MARICOPA COUNTY UNINCORPORATED AREA
HAZARD MITIGATION PLAN

Maricopa County
Department of Emergency Management
2035 N. 52nd Street
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Adopted August 18, 2004
Approved by FEMA November 29, 2004

ACKNOWLEDGEMENTS

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Salt River Project Team Members: (Public Utility)

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Bruce Hallin	Manager	Water Business Development & Strategic Analysis
William Powell	Manager	Risk Management
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Maricopa County Board of Supervisors:

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1. EXECUTIVE SUMMARY

Across the United States, natural and human-caused disasters have led to increasing levels of death, injury, property damage, and interruption of business and government services. The toll on families and individuals can be immense and damaged businesses cannot contribute to the economy. The time, money and effort to respond to and recover from these emergencies or disasters divert public resources and attention from other important programs and problems. With 71 federal or state declarations, 381 other events, and a combined total of 452 disaster events recorded, the 27 jurisdictions contained within Maricopa County, Arizona recognize the consequences of disasters and the need to reduce the impacts of natural and human-caused hazards.

The elected and appointed officials of Maricopa County also know that with careful selection, mitigation actions in the form of projects and programs can become long-term, cost effective means for reducing the impact of natural and human-caused hazards. Applying this knowledge the Maricopa County Hazard Mitigation Planning Group and the Maricopa County Hazard Mitigation Planning Team have collaborated to prepare this *Multi-Jurisdictional All-Hazard Mitigation Plan.* The Multi-Jurisdictional All-Hazard Mitigation Plan is the umbrella under which each of the 27 jurisdictional plans, to include the Maricopa County Unincorporated Area Hazard Mitigation Plan, has been developed. With the support of various city officials, county officials, URS Corporation consultants, the State of Arizona, Maricopa County Department of Emergency Management, and the Federal Emergency Management Agency (FEMA), this plan is the result of nearly a year's worth of work to develop a multi-hazard mitigation plan that will guide the County toward greater disaster resistance in full harmony with the character and needs of the community and region.

People and property in Maricopa County Unincorporated Area are at risk from a variety of hazards that have the potential for causing widespread loss of life and damage to property, infrastructure, and the environment. The purpose of hazard mitigation is to implement actions that eliminate the risk from hazards, or reduce the severity of the effects of hazards on people and property. Mitigation is any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Mitigation encourages long-term reduction of hazard vulnerability. The goal of mitigation is to save lives and reduce property damage. Mitigation can reduce the enormous cost of disasters to property owners and all levels of government. In addition, mitigation can protect critical community facilities, reduce exposure to liability and minimize community disruption. Preparedness, response, and recovery measures support the concept of mitigation and may directly support identified mitigation actions.

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* has been prepared in compliance with Section 322 of the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* (*Stafford Act* or the *Act*), 42 U.S. C. 5165, enacted under Sec. 104 the *Disaster Mitigation Act of 2000*, (*DMA 2000*) Public Law 106-390 of October 30, 2000. This plan identifies hazard mitigation measures intended to eliminate or reduce the effects of future disasters throughout the County, and was developed in a joint and cooperative venture by members of the Maricopa County Hazard Mitigation Planning Team and the Maricopa County Unincorporated Area Local Mitigation Planning Team.

Following each major disaster declaration, the County is required to review and update the Plan's goals, objectives, and actions. Additionally, plans must be reviewed, revised if appropriate, and resubmitted for approval within five years in order to continue to be eligible for Hazard Mitigation Grant Program (HMGP) project grant funding. It is, however, recommended that the plan be reviewed annually to ensure it remains current. Updates, amendments, or plan revisions should be submitted to FEMA for review. If updates are not necessary, the County should notify FEMA in writing that the plan was reviewed and it is determined that a plan update is not required. Updates may include new policy guidance or changes in program administration. Annual updates are an eligible activity under the Hazard Mitigation Grant Program (HMGP).

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2. OFFICIAL RECORD OF ADOPTION BY LOCAL JURISDICTION

2.1 DMA 2000 Requirements and Approach

The *Disaster Mitigation Act of 2000* addresses a range of topics, focused primarily on the importance of pre-disaster infrastructure mitigation planning to reduce disaster losses nationwide and to control and streamline the administration of both federal disaster relief and programs to promote mitigation activities. According to the Act, the purpose of Title I – Predisaster Hazard Mitigation is:

> *…to establish a national disaster hazard mitigation program –*
>
> *(1) to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters; and*
>
> *(2) to provide a source of predisaster hazard mitigation funding that will assist States and local governments (including Indian tribes) in implementing effective hazard mitigation measures that are designed to ensure the continued functionality of critical services and facilities after a natural disaster.*

Major provisions of the Act include the following: funding for pre-disaster mitigation activities; developing multi-hazard maps to better understand risk; establishing state and local government infrastructure mitigation planning requirements; defining how states can assume more responsibility in managing the Hazard Mitigation Grant Program (HMGP); and, adjusting ways in which management costs for projects are funded.

It is important to note that this document is designed as an instrument of mitigation primarily for natural disasters and other environmentally related events. Although some human involvement is implied with many of the hazards profiled herein, this document is not intended to address the prevention or mitigation of the possible impacts of terrorist activity. The term *terrorism* encompasses intentional, criminal or malicious acts involving Weapons of Mass Destruction (WMDs), including biological, chemical, nuclear, and radiological weapons; arson, incendiary, explosive, and armed attacks; industrial sabotage and intentional hazardous material releases; and cyber-terrorism (attacks via computer means). Therefore, while such a terrorist event could possibly trigger a response that is addressed through this document (e.g., chemical release), it is not the intent of the Maricopa County Multi-Jurisdictional All-Hazard Mitigation Plan or the State of Arizona Enhanced Hazard Mitigation Plan to preemptively address these specific events. Included in this plan is a description of parallel processes that are now underway to address terrorism.

