleston	South Carolina	45019	High	Low	High	Low	Q3	Low
Cherokee	South Carolina	45021	Mod	High	Mod	Mod	NOQ3	Mod
Chester	South Carolina	45023	Mod	Mod	Mod	Low	NOQ3	Mod
Chesterfield	South Carolina	45025	Mod	Mod	Mod	Low	NOQ3	Mod
Clarendon	South Carolina	45027	High	Low	Mod	Low	NOQ3	Mod
Colleton	South Carolina	45029	High	Low	High	Low	Q3	Mod
Darlington	South Carolina	45031	Mod	Low	Mod	Low	NOQ3	Mod
Dillon	South Carolina	45033	Mod	Low	Mod	Low	NOQ3	Mod
Dorchester	South Carolina	45035	High	Low	High	Low	NOQ3	Mod
Edgefield	South Carolina	45037	Mod	Low	Mod	Low	NOQ3	Mod
Fairfield	South Carolina	45039	Mod	Mod	Mod	Low	NOQ3	Mod
Florence	South Carolina	45041	High	Low	High	Mod	NOQ3	Mod
Georgetown	South Carolina	45043	High	Low	High	Low	Q3	Low
Greenville	South Carolina	45045	Mod	High	Mod	Mod	Q3	Mod
Greenwood	South Carolina	45047	Mod	Mod	Mod	Mod	NOQ3	Mod
Hampton	South Carolina	45049	Mod	Low	High	Low	Q3	Mod
Horry	South Carolina	45051	Mod	Low	High	Mod	Q3	Mod
Jasper	South Carolina	45053	Mod	Low	High	Low	Q3	Low
Kershaw	South Carolina	45055	Mod	Low	Mod	Low	NOQ3	Mod
Lancaster	South Carolina	45057	Mod	Mod	Mod	Low	NOQ3	Mod
Laurens	South Carolina	45059	Mod	Mod	Low	Low	NOQ3	Mod
Lee	South Carolina	45061	Mod	Low	Mod	Low	NOQ3	Mod
Lexington	South Carolina	45063	Mod	Mod	Mod	Mod	Q3	Mod
Marion	South Carolina	45067	High	Low	High	Low	NOQ3	Mod
Marlboro	South Carolina	45069	Mod	Low	Mod	Low	NOQ3	Mod
McCormick	South Carolina	45065	Mod	Mod	Mod	Low	NOQ3	Mod
Newberry	South Carolina	45071	Mod	Mod	Mod	Mod	NOQ3	Mod
Oconee	South Carolina	45073	Mod	High	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Orangeburg	South Carolina	45075	High	Low	High	Mod	NOQ3	Mod
Pickens	South Carolina	45077	Mod	High	Mod	Mod	NOQ3	Mod
Richland	South Carolina	45079	Mod	Mod	Mod	Mod	Q3	Mod
Saluda	South Carolina	45081	Mod	Mod	Mod	Low	Q3	Mod
Spartanburg	South Carolina	45083	Mod	High	Mod	Mod	Q3	Mod
Sumter	South Carolina	45085	Mod	Low	Mod	Low	Q3	Mod
Union	South Carolina	45087	Mod	Mod	Low	Low	NOQ3	Mod
Williamsburg	South Carolina	45089	High	Low	High	Low	NOQ3	Mod
York	South Carolina	45091	Mod	Mod	Low	Low	NOQ3	Mod
Aurora	South Dakota	46003	Mod	Mod	Low	Low	Q3	Mod
Beadle	South Dakota	46005	Mod	Low	Low	Low	Q3	Mod
Bennett	South Dakota	46007	Low	Low	Low	Low	NOQ3	Mod
Bon Homme	South Dakota	46009	Low	High	Mod	Mod	NOQ3	Mod
Brookings	South Dakota	46011	Low	Low	Mod	Mod	Q3	Mod
Brown	South Dakota	46013	Low	Low	Mod	Mod	Q3	Mod
Brule	South Dakota	46015	Mod	High	Low	Low	NOQ3	Mod
Buffalo	South Dakota	46017	Mod	High	Mod	Mod	NOQ3	Mod
Butte	South Dakota	46019	Low	High	Low	Low	Q3	Mod
Campbell	South Dakota	46021	Low	High	Low	Low	Q3	Mod
Charles Mix	South Dakota	46023	Low	High	Mod	Mod	Q3	Mod
Clark	South Dakota	46025	Low	Low	Low	Low	Q3	Mod
Clay	South Dakota	46027	Low	High	Mod	Mod	Q3	Mod
Codington	South Dakota	46029	Low	Low	Mod	Mod	Q3	Mod
Corson	South Dakota	46031	Low	High	Low	Low	NOQ3	Mod
Custer	South Dakota	46033	Low	High	Low	Low	Q3	Mod
Davison	South Dakota	46035	Low	Low	Mod	Mod	Q3	Mod
Day	South Dakota	46037	Low	Low	Low	Low	NOQ3	Mod
Deuel	South Dakota	46039	Low	Low	Low	Low	Q3	Mod
Dewey	South Dakota	46041	Low	High	Low	Low	Q3	Mod
Douglas	South Dakota	46043	Low	Low	Mod	Mod	Q3	Mod
Edmunds	South Dakota	46045	Low	Low	Low	Low	Q3	Mod
Fall River	South Dakota	46047	Low	High	Low	Low	Q3	Low
Faulk	South Dakota	46049	Low	Low	Low	Low	Q3	Mod
Grant	South Dakota	46051	Low	Low	Low	Low	Q3	Mod
Gregory	South Dakota	46053	Low	High	Low	Low	NOQ3	Mod
Haakon	South Dakota	46055	Low	High	Low	Low	Q3	Mod
Hamlin	South Dakota	46057	Low	Low	Low	Low	Q3	Mod
Hand	South Dakota	46059	Mod	Mod	Low	Low	Q3	Mod
Hanson	South Dakota	46061	Low	Low	Low	Low	Q3	Mod
Harding	South Dakota	46063	Low	High	Low	Low	Q3	Mod
Hughes	South Dakota	46065	Low	High	Low	Low	Q3	Mod
Hutchinson	South Dakota	46067	Low	Mod	Mod	Mod	Q3	Mod
Hyde	South Dakota	46069	Low	High	Low	Low	NOQ3	Mod
Jackson	South Dakota	46071	Low	High	Low	Low	Q3	Mod
Jerauld	South Dakota	46073	Mod	Mod	Low	Low	NOQ3	Mod
Jones	South Dakota	46075	Low	High	Low	Low	NOQ3	Mod
Kingsbury	South Dakota	46077	Low	Low	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Lake	South Dakota	46079	Low	Low	Mod	Mod	Q3	Mod
Lawrence	South Dakota	46081	Low	High	Low	Low	Q3	Low
Lincoln	South Dakota	46083	Low	Low	Mod	Mod	Q3	Mod
Lyman	South Dakota	46085	Low	High	Low	Low	Q3	Mod
Marshall	South Dakota	46091	Low	Low	Low	Low	Q3	Mod
McCook	South Dakota	46087	Low	Low	Mod	Mod	Q3	Mod
McPherson	South Dakota	46089	Low	Low	Low	Low	Q3	Mod
Meade	South Dakota	46093	Low	High	Low	Low	Q3	Mod
Mellette	South Dakota	46095	Low	High	Low	Low	NOQ3	Mod
Miner	South Dakota	46097	Low	Low	Mod	Mod	Q3	Mod
Minnehaha	South Dakota	46099	Low	Low	Mod	Mod	Q3	Mod
Moody	South Dakota	46101	Low	Low	Low	Low	Q3	Mod
Pennington	South Dakota	46103	Low	High	Low	Low	Q3	Mod
Perkins	South Dakota	46105	Low	High	Low	Low	Q3	Mod
Potter	South Dakota	46107	Low	High	Low	Low	NOQ3	Mod
Roberts	South Dakota	46109	Low	Low	Low	Low	Q3	Mod
Sanborn	South Dakota	46111	Mod	Low	Low	Low	Q3	Mod
Shannon	South Dakota	46113	Low	High	Low	Low	Q3	Mod
Spink	South Dakota	46115	Low	Low	Mod	Mod	Q3	Mod
Stanley	South Dakota	46117	Low	High	Low	Low	Q3	Mod
Sully	South Dakota	46119	Low	High	Low	Low	NOQ3	Mod
Todd	South Dakota	46121	Low	High	Low	Low	Q3	Mod
Tripp	South Dakota	46123	Low	High	Low	Low	Q3	Mod
Turner	South Dakota	46125	Low	Mod	Mod	Mod	Q3	Mod
Union	South Dakota	46127	Low	Mod	Mod	Mod	Q3	Mod
Walworth	South Dakota	46129	Low	High	Mod	Mod	Q3	Mod
Yankton	South Dakota	46135	Low	High	Mod	Mod	Q3	Mod
Ziebach	South Dakota	46137	Low	High	Low	Low	Q3	Mod
Anderson	Tennessee	47001	Mod	High	Low	Low	NOQ3	Mod
Bedford	Tennessee	47003	Mod	Mod	Low	Low	NOQ3	Mod
Benton	Tennessee	47005	Mod	Low	Low	Low	Q3	Mod
Bledsoe	Tennessee	47007	Mod	High	Low	Low	NOQ3	Mod
Blount	Tennessee	47009	Mod	High	Low	Low	NOQ3	Mod
Bradley	Tennessee	47011	Mod	Mod	Mod	Mod	NOQ3	Mod
Campbell	Tennessee	47013	Mod	High	Low	Low	NOQ3	Mod
Cannon	Tennessee	47015	Mod	Mod	Low	Low	NOQ3	Mod
Carroll	Tennessee	47017	Mod	Low	Low	Low	Q3	High
Carter	Tennessee	47019	Mod	High	Low	Low	NOQ3	Mod
Cheatham	Tennessee	47021	Mod	Low	Low	Low	Q3	Mod
Chester	Tennessee	47023	Mod	Low	Mod	Mod	Q3	High
Claiborne	Tennessee	47025	Mod	High	Low	Low	NOQ3	Mod
Clay	Tennessee	47027	Mod	Mod	Low	Low	Q3	Mod
Cocke	Tennessee	47029	Mod	High	Low	Low	NOQ3	Mod
Coffee	Tennessee	47031	Mod	Mod	Low	Low	NOQ3	Mod
Crockett	Tennessee	47033	High	Low	Low	Low	NOQ3	High
Cumberland	Tennessee	47035	Mod	High	Low	Low	NOQ3	Mod
Davidson	Tennessee	47037	Mod	Mod	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
De Kalb	Tennessee	47041	Mod	Mod	Low	Low	Q3	Mod
Decatur	Tennessee	47039	Mod	Low	Low	Low	Q3	Mod
Dickson	Tennessee	47043	Mod	Low	Low	Low	Q3	Mod
Dyer	Tennessee	47045	High	High	Mod	Mod	Q3	High
Fayette	Tennessee	47047	High	Low	Low	Low	NOQ3	High
Fentress	Tennessee	47049	Mod	High	Low	Low	NOQ3	Mod
Franklin	Tennessee	47051	Mod	High	Low	Low	NOQ3	Mod
Gibson	Tennessee	47053	High	Low	Low	Low	Q3	High
Giles	Tennessee	47055	Mod	Mod	Low	Low	NOQ3	Mod
Grainger	Tennessee	47057	Mod	High	Low	Low	NOQ3	Mod
Greene	Tennessee	47059	Mod	High	Low	Low	NOQ3	Mod
Grundy	Tennessee	47061	Mod	High	Low	Low	Q3	Mod
Hamblen	Tennessee	47063	Mod	High	Low	Low	NOQ3	Mod
Hamilton	Tennessee	47065	Mod	High	Low	Low	Q3	Mod
Hancock	Tennessee	47067	Mod	High	Low	Low	NOQ3	Mod
Hardeman	Tennessee	47069	Mod	Low	Low	Low	Q3	High
Hardin	Tennessee	47071	Mod	Low	Low	Low	Q3	Mod
Hawkins	Tennessee	47073	Mod	High	Low	Low	NOQ3	Mod
Haywood	Tennessee	47075	High	Low	Low	Low	NOQ3	High
Henderson	Tennessee	47077	Mod	Low	Low	Low	Q3	High
Henry	Tennessee	47079	Mod	Low	Low	Low	Q3	High
Hickman	Tennessee	47081	Mod	Low	Low	Low	NOQ3	Mod
Houston	Tennessee	47083	Mod	Low	Low	Low	Q3	Mod
Humphreys	Tennessee	47085	Mod	Low	Low	Low	Q3	Mod
Jackson	Tennessee	47087	Mod	Mod	Low	Low	Q3	Mod
Jefferson	Tennessee	47089	Mod	High	Low	Low	NOQ3	Mod
Johnson	Tennessee	47091	Mod	High	Low	Low	NOQ3	Mod
Knox	Tennessee	47093	Mod	High	Low	Low	NOQ3	Mod
Lake	Tennessee	47095	High	High	Low	Low	Q3	High
Lauderdale	Tennessee	47097	High	High	Mod	Mod	Q3	High
Lawrence	Tennessee	47099	Mod	Low	Mod	Mod	NOQ3	Mod
Lewis	Tennessee	47101	Mod	Low	Low	Low	NOQ3	Mod
Lincoln	Tennessee	47103	Mod	Mod	Mod	Mod	NOQ3	Mod
Loudon	Tennessee	47105	Mod	Mod	Low	Low	NOQ3	Mod
Macon	Tennessee	47111	Mod	Low	Low	Low	NOQ3	Mod
Madison	Tennessee	47113	Mod	Low	Mod	Mod	Q3	High
Marion	Tennessee	47115	Mod	High	Low	Low	NOQ3	Mod
Marshall	Tennessee	47117	Mod	Mod	Mod	Mod	NOQ3	Mod
Maury	Tennessee	47119	Mod	Low	Low	Low	Q3	Mod
McMinn	Tennessee	47107	Mod	High	Mod	Mod	NOQ3	Mod
McNairy	Tennessee	47109	Mod	Low	Low	Low	Q3	Mod
Meigs	Tennessee	47121	Mod	High	Low	Low	NOQ3	Mod
Monroe	Tennessee	47123	Mod	High	Low	Low	NOQ3	Mod
Montgomery	Tennessee	47125	Mod	Low	Low	Low	Q3	Mod
Moore	Tennessee	47127	Mod	Low	Low	Low	NOQ3	Mod
Morgan	Tennessee	47129	Mod	High	Low	Low	NOQ3	Mod
Obion	Tennessee	47131	High	High	Low	Low	Q3	High

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Overton	Tennessee	47133	Mod	High	Low	Low	NOQ3	Mod
Perry	Tennessee	47135	Mod	Low	Low	Low	NOQ3	Mod
Pickett	Tennessee	47137	Mod	High	Low	Low	NOQ3	Mod
Polk	Tennessee	47139	Mod	High	Low	Low	NOQ3	Mod
Putnam	Tennessee	47141	Mod	High	Low	Low	NOQ3	Mod
Rhea	Tennessee	47143	Mod	High	Low	Low	NOQ3	Mod
Roane	Tennessee	47145	Mod	High	Low	Low	NOQ3	Mod
Robertson	Tennessee	47147	Mod	Low	Low	Low	Q3	Mod
Rutherford	Tennessee	47149	Mod	Mod	Low	Low	Q3	Mod
Scott	Tennessee	47151	Mod	High	Low	Low	NOQ3	Mod
Sequatchie	Tennessee	47153	Mod	High	Low	Low	NOQ3	Mod
Sevier	Tennessee	47155	Mod	High	Low	Low	NOQ3	Mod
Shelby	Tennessee	47157	High	High	Mod	Mod	Q3	High
Smith	Tennessee	47159	Mod	Mod	Low	Low	NOQ3	Mod
Stewart	Tennessee	47161	Mod	Low	Low	Low	Q3	Mod
Sullivan	Tennessee	47163	Mod	High	Low	Low	NOQ3	Mod
Sumner	Tennessee	47165	Mod	Low	Mod	Mod	Q3	Mod
Tipton	Tennessee	47167	High	High	Mod	Mod	Q3	High
Trousdale	Tennessee	47169	Mod	Low	Mod	Mod	NOQ3	Mod
Unicoi	Tennessee	47171	Mod	High	Low	Low	NOQ3	Mod
Union	Tennessee	47173	Mod	High	Low	Low	NOQ3	Mod
Van Buren	Tennessee	47175	Mod	High	Low	Low	NOQ3	Mod
Warren	Tennessee	47177	Mod	High	Mod	Mod	NOQ3	Mod
Washington	Tennessee	47179	Mod	High	Low	Low	NOQ3	Mod
Wayne	Tennessee	47181	Mod	Low	Low	Low	NOQ3	Mod
Weakley	Tennessee	47183	High	Low	Mod	Mod	Q3	High