Table 2-1: DMA 2000 Requirements - Prerequisites

Section	Title	Requirement	Language
Prerequisites	Adoption by the Local Governing Body	§201.6(c)(5):	[The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner [Board of Supervisors], Tribal Council)…

Source: FEMA, July 11, 2002.

2.2 Official Record of Adoption

The Maricopa County Board of Supervisors adopted this plan on August 18, 2004. Following adoption, this plan was submitted to the Federal Emergency Management Agency (FEMA) for final approval. On November 29, 2004, FEMA approved the adopted plan, thereby ensuring continued availability of non-emergency Stafford Act funding, including Pre-Disaster Mitigation planning/project grants; Hazard Mitigation Grant Program planning/project grants; Fire Management Assistance Grant(s); and Public Assistance categories (C-G).

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3. INTRODUCTION

The purpose of this section is to provide an overview of the *Maricopa County Unincorporated Area Hazard Mitigation Plan*. This includes a review of the background, authority and purpose of the plan, and a description of the plan document.

3.1 Background

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* has been prepared in compliance with Section 322 of the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* (*Stafford Act* or the *Act*), 42 U.S. C. 5165, enacted under Sec. 104 the *Disaster Mitigation Act of 2000*, (*DMA 2000*) Public Law 106-390 of October 30, 2000. FEMA has further clarified the hazard mitigation planning requirements of the *Act* in a number of *Interim Final Rules.* FEMA has also clarified its methodology for evaluation of the hazard mitigation plans under *DMA 2000* in an *Interim Criteria* document as well as provided significant methodological assistance with its related *How-To Guides*. The *State of Arizona Enhanced Mitigation Plan* is based on the *Act*, the *Interim Final Rules*, and related documents.

On February 26, 2002, the Federal Emergency Management Agency (FEMA) published an *Interim Final Rule* in the Federal Register that established the hazard mitigation planning requirements enacted in the *Disaster Mitigation Act of 2000*. This rule addresses state mitigation planning, identifies new local mitigation planning requirements, authorizes Hazard Mitigation Grant Program (HMGP) funds for planning activities, and increases the amount of HMGP funds available to States that develop a comprehensive, enhanced mitigation plan. This rule also requires that repairs or construction funded by a disaster loan or grant must be carried out in accordance with applicable standards and states that FEMA may require safe land use and construction practices as a condition of grantees receiving disaster assistance under the Stafford Act. FEMA published a new *Interim Final Rule* in the October 1, 2002 Federal Register, whose primary purpose was to extend the date that state and local mitigation plans must be completed to be eligible for post-disaster assistance from November 1, 2003 to November 1, 2004.

FEMA prepared further guidance to assist states, local, and tribal governments to meet the new *DMA 2000* planning requirements through a document titled *State and Local Plan Interim Criteria Under the Disaster Mitigation Act of 2000.* The document has two major objectives:

- *To help federal and state reviewers evaluate mitigation plans from different jurisdictions in a fair and consistent manner; and*
- *To help state and local jurisdictions to develop new mitigation plans or modify existing ones in accordance with the criteria of Section 322.*

The requirements for an enhanced hazard mitigation plan according to the *Interim Criteria* are defined in tables with the corresponding *Maricopa County Unincorporated Area Hazard Mitigation Plan* sections.

3.1.1 Arizona's Growing Smarter Initiative

This Hazard Mitigation Plan has been created to identify a process through which local communities in Maricopa County can effectively plan for and mitigate the most severe natural hazards that affect the region. Since the nature of the built environment of Maricopa County is so closely tied to the ability of its communities to create effective mechanisms to address both natural and human caused disasters, it is essential that the mitigation planning process be well integrated with the local government comprehensive land use planning process. Given this linkage, it is beneficial to understand the nature of growth in Maricopa County, as well as the State of Arizona's statutory framework for local government planning and growth management.

Since 1973, most cities, towns, and counties in Arizona have been required to develop plans for communities looking at issues such as land use, circulation, housing, public services and facilities, and conservation, rehabilitation, and redevelopment. As growth rates significantly increased in the 1990s, a critical mass of political support emerged to provide more tools to assist in responding to the consequences of rapid growth. In 1998, the Arizona Legislature passed the *Growing Smarter Act*, which clarified and strengthened planning elements in the required plans of municipalities and counties and added four new elements, namely: Open Space, Growth Areas, Environmental

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Planning, and Cost of Development. In 2000, the Legislature passed *Growing Smarter/Plus* to further enhance land use planning statutes in Arizona. (Arizona Department of Commerce, 2004)

Among the highlights of Growing Smarter/Plus are the following:

- Requires larger and fast-growing cities to obtain voter approval of their general plans at least once every ten years;
- Requires mandatory rezoning conformance with General and Comprehensive Plans;
- Requires more effective public participation in the planning process;
- Requires cities and counties to exchange plans, coordinate with regional planning agencies, and encourages comments between entities prior to adoption to encourage regional coordination; and
- Requires landowner permission for plan designation and rezoning of private property to open space.