White	Tennessee	47185	Mod	High	Low	Low	NOQ3	Mod
Williamson	Tennessee	47187	Mod	Mod	Low	Low	Q3	Mod
Wilson	Tennessee	47189	Mod	Mod	Mod	Mod	NOQ3	Mod
Anderson	Texas	48001	Low	Low	Low	Low	NOQ3	Mod
Andrews	Texas	48003	Mod	Low	Low	Low	NOQ3	Mod
Angelina	Texas	48005	Low	Low	Mod	Mod	Q3	Mod
Aransas	Texas	48007	Low	Low	High	Mod	Q3	Mod
Archer	Texas	48009	Low	Low	Low	Low	Q3	Mod
Armstrong	Texas	48011	Low	Low	Mod	Mod	NOQ3	Mod
Atascosa	Texas	48013	Low	Mod	Mod	Low	NOQ3	Mod
Austin	Texas	48015	Low	Low	Mod	Mod	Q3	Mod
Bailey	Texas	48017	Low	Low	Mod	Mod	NOQ3	Mod
Bandera	Texas	48019	Low	Low	Low	Low	Q3	Mod
Bastrop	Texas	48021	Low	High	Mod	Low	Q3	Mod
Baylor	Texas	48023	Low	Low	Mod	Mod	NOQ3	Mod
Bee	Texas	48025	Low	Low	High	Mod	NOQ3	Mod
Bell	Texas	48027	Low	High	Mod	Mod	Q3	Mod
Bexar	Texas	48029	Low	High	Mod	Mod	Q3	Mod
Blanco	Texas	48031	Low	Low	Low	Low	Q3	Mod
Borden	Texas	48033	Low	Low	Low	Low	NOQ3	Mod
Bosque	Texas	48035	Low	Mod	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Bowie	Texas	48037	Low	High	Mod	Mod	Q3	High
Brazoria	Texas	48039	Low	Low	High	Mod	Q3	Mod
Brazos	Texas	48041	Low	Low	Mod	Low	Q3	Mod
Brewster	Texas	48043	Mod	Low	Low	Low	NOQ3	Low
Briscoe	Texas	48045	Low	Low	Mod	Mod	NOQ3	Mod
Brooks	Texas	48047	Low	Low	High	Low	Q3	Low
Brown	Texas	48049	Low	Low	Mod	Mod	NOQ3	Mod
Burleson	Texas	48051	Low	Low	Mod	Low	Q3	Mod
Burnet	Texas	48053	Low	Low	Low	Low	Q3	Mod
Caldwell	Texas	48055	Low	High	Mod	Mod	NOQ3	Mod
Calhoun	Texas	48057	Low	Low	High	Mod	Q3	Mod
Callahan	Texas	48059	Low	Low	Mod	Mod	NOQ3	Mod
Cameron	Texas	48061	Low	Low	High	Mod	Q3	Low
Camp	Texas	48063	Low	Low	Mod	Mod	NOQ3	Mod
Carson	Texas	48065	Low	Low	Mod	Mod	NOQ3	Mod
Cass	Texas	48067	Low	Low	Mod	Mod	NOQ3	Mod
Castro	Texas	48069	Low	Low	Mod	Mod	NOQ3	Mod
Chambers	Texas	48071	Low	Low	High	Mod	Q3	Mod
Cherokee	Texas	48073	Low	Low	Low	Low	NOQ3	Mod
Childress	Texas	48075	Low	Low	Mod	Mod	NOQ3	Mod
Clay	Texas	48077	Mod	Low	Low	Low	NOQ3	Mod
Cochran	Texas	48079	Low	Low	Mod	Mod	NOQ3	Mod
Coke	Texas	48081	Low	Low	Low	Low	NOQ3	Mod
Coleman	Texas	48083	Low	Low	Low	Low	NOQ3	Mod
Collin	Texas	48085	Low	High	Mod	Mod	Q3	Mod
Collingsworth	Texas	48087	Low	Low	Mod	Mod	NOQ3	Mod
Colorado	Texas	48089	Low	Low	Mod	Mod	NOQ3	Mod
Comal	Texas	48091	Low	High	Mod	Low	Q3	Mod
Comanche	Texas	48093	Low	Low	Mod	Mod	NOQ3	Mod
Concho	Texas	48095	Low	Low	Low	Low	NOQ3	Mod
Cooke	Texas	48097	Low	Mod	Mod	Mod	NOQ3	Mod
Coryell	Texas	48099	Low	Mod	Low	Low	NOQ3	Mod
Cottle	Texas	48101	Low	Low	Low	Low	NOQ3	Mod
Crane	Texas	48103	Mod	Low	Low	Low	NOQ3	Mod
Crockett	Texas	48105	Low	Low	Low	Low	NOQ3	Mod
Crosby	Texas	48107	Low	Low	Mod	Mod	NOQ3	Mod
Culberson	Texas	48109	Mod	Mod	Low	Low	NOQ3	Low
Dallam	Texas	48111	Low	Low	Low	Low	NOQ3	Mod
Dallas	Texas	48113	Low	High	Mod	Mod	Q3	Mod
Dawson	Texas	48115	Low	Low	Mod	Mod	NOQ3	Mod
De Witt	Texas	48123	Low	Low	Mod	Low	NOQ3	Mod
Deaf Smith	Texas	48117	Low	Mod	Low	Low	NOQ3	Mod
Delta	Texas	48119	Low	High	Low	Low	NOQ3	Mod
Denton	Texas	48121	Low	Mod	Mod	Mod	Q3	Mod
Dickens	Texas	48125	Low	Low	Low	Low	NOQ3	Mod
Dimmit	Texas	48127	Low	Low	Low	Low	NOQ3	Low
Donley	Texas	48129	Low	Low	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Duval	Texas	48131	Low	Low	Mod	Low	NOQ3	Low
Eastland	Texas	48133	Low	Low	Mod	Mod	Q3	Mod
Ector	Texas	48135	Mod	Low	Mod	Mod	NOQ3	Mod
Edwards	Texas	48137	Low	Low	Low	Low	Q3	Mod
El Paso	Texas	48141	Mod	Low	Low	Low	Q3	Low
Ellis	Texas	48139	Low	High	Mod	Mod	NOQ3	Mod
Erath	Texas	48143	Low	Low	Mod	Mod	NOQ3	Mod
Falls	Texas	48145	Low	High	Low	Low	NOQ3	Mod
Fannin	Texas	48147	Low	High	Mod	Mod	NOQ3	Mod
Fayette	Texas	48149	Low	Mod	Mod	Low	Q3	Mod
Fisher	Texas	48151	Low	Low	Mod	Mod	NOQ3	Mod
Floyd	Texas	48153	Low	Low	Mod	Mod	NOQ3	Mod
Foard	Texas	48155	Low	Low	Low	Low	NOQ3	Mod
Fort Bend	Texas	48157	Low	Low	High	Mod	Q3	Mod
Franklin	Texas	48159	Low	High	Mod	Mod	NOQ3	Mod
Freestone	Texas	48161	Low	Low	Low	Low	NOQ3	Mod
Frio	Texas	48163	Low	Low	Mod	Low	NOQ3	Mod
Gaines	Texas	48165	Mod	Low	Low	Low	NOQ3	Mod
Galveston	Texas	48167	Low	Low	High	Hig	h Q3	Mod
Garza	Texas	48169	Low	Low	Low	Low	NOQ3	Mod
Gillespie	Texas	48171	Low	Low	Low	Low	NOQ3	Mod
Glasscock	Texas	48173	Low	Low	Low	Low	NOQ3	Mod
Goliad	Texas	48175	Low	Low	High	Low	NOQ3	Mod
Gonzales	Texas	48177	Low	Mod	Mod	Low	NOQ3	Mod
Gray	Texas	48179	Low	Low	Mod	Mod	NOQ3	Mod
Grayson	Texas	48181	Low	Mod	Mod	Mod	Q3	Mod
Gregg	Texas	48183	Low	Low	Mod	Mod	NOQ3	Mod
Grimes	Texas	48185	Low	Low	Mod	Low	Q3	Mod
Guadalupe	Texas	48187	Low	High	Mod	Low	Q3	Mod
Hale	Texas	48189	Low	Low	Mod	Mod	NOQ3	Mod
Hall	Texas	48191	Low	Low	Mod	Mod	NOQ3	Mod
Hamilton	Texas	48193	Low	Low	Low	Low	NOQ3	Mod
Hansford	Texas	48195	Low	Low	Mod	Mod	NOQ3	Mod
Hardeman	Texas	48197	Low	Low	Mod	Mod	NOQ3	Mod
Hardin	Texas	48199	Low	Low	Mod	Low	Q3	Mod
Harris	Texas	48201	Low	Mod	High	Mod	NOQ3	Mod
Harrison	Texas	48203	Low	Low	Mod	Mod	NOQ3	Mod
Hartley	Texas	48205	Low	Low	Low	Low	NOQ3	Mod
Haskell	Texas	48207	Low	Low	Mod	Mod	NOQ3	Mod
Hays	Texas	48209	Low	High	Mod	Low	Q3	Mod
Hemphill	Texas	48211	Low	Low	Mod	Mod	NOQ3	Mod
Henderson	Texas	48213	Low	High	Mod	Mod	NOQ3	Mod
Hidalgo	Texas	48215	Low	Low	High	Low	Q3	Low
Hill	Texas	48217	Low	High	Mod	Mod	NOQ3	Mod
Hockley	Texas	48219	Low	Low	Mod	Mod	NOQ3	Mod
Hood	Texas	48221	Low	Low	Mod	Mod	NOQ3	Mod
Hopkins	Texas	48223	Low	High	Mod	Mod	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Houston	Texas	48225	Low	Low	Low	Low	Q3	Mod
Howard	Texas	48227	Low	Low	Mod	Mod	NOQ3	Mod
Hudspeth	Texas	48229	Mod	High	Low	Low	NOQ3	Low
Hunt	Texas	48231	Low	High	Mod	Mod	NOQ3	Mod
Hutchinson	Texas	48233	Low	Low	Mod	Mod	NOQ3	Mod
Irion	Texas	48235	Low	Low	Low	Low	NOQ3	Mod
Jack	Texas	48237	Low	Low	Low	Low	NOQ3	Mod
Jackson	Texas	48239	Low	Low	High	Mod	Q3	Mod
Jasper	Texas	48241	Low	Low	Mod	Low	Q3	Mod
Jeff Davis	Texas	48243	Mod	Mod	Low	Low	NOQ3	Low
Jefferson	Texas	48245	Low	Mod	High	Mod	Q3	Mod
Jim Hogg	Texas	48247	Low	Low	Mod	Low	NOQ3	Low
Jim Wells	Texas	48249	Low	Low	High	Mod	NOQ3	Low
Johnson	Texas	48251	Low	Mod	Mod	Mod	Q3	Mod
Jones	Texas	48253	Low	Low	Mod	Mod	NOQ3	Mod
Karnes	Texas	48255	Low	Low	Mod	Mod	NOQ3	Mod
Kaufman	Texas	48257	Low	High	Mod	Mod	NOQ3	Mod
Kendall	Texas	48259	Low	Low	Low	Low	Q3	Mod
Kenedy	Texas	48261	Low	Low	High	Low	Q3	Low
Kent	Texas	48263	Low	Low	Low	Low	NOQ3	Mod
Kerr	Texas	48265	Low	Low	Low	Low	Q3	Mod
Kimble	Texas	48267	Low	Low	Low	Low	NOQ3	Mod
King	Texas	48269	Low	Low	Low	Low	NOQ3	Mod
Kinney	Texas	48271	Low	Low	Low	Low	NOQ3	Mod
Kleberg	Texas	48273	Low	Low	High	Low	Q3	Low
Knox	Texas	48275	Low	Low	Mod	Mod	NOQ3	Mod
La Salle	Texas	48283	Low	Low	Mod	Low	NOQ3	Mod
Lamar	Texas	48277	Low	High	Mod	Mod	NOQ3	High
Lamb	Texas	48279	Low	Low	Mod	Mod	NOQ3	Mod
Lampasas	Texas	48281	Low	Low	Low	Low	NOQ3	Mod
Lavaca	Texas	48285	Low	Low	Mod	Low	NOQ3	Mod
Lee	Texas	48287	Low	Low	Mod	Mod	Q3	Mod
Leon	Texas	48289	Low	Low	Low	Low	NOQ3	Mod
Liberty	Texas	48291	Low	Low	High	Mod	Q3	Mod
Limestone	Texas	48293	Low	High	Low	Low	NOQ3	Mod
Lipscomb	Texas	48295	Low	Low	Low	Low	NOQ3	Mod
Live Oak	Texas	48297	Low	Low	Mod	Low	NOQ3	Mod
Llano	Texas	48299	Low	Low	Low	Low	Q3	Mod
Loving	Texas	48301	Mod	Low	Low	Low	NOQ3	Low
Lubbock	Texas	48303	Low	Low	Mod	Mod	Q3	Mod
Lynn	Texas	48305	Low	Low	Mod	Mod	NOQ3	Mod
Madison	Texas	48313	Low	Low	Mod	Low	Q3	Mod
Marion	Texas	48315	Low	Low	Mod	Mod	NOQ3	Mod
Martin	Texas	48317	Low	Low	Mod	Mod	NOQ3	Mod
Mason	Texas	48319	Low	Low	Low	Low	Q3	Mod
Matagorda	Texas	48321	Low	Low	High	Mod	Q3	Mod
Maverick	Texas	48323	Low	Low	Low	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
McCulloch	Texas	48307	Low	Low	Low	Low	NOQ3	Mod
McLennan	Texas	48309	Low	High	Mod	Mod	Q3	Mod
McMullen	Texas	48311	Low	Low	Mod	Low	NOQ3	Mod
Medina	Texas	48325	Low	High	Low	Low	Q3	Mod
Menard	Texas	48327	Low	Low	Low	Low	NOQ3	Mod
Midland	Texas	48329	Low	Low	Mod	Mod	NOQ3	Mod
Milam	Texas	48331	Low	High	Low	Low	NOQ3	Mod
Mills	Texas	48333	Low	Low	Low	Low	NOQ3	Mod
Mitchell	Texas	48335	Low	Low	Mod	Mod	NOQ3	Mod
Montague	Texas	48337	Low	Low	Mod	Mod	NOQ3	Mod
Montgomery	Texas	48339	Low	Low	Mod	Mod	Q3	Mod
Moore	Texas	48341	Low	Low	Mod	Mod	NOQ3	Mod
Morris	Texas	48343	Low	Low	Mod	Mod	NOQ3	Mod
Motley	Texas	48345	Low	Low	Low	Low	NOQ3	Mod
Nacogdoches	Texas	48347	Low	Low	Mod	Mod	Q3	Mod
Navarro	Texas	48349	Low	High	Mod	Mod	NOQ3	Mod
Newton	Texas	48351	Low	Low	Mod	Low	NOQ3	Mod
Nolan	Texas	48353	Low	Low	Mod	Mod	NOQ3	Mod
Nueces	Texas	48355	Low	Low	High	Mod	Q3	Low
Ochiltree	Texas	48357	Low	Low	Mod	Mod	NOQ3	Mod
Oldham	Texas	48359	Low	Low	Low	Low	NOQ3	Mod
Orange	Texas	48361	Low	Mod	High	Mod	Q3	Mod
Palo Pinto	Texas	48363	Low	Low	Mod	Mod	NOQ3	Mod
Panola	Texas	48365	Low	Low	Mod	Mod	NOQ3	Mod
Parker	Texas	48367	Low	Low	Mod	Mod	NOQ3	Mod
Parmer	Texas	48369	Low	Low	Mod	Mod	NOQ3	Mod
Pecos	Texas	48371	Mod	Low	Low	Low	NOQ3	Low
Polk	Texas	48373	Low	Low	Mod	Low	Q3	Mod
Potter	Texas	48375	Low	Low	Mod	Mod	Q3	Mod
Presidio	Texas	48377	Mod	Low	Low	Low	NOQ3	Low
Rains	Texas	48379	Low	Low	Mod	Mod	NOQ3	Mod
Randall	Texas	48381	Low	Low	Mod	Mod	NOQ3	Mod
Reagan	Texas	48383	Low	Low	Low	Low	NOQ3	Mod
Real	Texas	48385	Low	Low	Low	Low	Q3	Mod
Red River	Texas	48387	Low	High	Low	Low	NOQ3	High
Reeves	Texas	48389	Mod	Low	Low	Low	NOQ3	Low
Refugio	Texas	48391	Low	Low	High	Low	NOQ3	Mod
Roberts	Texas	48393	Low	Low	Low	Low	NOQ3	Mod
Robertson	Texas	48395	Low	Low	Low	Low	NOQ3	Mod
Rockwall	Texas	48397	Low	High	Mod	Mod	NOQ3	Mod
Runnels	Texas	48399	Low	Low	Mod	Mod	NOQ3	Mod
Rusk	Texas	48401	Low	Low	Mod	Mod	NOQ3	Mod
Sabine	Texas	48403	Low	Low	Mod	Low	NOQ3	Mod
San Augustine	Texas	48405	Low	Low	Mod	Low	Q3	Mod
San Jacinto	Texas	48407	Low	Low	Mod	Low	Q3	Mod
San Patricio	Texas	48409	Low	Low	High	Mod	Q3	Low
San Saba	Texas	48411	Low	Low	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Schleicher	Texas	48413	Low	Low	Low	Low	NOQ3	Mod
Scurry	Texas	48415	Low	Low	Mod	Mod	NOQ3	Mod
Shackelford	Texas	48417	Low	Low	Low	Low	NOQ3	Mod
Shelby	Texas	48419	Low	Low	Mod	Mod	Q3	Mod
Sherman	Texas	48421	Low	Low	Mod	Mod	NOQ3	Mod
Smith	Texas	48423	Low	Low	Mod	Mod	NOQ3	Mod
Somervell	Texas	48425	Low	Low	Low	Low	NOQ3	Mod
Starr	Texas	48427	Low	Low	Mod	Low	NOQ3	Low
Stephens	Texas	48429	Low	Low	Low	Low	NOQ3	Mod
Sterling	Texas	48431	Low	Low	Low	Low	NOQ3	Mod
Stonewall	Texas	48433	Low	Low	Low	Low	NOQ3	Mod
Sutton	Texas	48435	Low	Low	Low	Low	NOQ3	Mod
Swisher	Texas	48437	Low	Low	Mod	Mod	NOQ3	Mod