Perhaps the most relevant requirement of Growing Smarter/Plus concerning hazard mitigation is the mandate that new general plans in Arizona include an *Environmental Planning/Safety Element*, which contains analysis, policies, and strategies to address any anticipated effects of the plan's elements and new development called for by the plan on air and water quality and natural resources. These requirements, while instituted prior to DMA 2000, set the stage for effective coordination between land use planning and mitigation planning.

3.2 Plan Purpose and Authority

As noted above, the *Maricopa County Unincorporated Area Hazard Mitigation Plan* has been prepared in compliance with the *Disaster Mitigation Act of 2000*, the *Interim Final Rules*, and related documents. In addition to complying with the legislation, the overall purpose of the plan is to establish a comprehensive disaster hazard mitigation program to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural and human-caused disasters in the community. A more detailed description of the goals of the *Maricopa County Unincorporated Area Hazard Mitigation Plan* may be found in Section 8 of this document. The Maricopa County Unincorporated Area Local Planning Team has prepared this plan with the assistance of the Maricopa County Department of Emergency Management and URS Corporation.

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* is intended to serve many purposes. These include the following:

- *Enhance Public Awareness and Understanding* – to help residents of the County better understand the natural and human-caused hazards that threaten public health, safety, and welfare; economic vitality; and the operational capability of important institutions;
- *Create a Decision Tool for Management* – to provide information that managers and leaders of local government, business and industry, community associations, and other key institutions and organizations need to take action to address vulnerabilities to future disasters;
- *Promote Compliance with State and Federal Program Requirements* – to insure that Maricopa County can take full advantage of state and federal grant programs, policies, and regulations that encourage or mandate that local governments develop comprehensive hazard mitigation plans;
- *Enhance Local Policies for Hazard Mitigation Capability* – to provide the policy basis for mitigation actions that should be promulgated by participating jurisdictions to create a more disaster-resistant future; and
- *Inter-Jurisdictional Coordination of Mitigation-Related Programming* – to ensure that proposals for mitigation initiatives are reviewed and coordinated between Maricopa County and the other jurisdictions contained within the County; and
- *Regulatory Compliance* – To qualify for certain forms of federal aid for pre and post-disaster funding, local jurisdictions must comply with the federal Disaster Mitigation Act of 2000 (DMA 2000) and its implementing regulations (44 CFR Section 201.6, published February 26, 2002). DMA 2000 intends for hazard mitigation plans to remain relevant and current. Therefore, it requires that State hazard mitigation plans are updated

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every three years and local plans, including Maricopa County's, every five years. This means that the Hazard Mitigation Plan for Maricopa County uses a "five-year planning horizon". It is designed to carry the County through the next five years, after which its assumptions, goals, and objectives will be revisited and the plan resubmitted for approval.

In the past, federal legislation has provided funding for disaster relief, recovery, and some hazard mitigation planning. The Disaster Mitigation Act of 2000 (DMA 2000) is the latest legislation to improve this planning process and was put into motion on October 10, 2000, when the President signed the Act (Public Law 106-390). The new legislation reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur. As such, this Act establishes a pre-disaster hazard mitigation program and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP).

Section 322 of the Act specifically addresses mitigation planning at the state and local levels. It identifies new requirements that allow HMGP funds to be used for planning activities, and increases the amount of HMGP funds available to states that have developed a comprehensive, enhanced mitigation plan prior to a disaster. States and communities must have an approved mitigation plan in place prior to receiving post-disaster HMGP funds. Local and tribal mitigation plans must demonstrate that their proposed mitigation measures are based on a sound planning process that accounts for the risk to and the capabilities of the individual communities.

DMA 2000 is intended to facilitate cooperation between state and local authorities, prompting them to work together. It encourages and rewards local and state pre-disaster planning and promotes sustainability as a strategy for disaster resistance. This enhanced planning network will better enable local and state governments to articulate accurate needs for mitigation, resulting in faster allocation of funding and more effective risk reduction projects.

To implement the new DMA 2000 requirements, FEMA prepared an Interim Final Rule, published in the Federal Register on February 26, 2002, at 44 CFR Parts 201 and 206, which establishes planning and funding criteria for states and local communities.

The Hazard Mitigation Plan for Unincorporated Maricopa County, Arizona has been prepared to meet FEMA requirements thus making Maricopa County, the Flood Control District of Maricopa County, and Salt River Project eligible applicant agents for funding and technical assistance from state and federal hazard mitigation programs.

3.3 Plan Description

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* consists of the following primary functions. Note, where possible, the unincorporated communities were separately defined; however, there are data limitations where the only information available was for the County as a whole.

Community Description

To provide an adequate background for the hazard profiles and risk assessments that are presented in subsequent chapters, Maricopa County hazards were described in some detail. These descriptions include a general history and background for the County Unincorporated Area, and also include discussion regarding the historical trends for demographic, population, and economic conditions that have shaped these areas. County Unincorporated Area community profiles also include a brief identification of growth trends and general plan themes that are currently being experienced in the area.

Historical Record, Hazard Profiles, Vulnerability Assessment

Through this procedure the planning team identified and compiled relevant data on all potential natural hazards that threaten county unincorporated areas in Maricopa County. Information collected includes historical data on natural hazard events that have occurred in and around participating jurisdictions and how these events impacted their people and property.

Based upon historical occurrences and best available data from agencies such as FEMA and the National Weather Service, the planning team identified and described all natural hazards that threaten unincorporated areas in Maricopa County. Detailed hazard profiles include information on the frequency, magnitude, location and impact for

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each hazard in addition to estimating the probabilities for future hazard events. Maps are included to delineate identified hazard areas and previous hazard occurrences.