Tarrant	Texas	48439	Low	Mod	Mod	Mod	Q3	Mod
Taylor	Texas	48441	Low	Low	Mod	Mod	NOQ3	Mod
Terrell	Texas	48443	Low	Low	Low	Low	NOQ3	Low
Terry	Texas	48445	Low	Low	Mod	Mod	NOQ3	Mod
Throckmorton	Texas	48447	Low	Low	Mod	Mod	NOQ3	Mod
Titus	Texas	48449	Low	Low	Mod	Mod	NOQ3	Mod
Tom Green	Texas	48451	Low	Low	Low	Low	NOQ3	Mod
Travis	Texas	48453	Low	High	Mod	Mod	Q3	Mod
Trinity	Texas	48455	Low	Low	Mod	Low	Q3	Mod
Tyler	Texas	48457	Low	Low	Mod	Low	NOQ3	Mod
Upshur	Texas	48459	Low	Low	Mod	Mod	NOQ3	Mod
Upton	Texas	48461	Low	Low	Low	Low	NOQ3	Mod
Uvalde	Texas	48463	Low	Low	Low	Low	Q3	Mod
Val Verde	Texas	48465	Low	Low	Low	Low	NOQ3	Mod
Van Zandt	Texas	48467	Low	Low	Low	Low	NOQ3	Mod
Victoria	Texas	48469	Low	Low	High	Mod	Q3	Mod
Walker	Texas	48471	Low	Low	Mod	Low	Q3	Mod
Waller	Texas	48473	Low	Low	Mod	Mod	Q3	Mod
Ward	Texas	48475	Mod	Low	Low	Low	NOQ3	Low
Washington	Texas	48477	Low	Low	Mod	Mod	Q3	Mod
Webb	Texas	48479	Low	Low	Mod	Low	Q3	Low
Wharton	Texas	48481	Low	Low	High	Mod	Q3	Mod
Wheeler	Texas	48483	Low	Low	Mod	Mod	NOQ3	Mod
Wichita	Texas	48485	Low	Low	Mod	Mod	Q3	Mod
Wilbarger	Texas	48487	Low	Low	Mod	Mod	NOQ3	Mod
Willacy	Texas	48489	Low	Low	High	Low	Q3	Low
Williamson	Texas	48491	Low	High	Mod	Mod	NOQ3	Mod
Wilson	Texas	48493	Low	Mod	Mod	Low	NOQ3	Mod
Winkler	Texas	48495	Mod	Low	Low	Low	NOQ3	Low
Wise	Texas	48497	Low	Low	Mod	Mod	NOQ3	Mod
Wood	Texas	48499	Low	Low	Mod	Mod	NOQ3	Mod
Yoakum	Texas	48501	Low	Low	Low	Low	NOQ3	Mod
Young	Texas	48503	Low	Low	Mod	Mod	NOQ3	Mod
Zapata	Texas	48505	Low	Low	Mod	Low	NOQ3	Low

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Zavala	Texas	48507	Low	Low	Low	Low	NOQ3	Mod
Beaver	Utah	49001	Mod	High	Low	Low	NOQ3	Low
Box Elder	Utah	49003	High	High	Low	Low	NOQ3	Low
Cache	Utah	49005	High	High	Low	Low	NOQ3	Low
Carbon	Utah	49007	Mod	Low	Low	Low	NOQ3	Low
Daggett	Utah	49009	Mod	High	Low	Low	NOQ3	Low
Davis	Utah	49011	High	High	Low	Low	NOQ3	Low
Duchesne	Utah	49013	Mod	High	Low	Low	NOQ3	Low
Emery	Utah	49015	Mod	High	Low	Low	NOQ3	Low
Garfield	Utah	49017	Mod	High	Low	Low	NOQ3	Low
Grand	Utah	49019	Mod	High	Low	Low	NOQ3	Low
Iron	Utah	49021	Mod	High	Low	Low	NOQ3	Low
Juab	Utah	49023	Mod	High	Low	Low	NOQ3	Low
Kane	Utah	49025	Mod	High	Low	Low	NOQ3	Low
Millard	Utah	49027	Mod	High	Low	Low	NOQ3	Low
Morgan	Utah	49029	High	High	Low	Low	NOQ3	Low
Piute	Utah	49031	Mod	High	Low	Low	NOQ3	Low
Rich	Utah	49033	Mod	High	Low	Low	NOQ3	Low
Salt Lake	Utah	49035	High	High	Low	Low	Q3	Low
San Juan	Utah	49037	Mod	High	Low	Low	NOQ3	Low
Sanpete	Utah	49039	Mod	High	Low	Low	NOQ3	Low
Sevier	Utah	49041	Mod	High	Low	Low	NOQ3	Low
Summit	Utah	49043	High	High	Low	Low	NOQ3	Low
Tooele	Utah	49045	Mod	Low	Low	Low	NOQ3	Low
Uintah	Utah	49047	Mod	High	Low	Low	NOQ3	Low
Utah	Utah	49049	High	High	Low	Low	Q3	Low
Wasatch	Utah	49051	Mod	High	Low	Low	NOQ3	Low
Washington	Utah	49053	Mod	Mod	Low	Low	NOQ3	Low
Wayne	Utah	49055	Mod	High	Low	Low	NOQ3	Low
Weber	Utah	49057	High	High	Low	Low	NOQ3	Low
Addison	Vermont	50001	Mod	High	Low	Low	NOQ3	Mod
Bennington	Vermont	50003	Mod	High	Low	Low	NOQ3	Mod
Caledonia	Vermont	50005	Mod	High	Low	Low	NOQ3	Mod
Chittenden	Vermont	50007	Mod	High	Low	Low	NOQ3	High
Essex	Vermont	50009	Mod	Low	Low	Low	NOQ3	Mod
Franklin	Vermont	50011	Mod	High	Low	Low	NOQ3	High
Grand Isle	Vermont	50013	Mod	High	Low	Low	NOQ3	High
Lamoille	Vermont	50015	Mod	High	Low	Low	NOQ3	Mod
Orange	Vermont	50017	Mod	High	Low	Low	NOQ3	Mod
Orleans	Vermont	50019	Mod	High	Low	Low	NOQ3	Mod
Rutland	Vermont	50021	Mod	High	Low	Low	Q3	Mod
Washington	Vermont	50023	Mod	High	Low	Low	Q3	Mod
Windham	Vermont	50025	Mod	High	Low	Low	Q3	High
Windsor	Vermont	50027	Mod	High	Low	Low	Q3	Mod
Accomack	Virginia	51001	Low	Low	High	Low	Q3	Mod
Albemarle	Virginia	51003	Mod	High	Low	Low	Q3	Mod
Alexandria	Virginia	51510	Low	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Alleghany	Virginia	51005	Mod	High	Low	Low	NOQ3	Mod
Amelia	Virginia	51007	Mod	Low	Low	Low	NOQ3	Mod
Amherst	Virginia	51009	Mod	High	Low	Low	NOQ3	Mod
Appomattox	Virginia	51011	Mod	High	Low	Low	NOQ3	Mod
Arlington	Virginia	51013	Low	High	Low	Low	NOQ3	Mod
Augusta	Virginia	51015	Mod	High	Low	Low	Q3	Mod
Bath	Virginia	51017	Mod	High	Low	Low	Q3	Mod
Bedford	Virginia	51019	Mod	High	Low	Low	Q3	Mod
Bedford City	Virginia	51515	Mod	High	Low	Low	Q3	Mod
Bland	Virginia	51021	Mod	Mod	Low	Low	NOQ3	Mod
Botetourt	Virginia	51023	Mod	High	Low	Low	Q3	Mod
Bristol	Virginia	51520	Mod	High	Mod	Mod	NOQ3	Mod
Brunswick	Virginia	51025	Mod	Low	Low	Low	Q3	Mod
Buchanan	Virginia	51027	Mod	High	Low	Low	Q3	Mod
Buckingham	Virginia	51029	Mod	High	Low	Low	NOQ3	Mod
Buena Vista	Virginia	51530	Mod	High	Low	Low	Q3	Mod
Campbell	Virginia	51031	Mod	High	Low	Low	Q3	Mod
Carolinae	Virginia	51033	Mod	High	Low	Low	NOQ3	Mod
Carroll	Virginia	51035	Mod	High	Low	Low	NOQ3	Mod
Charles City	Virginia	51036	Mod	High	Low	Low	NOQ3	Mod
Charlotte	Virginia	51037	Mod	Low	Low	Low	NOQ3	Mod
Charlottesville	Virginia	51540	Mod	High	Low	Low	Q3	Mod
Chesapeake	Virginia	51550	Low	Low	High	Low	NOQ3	Mod
Chesterfield	Virginia	51041	Mod	High	Mod	Mod	NOQ3	Mod
Clarke	Virginia	51043	Low	High	Low	Low	NOQ3	Mod
Clifton Forge	Virginia	51560	Mod	High	Low	Low	NOQ3	Mod
Colonial Heights	Virginia	51570	Mod	High	Low	Low	NOQ3	Mod
Covington	Virginia	51580	Mod	High	Low	Low	NOQ3	Mod
Craig	Virginia	51045	Mod	High	Low	Low	NOQ3	Mod
Culpeper	Virginia	51047	Mod	High	Low	Low	Q3	Mod
Cumberland	Virginia	51049	Mod	Low	Low	Low	NOQ3	Mod
Danville	Virginia	51590	Low	Mod	Low	Low	Q3	Mod
Dickenson	Virginia	51051	Mod	High	Low	Low	NOQ3	Mod
Dinwiddie	Virginia	51053	Mod	Low	Low	Low	NOQ3	Mod
Emporia	Virginia	51595	Low	Low	High	Hig	h NOQ	Mod
Essex	Virginia	51057	Low	Mod	Low	Low	NOQ3	Mod
Fairfax	Virginia	51059	Low	High	Mod	Mod	NOQ3	Mod
Fairfax City	Virginia	51600	Low	Low	Low	Low	Q3	Mod
Falls Chruch	Virginia	51610	Low	Low	High	Hig	h NOQ	Mod
Fauquier	Virginia	51061	Mod	High	Low	Low	NOQ3	Mod
Floyd	Virginia	51063	Mod	High	Low	Low	NOQ3	Mod
Fluvanna	Virginia	51065	Mod	High	Low	Low	Q3	Mod
Franklin	Virginia	51067	Mod	High	Low	Low	NOQ3	Mod
Franklin City	Virginia	51620	Low	Low	High	Hig	h NOQ	Mod
Frederick	Virginia	51069	Low	High	Low	Low	NOQ3	Mod
Fredericksburg	Virginia	51630	Mod	High	Low	Low	NOQ3	Mod
Galax	Virginia	51640	Mod	High	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Giles	Virginia	51071	Mod	High	Low	Low	Q3	Mod
Gloucester	Virginia	51073	Low	Mod	Mod	Low	Q3	Mod
Goochland	Virginia	51075	Mod	Low	Low	Low	NOQ3	Mod
Grayson	Virginia	51077	Mod	High	Low	Low	NOQ3	Mod
Greene	Virginia	51079	Mod	High	Low	Low	Q3	Mod
Greensville	Virginia	51081	Low	Low	Mod	Low	NOQ3	Mod
Halifax	Virginia	51083	Mod	High	Low	Low	Q3	Mod
Hampton	Virginia	51650	Low	Mod	High	Low	Q3	Mod
Hanover	Virginia	51085	Mod	High	Low	Low	NOQ3	Mod
Harrisonburg	Virginia	51660	Mod	High	Low	Low	Q3	Mod
Henrico	Virginia	51087	Mod	High	Low	Low	NOQ3	Mod
Henry	Virginia	51089	Mod	High	Low	Low	NOQ3	Mod
Highland	Virginia	51091	Low	High	Low	Low	NOQ3	Mod
Hopewell	Virginia	51670	Mod	High	Mod	Mod	NOQ3	Mod
Isle of Wight	Virginia	51093	Low	Mod	Mod	Low	NOQ3	Mod
James City	Virginia	51095	Low	Mod	Mod	Low	NOQ3	Mod
King and Queen	Virginia	51097	Mod	Low	Mod	Low	NOQ3	Mod
King George	Virginia	51099	Low	High	Low	Low	NOQ3	Mod
King William	Virginia	51101	Mod	High	Low	Low	NOQ3	Mod
Lancaster	Virginia	51103	Low	Mod	Mod	Low	Q3	Mod
Lee	Virginia	51105	Mod	High	Low	Low	NOQ3	Mod
Lexington	Virginia	51678	Mod	Low	Low	Low	Q3	Mod
Loudoun	Virginia	51107	Low	High	Low	Low	NOQ3	Mod
Louisa	Virginia	51109	Mod	Low	Low	Low	NOQ3	Mod
Lunenburg	Virginia	51111	Mod	Low	Low	Low	NOQ3	Mod
Lynchburg	Virginia	51680	Mod	High	Low	Low	Q3	Mod
Madison	Virginia	51113	Mod	High	Low	Low	Q3	Mod
Manassas City	Virginia	51683	Low	Low	Low	Low	Q3	Mod
Manassas Park City	Virginia	51685	Low	Low	Low	Low	Q3	Mod
Martinsville	Virginia	51690	Mod	High	Low	Low	NOQ3	Mod
Mathews	Virginia	51115	Low	Low	High	Low	Q3	Mod
Mecklenburg	Virginia	51117	Mod	Mod	Low	Low	NOQ3	Mod
Middlesex	Virginia	51119	Low	Mod	Mod	Low	Q3	Mod
Montgomery	Virginia	51121	Mod	High	Low	Low	NOQ3	Mod
Nelson	Virginia	51125	Mod	High	Low	Low	NOQ3	Mod
New Kent	Virginia	51127	Mod	Mod	Low	Low	NOQ3	Mod
Newport News	Virginia	51700	Low	Mod	Mod	Mod	Q3	Mod
Norfolk	Virginia	51710	Low	Low	High	Hig	h Q3	Mod
Northampton	Virginia	51131	Low	Low	High	Mod	Q3	Mod
Northumberland	Virginia	51133	Low	Mod	Mod	Low	Q3	Mod
Norton	Virginia	51720	Mod	High	Low	Low	Q3	Mod
Nottoway	Virginia	51135	Mod	Low	Low	Low	NOQ3	Mod
Orange	Virginia	51137	Mod	High	Low	Low	Q3	Mod
Page	Virginia	51139	Mod	High	Low	Low	NOQ3	Mod
Patrick	Virginia	51141	Mod	High	Low	Low	NOQ3	Mod
Petersburg	Virginia	51730	Mod	High	High	Hig	h NOQ	Mod
Pittsylvania	Virginia	51143	Mod	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Poquoson City	Virginia	51735	Low	Low	High	Low	Q3	Mod
Portsmouth	Virginia	51740	Low	Low	High	Mod	Q3	Mod
Powhatan	Virginia	51145	Mod	Low	Low	Low	NOQ3	Mod
Prince Edward	Virginia	51147	Mod	High	Low	Low	NOQ3	Mod
Prince George	Virginia	51149	Mod	High	Low	Low	NOQ3	Mod
Prince William	Virginia	51153	Low	High	Low	Low	Q3	Mod
Pulaski	Virginia	51155	Mod	High	Low	Low	NOQ3	Mod
Radford	Virginia	51750	Mod	Mod	Low	Low	NOQ3	Mod
Rappahannock	Virginia	51157	Mod	High	Low	Low	Q3	Mod
Richmond	Virginia	51159	Low	Mod	Mod	Low	Q3	Mod
Richmond City	Virginia	51760	Mod	High	Mod	Mod	NOQ3	Mod
Roanoke	Virginia	51161	Mod	High	Low	Low	Q3	Mod
Roanoke City	Virginia	51770	Mod	High	Mod	Mod	Q3	Mod
Rockbridge	Virginia	51163	Mod	High	Low	Low	Q3	Mod
Rockingham	Virginia	51165	Mod	High	Low	Low	Q3	Mod
Russell	Virginia	51167	Mod	High	Low	Low	NOQ3	Mod
Salem	Virginia	51775	Mod	Mod	Low	Low	Q3	Mod
Scott	Virginia	51169	Mod	High	Low	Low	NOQ3	Mod
Shenandoah	Virginia	51171	Mod	High	Low	Low	NOQ3	Mod
Smyth	Virginia	51173	Mod	High	Low	Low	NOQ3	Mod
South Boston	Virginia	51780	Low	Mod	High	Hig	h Q3	Mod
Southampton	Virginia	51175	Low	Low	Mod	Low	NOQ3	Mod
Spotsylvania	Virginia	51177	Mod	High	Low	Low	NOQ3	Mod
Stafford	Virginia	51179	Mod	High	Low	Low	NOQ3	Mod
Staunton	Virginia	51790	Mod	Low	Low	Low	Q3	Mod
Suffolk	Virginia	51800	Low	Mod	Mod	Low	NOQ3	Mod
Surry	Virginia	51181	Low	Mod	Mod	Low	NOQ3	Mod
Sussex	Virginia	51183	Low	High	Mod	Low	NOQ3	Mod
Tazewell	Virginia	51185	Mod	High	Low	Low	NOQ3	Mod
Virginia Beach	Virginia	51810	Low	Low	High	Mod	Q3	Mod