Risk Assessment

This section reflects the collection and integration of the best available data, including an inventory of assets that may be affected by natural hazards such as people, housing units, critical facilities, special facilities, infrastructure and lifelines, hazardous materials facilities and commercial facilities.

This data was compiled by assessing the potential impacts from each hazard using FEMA's Hazards U.S. (HAZUS) multi-hazard loss estimation model and other risk modeling techniques. The subsequent information provides Maricopa County leadership with information that outlines the full range of hazards they face and potential social impacts, damages and economic losses.

Capability Assessment and Goals, Objectives and Actions

Based upon the findings of the capability assessment and the risk assessment, the consultant team worked with the Maricopa County Local Mitigation Planning Team towards drafting an overall mitigation strategy for the County. These groups collaborated to engage in an interactive planning process by facilitating discussion on possible mitigation activities and by gaining consensus on the identification of the general planning goals and target objectives for the hazard mitigation plan. Based upon these goals and objectives, Maricopa County reviewed and adopted a comprehensive range of appropriate mitigation measures to address the many risks facing the county unincorporated area. Such measures include preventive actions, property protection techniques, natural resource protection strategies, structural projects, emergency services and public information and awareness activities.

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4. JURISDICTIONAL PARTICIPATION INFORMATION

This section provides a brief summary of the personnel responsible for the distribution of materials and the parties responsible for supporting the Plan through its review process.

4.1 Primary Point of Contact

The following are the contact details for the primary contact person for hazard mitigation activities in the Maricopa County Hazard Mitigation Plan. For information purposes, the following are the contact details for the primary contact person for hazard mitigation activities in Unincorporated Maricopa County:

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Mobile: 602 725 7184 (duty)
E-Mail: padillaj001@mail.maricopa.gov

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Flood Control District of Maricopa County
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4.2 Promulgation Authority Information

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* was reviewed and approved by the following promulgation authorities:

1. Andrew Kunasek, Chairman of the Board of Supervisors
2. Fran McCarroll, Clerk of the Board of Supervisors

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5. PLANNING PROCESS DOCUMENTATION

This section includes the delineation of various DMA 2000 regulatory requirements, as well as the identification of key stakeholders and planning team members within Maricopa County. In addition, the necessary public involvement meetings and actions that were applied to this process are also detailed.

5.1 DMA 2000 Requirements

The table shown below illustrates the various DMA 2000 requirements for documentation of the planning process.

Table 5-1: DMA 2000 Requirements – Planning Process

Section	Title	Requirement	Language
Planning Process	Documentation of the Planning Process	CFR §201.6(c)(1):	[The plan must document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

Source: FEMA, July 11, 2002.

5.2 Planning Team

The personnel listed below are representatives of Maricopa County Departments and Related Agencies.

Maricopa County Unincorporated Area Local Mitigation Planning Team:

Margaret Ayala	MCDEM-EM Planner	HMP Project Manager
Glen Floe	MCDEM-EM Planner	HMP Back-up
Tim Newbill	MCDEM-EM Planner	LEPC staff support
Bob Spencer	MCDEM-Director	
Warren Leek	MCDEM-Operations Supervisor	
Michael Philp	MCDEM-GIS Analyst	GIS HMP Support
Ruth Aud	MCDEM-EM Planner	PVNGS Planner
Dennis Cvancara	MCDEM-EM Planner	Hospital Liaison
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Ed Copp	Principal Planning Analyst	Risk Management
Bruce Hallin	Manager	Water Business Development & Strategic Analysis
William Powell	Manager	Risk Management
Yvonne Reinink	Senior Engineer	Water Resource Operations
Tim Skarupa	Senior Hydrologist	Water Resource Operations
Mike Voda	Principal Civil Engineer	Electric System Planning & Performance
Wayne Wisdom	Manager	Electric System Planning & Performance

5.3 Public Involvement

To address the requirements of DMA 2000, the Maricopa County Department of Emergency Management (MCDEM) convened a Countywide Mitigation Planning Group that consisted of representatives of all 27 communities participating in the hazard mitigation planning process (i.e., Maricopa County, all of the cities and towns within the county, the Ft. McDowell Yavapai Nation, and the Salt River Pima-Maricopa Indian Community). This group met regularly between March 2003 and April 2004 to help craft and review important common elements of the plan. In addition, to support the activities of the Mitigation Planning Group and focus on unique community issues, the County worked with each jurisdiction to convene a Local Mitigation Planning Team. These teams contributed essential understanding of and information about the status of hazard mitigation planning in the communities and developed mitigation goals, objectives, and actions for their communities.

A series of public workshops were also held over a two-week period in early June of 2004. These workshops included a presentation of the overall planning process, all milestones achieved, and maps of many hazards identified in the Risk Assessment portion of the Plan. The emphasis of these meetings was to educate citizens, public officials, and business leaders about the hazard mitigation planning process. Topics presented included hazard mitigation planning and its benefits, steps in the hazard mitigation planning process, and the importance of community input and participation. The primary focus, however, was gathering community input into the local Goals, Objectives, and Mitigation Actions that each of the various jurisdictions had drafted. To permit each community in the region equal access to area citizens who might be interested in participating in the process, the open houses were dispersed on a subregional level. These subregions, dates and times, and locations for the public open houses are described below. Notification and meeting announcements for these public meetings varied greatly from community to community, and were facilitated through the City Clerk's Office for each individual jurisdiction.

In addition to the public open houses, interested citizens were also encouraged to participate in the local community adoption process which, depending upon the community, may have included two public meetings and a formal public hearing.

In general, public involvement did not prove to be a valuable asset in the development of the local plans. Feedback from the public, which was hoped to re-prioritize or solidify the Action Strategies and the Goals, Objectives, and Action sections of the plans, was not achieved because of the small turnout from the public. Public open houses did prove to be valuable, however, as a tool to communicate with the many representatives of the local communities who were present at the subregional workshops.

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Subregion/Communities Covered	Date and Time	Location
Northeast Valley Scottsdale, Carefree, Cave Creek, Fountain Hills, Ft. Mc Dowell, Salt River Indian Community, Paradise Valley, NE Phoenix and unincorporated Maricopa County	June 1, 2004 6:00 PM to 8:00 PM	Mustang Library 10101 N. 90th Street Scottsdale (south of Shea)
Northwest Valley: Peoria, El Mirage, Glendale, Surprise, Wickenburg, Young Town, NW Phoenix and unincorporated Maricopa County	June 2, 2004 6:30 PM to 8:00 PM	Peoria Fire/Police Administration Building 8351 W. Cinnabar Peoria
Avondale, Buckeye, Gila Bend, Goodyear, Litchfield Park, Tolleson, Phoenix and unincorporated Maricopa County	June 9, 2004 6:00 PM to 7:30 PM	Avondale Fire Administration 1825 North 107th Avenue Avondale
Southeast Valley Gilbert, Chandler, Mesa, Tempe, Queen Creek, Guadalupe, SE Phoenix and unincorporated Maricopa County	June 10, 2004 5:00 PM to 6:30 PM	Town of Gilbert Council Chambers 50 E. Civic Center Gilbert

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6. COMMUNITY DESCRIPTION

The purpose of this section is to provide basic background information on Maricopa County Unincorporated Area. Information provided includes location, land ownership, population, economy, development patterns, and planning information.

Historically, most hazards affect numerous jurisdictions within the County. As such, information may not be available at the jurisdictional level for many hazards because the information is only available at the county or state level.

6.1 Maricopa County

Maricopa County, located in central Arizona within the upper Sonoran Desert, encompasses 9,226 square miles. Maricopa County has experienced rapid and robust growth throughout its history. Promoting economic opportunity, a beneficial climate, and an active lifestyle, growth has transformed the region from an agricultural center to a vibrant commercial, industrial, and recreational hub. Maricopa County encompasses 24 towns and cities, as well as approximately 15 unincorporated communities. Some 7,421 square miles are unincorporated (Maricopa County Planning, 2003).

As illustrated in Figure, the County is bisected by the Salt River, which runs from northeast to southwest, and joins the Gila River near the center of the county, continuing in a southwesterly direction towards the Colorado River, joining it near Yuma. Varying in elevation from 436 feet above sea level in the southwest to 7,645 feet in the northeast, the county contains several diverse plant and animal communities. Maricopa County has one of the most ample water supplies of any desert region in the west, and is supplemented by a series of dams and reservoirs. The watershed of the Salt and Verde Rivers, for example, is impounded behind the dams of the Salt River Project. In addition, the Central Arizona Project canal, which brings water from the Colorado River, can supply more than a fifth of the total water for the county.

Maricopa County was originally inhabited by Native Americans, who abandoned the area during the 1300's for unexplained reasons. Agriculture was the prominent activity in the region and was reestablished during the 1860's as the first European settlers migrated to the Salt River Valley. Rapid growth and robust development have been the hallmark of Maricopa County ever since. In 1870 the town site of Phoenix was established, and on February 14, 1871, the Territorial Legislature created Maricopa County. By 1872, there were over 700 people in the county with 5,000 acres under cultivation. The arrival of the railroad in 1877 caused a surge in economic activity. In the early 1900s, the larger farm parcels scattered throughout the region were divided into small farm communities such as Chandler, Gilbert, and Tolleson. In 1902—at the request of President Theodore Roosevelt—after a series of devastating floods, Congress passed the Reclamation Act of 1902. Shortly thereafter, the U.S. Bureau of

Reclamation started construction on Theodore Roosevelt Dam east of Phoenix. Irrigated agricultural production and population exploded after the completion of Roosevelt Dam in 1912, providing the region with a reliable water supply. Maricopa County quickly became one of the leading agricultural producing counties in the United States.

During this period, the County also became a winter haven for tourists. Growth in the area continued as tourism, automobile travel, military, and industrial activities came to the county. Construction continued on residential developments, highways, and commercial districts, making Maricopa County an increasingly popular place to live. Until the end of World War II, the traditional economic engines of both the State of Arizona and Maricopa County were known as the five "Cs": cotton, copper, cattle, climate, and citrus. Newly established wartime industries fueled the monumental growth of the county in the post-war era. By 1960, the population was over 660,000 people, and reached one million residents in the early 1970s. Combined with the general economic expansion of the 1980s and the rush to the Sun Belt, Maricopa County claimed over 2.2 million residents by 1990. Even with economic sluggishness in the early 1990s, the region continued to grow.

Today Maricopa County's residents are governed under a District form of government, which includes a five member County Board of Supervisors elected from County Districts for a term of four years. Many other County officials, including County Sheriff, are also elected to their positions.