Warren	Virginia	51187	Low	High	Low	Low	Q3	Mod
Washington	Virginia	51191	Mod	High	Low	Low	NOQ3	Mod
Waynesboro	Virginia	51820	Mod	High	Low	Low	Q3	Mod
Westmoreland	Virginia	51193	Low	Mod	Low	Low	Q3	Mod
Williamsburg	Virginia	51830	Low	Low	Mod	Low	NOQ3	Mod
Winchester	Virginia	51840	Low	Mod	Low	Low	NOQ3	Mod
Wise	Virginia	51195	Mod	High	Low	Low	Q3	Mod
Wythe	Virginia	51197	Mod	High	Low	Low	NOQ3	Mod
York	Virginia	51199	Low	Mod	High	Low	Q3	Mod
Adams	Washington	53001	Mod	Mod	Low	Low	Q3	Low
Asotin	Washington	53003	Mod	High	Low	Low	Q3	Low
Benton	Washington	53005	Mod	High	Low	Low	Q3	Low
Chelan	Washington	53007	Mod	High	Low	Low	Q3	Low
Clallam	Washington	53009	High	High	Low	Low	Q3	Low
Clark	Washington	53011	Mod	High	Low	Low	Q3	High
Columbia	Washington	53013	Mod	High	Low	Low	Q3	Low
Cowlitz	Washington	53015	Mod	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Douglas	Washington	53017	Mod	High	Low	Low	Q3	Low
Ferry	Washington	53019	Mod	High	Low	Low	Q3	Low
Franklin	Washington	53021	Mod	High	Low	Low	Q3	Low
Garfield	Washington	53023	Mod	High	Low	Low	Q3	Low
Grant	Washington	53025	Mod	High	Low	Low	Q3	Low
Grays Harbor	Washington	53027	High	High	Low	Low	Q3	Low
Island	Washington	53029	High	High	Low	Low	Q3	Low
Jefferson	Washington	53031	High	High	Low	Low	Q3	Low
King	Washington	53033	High	High	Low	Low	Q3	Low
Kitsap	Washington	53035	High	High	Low	Low	Q3	Low
Kittitas	Washington	53037	Mod	High	Low	Low	Q3	Low
Klickitat	Washington	53039	Mod	High	Low	Low	Q3	Mod
Lewis	Washington	53041	Mod	High	Low	Low	Q3	Low
Lincoln	Washington	53043	Mod	High	Low	Low	Q3	Low
Mason	Washington	53045	Mod	High	Low	Low	Q3	Low
Okanogan	Washington	53047	Mod	High	Low	Low	Q3	Low
Pacific	Washington	53049	High	High	Low	Low	Q3	Low
Pend Oreille	Washington	53051	Mod	Low	Low	Low	Q3	Low
Pierce	Washington	53053	Mod	High	Low	Low	Q3	Low
San Juan	Washington	53055	Mod	Low	Low	Low	Q3	Low
Skagit	Washington	53057	Mod	Mod	Low	Low	Q3	Low
Skamania	Washington	53059	Mod	High	Low	Low	Q3	High
Snohomish	Washington	53061	High	High	Low	Low	Q3	Low
Spokane	Washington	53063	Mod	High	Low	Low	Q3	Low
Stevens	Washington	53065	Mod	High	Low	Low	Q3	Low
Thurston	Washington	53067	Mod	High	Low	Low	Q3	Low
Wahkiakum	Washington	53069	Mod	High	Low	Low	Q3	Low
Walla Walla	Washington	53071	Mod	Low	Low	Low	Q3	Low
Whatcom	Washington	53073	Mod	High	Low	Low	Q3	Mod
Whitman	Washington	53075	Mod	Low	Low	Low	Q3	Low
Yakima	Washington	53077	Mod	High	Low	Low	Q3	Low
Barbour	West Virginia	54001	Low	High	Low	Low	Q3	Mod
Berkeley	West Virginia	54003	Low	High	Low	Low	NOQ3	Mod
Boone	West Virginia	54005	Mod	High	Low	Low	NOQ3	Mod
Braxton	West Virginia	54007	Low	High	Low	Low	Q3	Mod
Brooke	West Virginia	54009	Low	High	Low	Low	Q3	Mod
Cabell	West Virginia	54011	Low	High	Low	Low	Q3	Mod
Calhoun	West Virginia	54013	Low	High	Low	Low	Q3	Mod
Clay	West Virginia	54015	Low	High	Low	Low	Q3	Mod
Doddridge	West Virginia	54017	Low	High	Low	Low	NOQ3	Mod
Fayette	West Virginia	54019	Mod	High	Low	Low	Q3	Mod
Gilmer	West Virginia	54021	Low	High	Low	Low	Q3	Mod
Grant	West Virginia	54023	Low	High	Low	Low	Q3	Mod
Greenbrier	West Virginia	54025	Mod	High	Low	Low	Q3	Mod
Hampshire	West Virginia	54027	Low	High	Low	Low	NOQ3	Mod
Hancock	West Virginia	54029	Low	High	Low	Low	Q3	Mod
Hardy	West Virginia	54031	Low	High	Low	Low	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Harrison	West Virginia	54033	Low	High	Low	Low	Q3	Mod
Jackson	West Virginia	54035	Low	High	Low	Low	Q3	Mod
Jefferson	West Virginia	54037	Low	High	Low	Low	NOQ3	Mod
Kanawha	West Virginia	54039	Mod	High	Low	Low	Q3	Mod
Lewis	West Virginia	54041	Low	High	Low	Low	Q3	Mod
Lincoln	West Virginia	54043	Mod	High	Low	Low	Q3	Mod
Logan	West Virginia	54045	Mod	High	Low	Low	Q3	Mod
Marion	West Virginia	54049	Low	High	Low	Low	NOQ3	Mod
Marshall	West Virginia	54051	Low	High	Low	Low	Q3	Mod
Mason	West Virginia	54053	Low	High	Low	Low	Q3	Mod
McDowell	West Virginia	54047	Mod	High	Low	Low	Q3	Mod
Mercer	West Virginia	54055	Mod	High	Low	Low	NOQ3	Mod
Mineral	West Virginia	54057	Low	High	Low	Low	NOQ3	Mod
Mingo	West Virginia	54059	Mod	High	Low	Low	Q3	Mod
Monongalia	West Virginia	54061	Low	High	Low	Low	NOQ3	Mod
Monroe	West Virginia	54063	Mod	High	Low	Low	NOQ3	Mod
Morgan	West Virginia	54065	Low	High	Low	Low	NOQ3	Mod
Nicholas	West Virginia	54067	Mod	High	Low	Low	NOQ3	Mod
Ohio	West Virginia	54069	Low	High	Low	Low	Q3	Mod
Pendleton	West Virginia	54071	Low	High	Low	Low	NOQ3	Mod
Pleasants	West Virginia	54073	Low	High	Low	Low	NOQ3	Mod
Pocahontas	West Virginia	54075	Mod	High	Low	Low	NOQ3	Mod
Preston	West Virginia	54077	Low	High	Low	Low	NOQ3	Mod
Putnam	West Virginia	54079	Low	High	Low	Low	Q3	Mod
Raleigh	West Virginia	54081	Mod	High	Low	Low	Q3	Mod
Randolph	West Virginia	54083	Low	High	Low	Low	Q3	Mod
Ritchie	West Virginia	54085	Low	High	Low	Low	NOQ3	Mod
Roane	West Virginia	54087	Low	High	Low	Low	Q3	Mod
Summers	West Virginia	54089	Mod	High	Low	Low	Q3	Mod
Taylor	West Virginia	54091	Low	High	Low	Low	NOQ3	Mod
Tucker	West Virginia	54093	Low	High	Low	Low	Q3	Mod
Tyler	West Virginia	54095	Low	High	Low	Low	Q3	Mod
Upshur	West Virginia	54097	Low	High	Low	Low	Q3	Mod