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Maricopa County is located in south-central Arizona and encompasses 9,226 square miles, 98 square miles of which are water. As shown in Figure 6-1, Maricopa County is bisected by the Salt River, which runs northeast to southwest, and joins the Gila River near the center of the county. Several major roadways support both local and regional transportation needs in Maricopa County. Interstates 10, 17, and 8 all intersection in or near Phoenix, and provide access to surrounding states. Several other State and US Highways provide local and regional access throughout Arizona. Sky Harbor International Airport, located in central Phoenix, is one of the busiest air travel facilities in the United States.

Federal and State government entities own 50 percent of Maricopa County land, including the U.S. Bureau of Land Management (28 percent), the U.S. Forest Service (11 percent), and the State of Arizona (11 percent). An additional 16 percent is publicly owned, and 5 percent is Indian reservation land. Arizona's warm climate and the year-round availability of recreational areas and parks have led to Maricopa County becoming a major tourism destination.

Today, Maricopa County contains more than half of Arizona's overall population. Growing 44.8 percent from 1990 to 2000, Maricopa County is expected to have 4.5 million residents by the year 2020, as shown in Table 6-1. If these growth trends continue Maricopa County's population will nearly double by the year 2030.

Table 6-1: Maricopa County Population

Jurisdiction	1990	2000	2002	2010	2020	2030
Maricopa County	2,122,101	3,096,600	3,296,250	4,134,200	5,164,300	6,140,100
Major Cities/ Communities						
Chandler	90,533	185,300	194,390	260,000	286,600	288,600
Glendale	148,134	230,300	227,495	290,400	308,100	312,200
Mesa	288,091	441,800	427,550	537,900	617,800	647,800
Peoria	50,168	114,100	122,655	160,800	206,600	253,400
Phoenix	983,403	1,350,500	1,365,675	1,700,300	2,022,500	2,187,500
Scottsdale	130,069	204,300	214,090	253,100	287,300	292,700
Tempe	141,865	158,900	159,425	176,400	189,200	196,700

Note: Figures for 1990 from Arizona Dept. of Commerce. Figures for 2000, 2010, 2020, 2030 from MAG; Figures for 2002 from AZ DES (projection dates from 1997).

Metropolitan Maricopa County is the state's center of economic activity and is also home to a growing high-tech industry. The majority of workers in Maricopa County are employed in the services sector, followed by retail trades, government (Federal, State, and local), manufacturing, and finance/real estate/insurance. Major employers in Maricopa County include the State of Arizona, Maricopa County, the U.S. Postal Service, American Express, Arizona State University, Wal-Mart, and Wells Fargo Bank.

In the 1990's Maricopa County was the fastest growing county in the United States, gaining nearly 1 million new residents during this decade. Due to rapidly increasing development pressures and an appreciation for planning on a regional level, the County has committed to developing a development strategy that covers all of unincorporated Maricopa County. The *Maricopa County Comprehensive Plan*, now complete, compliments local development strategies that have been employed by all of the major communities in the greater metropolitan area. The Land Use Plan contained within this document is illustrated in Figure 6-2.

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Figure 6-1: Maricopa County General Features

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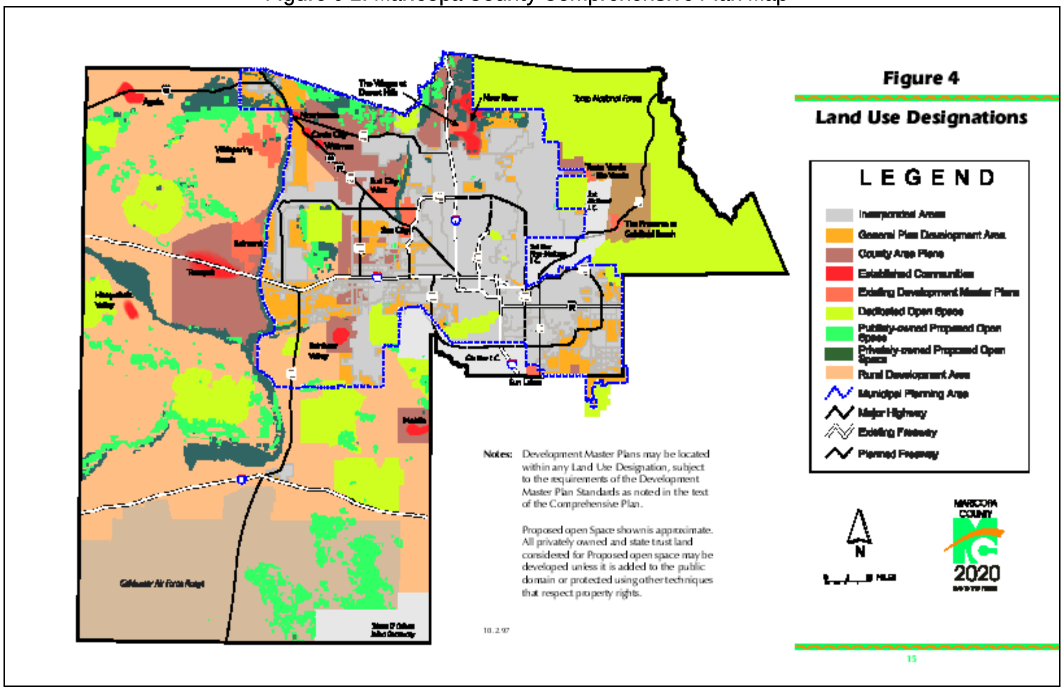
Figure 6-2: Maricopa County Comprehensive Plan Map



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7. RISK ASSESSMENT

The purpose of this section is to identify the hazards that can affect Unincorporated Maricopa County, profile the major hazards, assess the risk of such hazards, describe the county unincorporated area's vulnerability, and estimate potential losses from the hazards. Each of these tasks is described in detail below. It is notable that this is the first time that a comprehensive effort of this kind has been undertaken in Arizona.

This integrated information-gathering method was employed because many hazard events are likely to affect numerous jurisdictions within such a consolidated urban area. However, evaluation of hazard event scenarios is complicated because information is not available at the jurisdictional level for many hazards because the information is only available at the county or state level. Because of this inconsistency, hazard and community information has been provided at the most localized level possible.

7.1 DMA 2000 Requirements and Approach

The requirements for the risk assessment according to *DMA 2000* are shown in Table 7-1. While technically only natural hazards are addressed, most human-caused hazards are included in this plan in at least a preliminary manner. In order to meet these requirements, Unincorporated Maricopa County used the step-wise approach to the risk assessment detailed in *Understanding Your Risks: Identifying Hazards and Estimating Losses* (FEMA 2001). This approach consists of the following major steps:

- Identify and screen hazards
- Profile hazards
- Inventory assets
- Estimate losses
- Identify future risks

Table 7-1: DMA 2000 Requirements – Risk Assessment

Section	Title	Requirement	Language
Risk Assessment	Identifying Hazards	§201.6(c)(2)(i):	[The risk assessment shall include a] description of the type … of all natural hazards that can affect the jurisdiction…
Risk Assessment	Profiling Hazard Events	§201.6(c)(2)(i):	[The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.
Risk Assessment	Assessing Vulnerability: Identifying Assets	§201.6(c)(2)(ii)(A):	[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. The plan should describe vulnerability in terms of: The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas…
Risk Assessment	Assessing Vulnerability: Estimating Potential Losses	§201.6(c)(2)(ii)(B):	[The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate…
Risk Assessment	Assessing Vulnerability: Analyzing	§201.6(c)(2)(ii)(C):	[The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use

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Table 7-1: DMA 2000 Requirements – Risk Assessment			
Section	Title	Requirement	Language
	Development Trends		decisions.
Risk Assessment	Multi-Jurisdictional Risk Assessment	§201.6(c)(2) (iii):	For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

Source: FEMA, July 11, 2002.

7.2 Hazard Identification and Screening

The first step in the risk assessment process is the identification and screening of hazards. Hazards identified include natural and human-caused hazards that might affect persons and property in Unincorporated Maricopa County. This includes hazards that have occurred in the past as well as those that may occur in the future (even if they have not yet occurred). Then the list of all possible hazards is screened to focus on the most likely or most damaging hazards.

To aid in identifying and screening hazards, a database of historical hazard events for communities and county unincorporated areas in Maricopa County was developed. Where possible, the information listed in Table 7-2 was recorded for each entry. In many cases, information on an event could not be found for particular fields, such as property damage. However, as illustrated through Table 7-3, the database ultimately grew to approximately 452 entries, providing useful resources for the analysis of historical hazards in Unincorporated Maricopa County. It should be noted that reported information regarding fatalities, injuries, and property damage is available for only a small proportion of the total number of records and should, at best, be considered representative of the total damage caused by the hazard event.

Table 7-2: Unincorporated Maricopa County Historical Hazard Event Database Fields
Year
Event Date
Event Category
Event Sub-Category
City / Location Affected
Counties Affected
Disaster/Emergency Declared?
Declaration Type / No
State Declaration Date
Federal Declaration Date
Declaration Type
State Expenditures
Federal Expenditures
Fatalities
Injuries
Property Damage ($)
Crop / Livestock Damage ($)
Description
Source

Source: URS, October 2003.

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The hazard event database was populated in a step-wise manner. The first step was to review records from the Maricopa County Department of Emergency Management (MCDEM), Arizona Division of Emergency Management (ADEM), Federal Emergency Management Agency (FEMA), and United States Department of Agriculture (USDA), in order to identify and enter events that were declared a disaster or emergency by one or more of the following:

- Governor of Arizona
- Secretary of the U.S. Department of Agriculture
- President of the United States

Next, events were identified and entered that, while not declared a disaster or emergency, caused sufficient one-time or repetitive damage to be considered a hazard (other events). In order to limit the number of entries, the other events had to meet one or more of following criteria:

- 1 or more fatalities
- 1 or more injuries
- $50,000 or more in damages
- Significant event, as expressed in historical records or according to defined criteria

The first three criteria are useful in order to screen the large number of hazard event records from the last 20-30 years. This includes records from such agencies as the Arizona State Land Department (ASLD), National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA), US Geological Survey (USGS), and US Forest Service (USFS). The last criteria enables the inclusion of historic hazard events that occurred prior to this time which often have relatively little specific information, but were considered significant enough to have gone into one or more historical records. Such entries were typically from narrative descriptions cited in a wide variety of sources that had been identified by the MCDEM and the ADEM.