Wayne	West Virginia	54099	Mod	High	Low	Low	Q3	Mod
Webster	West Virginia	54101	Low	High	Low	Low	NOQ3	Mod
Wetzel	West Virginia	54103	Low	High	Low	Low	Q3	Mod
Wirt	West Virginia	54105	Low	High	Low	Low	Q3	Mod
Wood	West Virginia	54107	Low	High	Low	Low	Q3	Mod
Wyoming	West Virginia	54109	Mod	High	Low	Low	Q3	Mod
Adams	Wisconsin	55001	Low	Mod	Mod	Mod	NOQ3	Mod
Ashland	Wisconsin	55003	Low	Mod	Low	Low	NOQ3	Mod
Barron	Wisconsin	55005	Low	Low	Mod	Mod	NOQ3	Mod
Bayfield	Wisconsin	55007	Low	Mod	Low	Low	Q3	Mod
Brown	Wisconsin	55009	Low	Mod	Mod	Mod	Q3	Mod
Buffalo	Wisconsin	55011	Low	High	Low	Low	NOQ3	Mod
Burnett	Wisconsin	55013	Low	Low	Low	Low	NOQ3	Mod
Calumet	Wisconsin	55015	Low	Mod	Mod	Mod	Q3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Chippewa	Wisconsin	55017	Low	Low	Mod	Mod	Q3	Mod
Clark	Wisconsin	55019	Low	Low	Low	Low	Q3	Mod
Columbia	Wisconsin	55021	Low	Mod	Mod	Mod	NOQ3	Mod
Crawford	Wisconsin	55023	Low	High	Low	Low	NOQ3	Mod
Dane	Wisconsin	55025	Low	Mod	Mod	Mod	Q3	Mod
Dodge	Wisconsin	55027	Low	Mod	Mod	Mod	Q3	Mod
Door	Wisconsin	55029	Low	Mod	Low	Low	NOQ3	Mod
Douglas	Wisconsin	55031	Low	High	Low	Low	NOQ3	High
Dunn	Wisconsin	55033	Low	Low	Low	Low	NOQ3	Mod
Eau Claire	Wisconsin	55035	Low	Low	Mod	Mod	Q3	Mod
Florence	Wisconsin	55037	Low	Low	Low	Low	NOQ3	Mod
Fond Du Lac	Wisconsin	55039	Low	Mod	Mod	Mod	Q3	Mod
Forest	Wisconsin	55041	Low	Low	Low	Low	NOQ3	Mod
Grant	Wisconsin	55043	Low	High	Mod	Mod	NOQ3	Mod
Green	Wisconsin	55045	Low	Mod	Mod	Mod	NOQ3	Mod
Green Lake	Wisconsin	55047	Low	Mod	Mod	Mod	NOQ3	Mod
Iowa	Wisconsin	55049	Low	Mod	Low	Low	NOQ3	Mod
Iron	Wisconsin	55051	Low	Mod	Low	Low	NOQ3	Mod
Jackson	Wisconsin	55053	Low	Low	Low	Low	NOQ3	Mod
Jefferson	Wisconsin	55055	Low	Low	Mod	Mod	Q3	Mod
Juneau	Wisconsin	55057	Low	Mod	Mod	Mod	NOQ3	Mod
Kenosha	Wisconsin	55059	Low	High	Low	Low	NOQ3	Mod
Kewaunee	Wisconsin	55061	Low	Mod	Mod	Mod	NOQ3	Mod
La Crosse	Wisconsin	55063	Low	High	Low	Low	Q3	Mod
Lafayette	Wisconsin	55065	Low	Mod	Mod	Mod	NOQ3	Mod
Langlade	Wisconsin	55067	Low	Low	Low	Low	NOQ3	Mod
Lincoln	Wisconsin	55069	Low	Low	Low	Low	NOQ3	Mod
Manitowoc	Wisconsin	55071	Low	Mod	Mod	Mod	Q3	Mod
Marathon	Wisconsin	55073	Low	Low	Low	Low	Q3	Mod
Marinette	Wisconsin	55075	Low	Low	Low	Low	Q3	Mod
Marquette	Wisconsin	55077	Low	Mod	Mod	Mod	NOQ3	Mod
Menominee	Wisconsin	55078	Low	Low	Low	Low	NOQ3	Mod
Milwaukee	Wisconsin	55079	Low	Mod	Mod	Mod	Q3	Mod
Monroe	Wisconsin	55081	Low	Mod	Low	Low	NOQ3	Mod
Oconto	Wisconsin	55083	Low	Mod	Low	Low	NOQ3	Mod
Oneida	Wisconsin	55085	Low	Low	Low	Low	NOQ3	Mod
Outagamie	Wisconsin	55087	Low	Mod	Low	Low	Q3	Mod
Ozaukee	Wisconsin	55089	Low	Mod	Low	Low	Q3	Mod
Pepin	Wisconsin	55091	Low	High	Low	Low	NOQ3	Mod
Pierce	Wisconsin	55093	Low	High	Low	Low	NOQ3	Mod
Polk	Wisconsin	55095	Low	Low	Low	Low	NOQ3	Mod
Portage	Wisconsin	55097	Low	Low	Low	Low	NOQ3	Mod
Price	Wisconsin	55099	Low	Low	Low	Low	NOQ3	Mod
Racine	Wisconsin	55101	Low	High	Mod	Mod	Q3	Mod
Richland	Wisconsin	55103	Low	Low	Low	Low	NOQ3	Mod
Rock	Wisconsin	55105	Low	Low	Mod	Mod	NOQ3	Mod
Rusk	Wisconsin	55107	Low	Low	Low	Low	NOQ3	Mod

County	State	FIPS	EQ	LS	Wind	Torn	Flood	Icing
Sauk	Wisconsin	55111	Low	Mod	Low	Low	NOQ3	Mod
Sawyer	Wisconsin	55113	Low	Low	Low	Low	NOQ3	Mod
Shawano	Wisconsin	55115	Low	Mod	Low	Low	NOQ3	Mod
Sheboygan	Wisconsin	55117	Low	Mod	Low	Low	NOQ3	Mod
St. Croix	Wisconsin	55109	Low	Low	Mod	Mod	NOQ3	Mod
Taylor	Wisconsin	55119	Low	Low	Low	Low	NOQ3	Mod
Trempealeau	Wisconsin	55121	Low	High	Low	Low	NOQ3	Mod
Vernon	Wisconsin	55123	Low	High	Low	Low	NOQ3	Mod
Vilas	Wisconsin	55125	Low	Low	Low	Low	NOQ3	Mod
Walworth	Wisconsin	55127	Low	Low	Mod	Mod	NOQ3	Mod
Washburn	Wisconsin	55129	Low	Low	Low	Low	Q3	Mod
Washington	Wisconsin	55131	Low	Low	Low	Low	NOQ3	Mod
Waukesha	Wisconsin	55133	Low	Low	Mod	Mod	Q3	Mod
Waupaca	Wisconsin	55135	Low	Low	Low	Low	Q3	Mod
Waushara	Wisconsin	55137	Low	Low	Low	Low	NOQ3	Mod
Winnebago	Wisconsin	55139	Low	Mod	Low	Low	Q3	Mod
Wood	Wisconsin	55141	Low	Low	Low	Low	Q3	Mod
Albany	Wyoming	56001	Mod	Mod	Low	Low	Q3	Low
Big Horn	Wyoming	56003	Mod	High	Low	Low	NOQ3	Low
Campbell	Wyoming	56005	Mod	High	Low	Low	NOQ3	Low
Carbon	Wyoming	56007	Mod	High	Low	Low	NOQ3	Low
Converse	Wyoming	56009	Mod	Mod	Low	Low	NOQ3	Low
Crook	Wyoming	56011	Mod	High	Low	Low	NOQ3	Low
Fremont	Wyoming	56013	Mod	High	Low	Low	NOQ3	Low
Goshen	Wyoming	56015	Mod	Mod	Mod	Mod	NOQ3	Low
Hot Springs	Wyoming	56017	Mod	High	Low	Low	NOQ3	Low
Johnson	Wyoming	56019	Mod	High	Low	Low	NOQ3	Low
Laramie	Wyoming	56021	Mod	Mod	Mod	Mod	NOQ3	Low
Lincoln	Wyoming	56023	High	High	Low	Low	NOQ3	Low
Natrona	Wyoming	56025	Mod	High	Low	Low	Q3	Low
Niobrara	Wyoming	56027	Mod	High	Low	Low	NOQ3	Low
Park	Wyoming	56029	High	High	Low	Low	NOQ3	Low
Platte	Wyoming	56031	Mod	Mod	Low	Low	NOQ3	Low
Sheridan	Wyoming	56033	Mod	High	Low	Low	NOQ3	Low
Sublette	Wyoming	56035	High	High	Low	Low	NOQ3	Low
Sweetwater	Wyoming	56037	Mod	High	Low	Low	Q3	Low
Teton	Wyoming	56039	High	High	Low	Low	NOQ3	Low
Uinta	Wyoming	56041	High	High	Low	Low	NOQ3	Low
Washakie	Wyoming	56043	Mod	High	Low	Low	NOQ3	Low
Weston	Wyoming	56045	Mod	High	Low	Low	NOQ3	Low

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