The hazard event database was used to conduct a preliminary evaluation of hazards in Maricopa County, as shown in Table 7-3. The hazard event database used for Maricopa County is a subset of the database used for the State of Arizona. A decision was made by the Maricopa County Hazard Mitigation Planning Group to profile the hazards in detail based on a number of factors, including the following:

- Prior knowledge of the relative risk presented by the hazards
- Information from the hazard event database
- The ability to mitigate the hazard via the *DMA2000* process
- The known or expected availability of information on the hazard

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Table 7-3: Historical Record of Hazards in Maricopa County by Type							
	Historical Records						Further Evaluation As Major Hazard?
	Number of Records			Recorded Damages			
Hazard	Declarations	Other Events	Total	Fatalities	Injuries	Losses ($)	
Aviation Accident	0	13	13	0	0	$0	No
Civil Disturbance	0	1	1	0	0	$0	No
Dam Failure	0	0	0	0	0	$0	Yes
Disease	6	7	13	49	82	$145,408	Yes
Drought	12	86	98	0	0	$300,000,000	Yes
Dust Storm	0	3	3	1	41	$200,000	No
Earthquake	0	1	1	0	0	$0	Yes
Expansive Soil	0	0	0	0	0	$0	No
Extreme Cold	0	1	1	0	0	$0	No
Extreme Heat	0	10	10	0	0	$0	Yes
Fire	0	2	2	0	0	$0	No
Fissure	0	0	0	0	0	$0	No
Flood	10	25	35	21	116	$1,285,017,166	Yes
Fog	0	1	1	0	8	$0	No
Hail	0	4	4	0	3	$500,000	Yes
HAZMAT Event	4	35	39	0	9	$100,000,000	Yes
Landslide	0	0	0	0	0	$0	No
Lightning	0	22	22	4	22	$5,459,000	Yes
Meteor Strike	0	0	0	0	0	$0	No
Miscellaneous	4	0	4	0	0	$0	No
Mine Accident	0	0	0	0	0	$0	No
Nuclear Incident	0	0	0	0	0	$0	No
Prison Problem	2	0	2	0	0	$0	No
Public Safety	1	0	1	0	0	$0	No
Search and Rescue	0	1	1	0	0	$0	No
Service Interruption	2	1	3	0	0	$0	No
Severe Wind	0	5	5	1	0	$30,000	Yes
Subsidence	0	1	1	0	0	$3,000,000	Yes
Terrorism	2	0	2	0	0	$0	No
Thunderstorm	11	68	79	4	82	$396,856,000	Yes
Tornado	0	16	16	0	57	$34,300,000	Yes
Tropical Cyclone	1	7	8	23	0	$380,800,000	Yes
Volcano	0	0	0	0	0	$0	No
Wildfire	16	67	83	0	0	$0	Yes
Winter Storm	0	4	4	1	0	$100,000	No
Total	71	381	452	104	420	$2,506,407,574	

Note: Information on fatalities, injuries, and property damage is available for only a small proportion of the total number of records and should be considered indicative. Declarations refers to Presidential, USDA, or Gubernatorial declared disasters or emergencies. Events refer to undeclared events with 1 or more fatalities, 1 or more injuries, $50,000 or more in damages, or historically significant event (as expressed in historical records). The hazard event database covers the period 1830 to 2002, although approximately 90 percent of the records are from 1970 or more recently. Long-term hazard events, such as droughts, were entered for each reported year of occurrence.

Source: URS, October 2003.

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7.3 Hazard Profiles

The hazards selected for profiling were examined in a methodical manner based on the following four factors, with each factor considered in detail for the hazards profiled:

- Nature: This topic provides basic information about the hazard that is sufficient to enable a user of the plan to comprehend its nature and distinguish it from other hazards. It also provides a basis for leaders to understand the subsequent vulnerability assessment and loss estimates. The information for this section is drawn mainly from FEMA and other national agencies.
- History: Background information about previous occurrences of the hazard is provided. The focus is on disasters and other events that have occurred in the unincorporated area of Maricopa County and, where Maricopa County information is lacking, on major occurrences elsewhere in the United States. The information in this section is drawn mainly from the database of historical hazard events in Arizona.
- Probability and Magnitude: As the title indicates, the focus of this topic is the probability or frequency of the hazard in Arizona as well its magnitude. The information in this section is drawn from a combination of FEMA and other national sources, Maricopa County expertise, and the Maricopa County hazard event database. Where possible, the focus of this section is on a commonly accepted design event.
- Warning Time: This topic provides information on the amount of time available for preparation prior to the occurrence of the design event. The information in this section is drawn from a combination of FEMA and other national sources, Maricopa County expertise, and the Maricopa County hazard event database.

In an effort to provide as much information as possible about each hazard, extensive text analysis as well as associated tables and graphics have been included for each of the hazard profiles below. These hazards profiles should be considered introductory, with additional and more detailed analysis available by the many sources cited below.

7.3.1 Dam Failure

7.3.1.1 Nature

A dam is a barrier constructed across a watercourse in order to store, control, or divert water, which is usually constructed of earth, rock, concrete, or mine tailings. The water impounded behind a dam is referred to as the reservoir and is measured in acre-feet, with one acre-foot being the volume of water that covers one acre of land to a depth of one foot. One acre-foot is equal to 325,851 gallons. Due to topography, even a small dam may have a reservoir containing many acre-feet of water. A dam failure is the collapse, breach, or other failure of a dam that causes downstream flooding. Dam failures may result from natural events, human-caused events, or a combination thereof. Due to the lack of advance warning, failures from natural events, such as hurricanes, earthquakes, or landslides, may be particularly severe. Prolonged rainfall that produces flooding is the most common cause of dam failure (FEMA, 1997).

Dam failures usually occur when the spillway capacity is inadequate and water overtops the dam or when internal erosion through the dam foundation occurs (also known as piping). If internal erosion or overtopping cause a full structural breach, a high-velocity, debris-laden wall of water is released and rushes downstream, damaging or destroying whatever is in its path. Dam failures may result from one or more the following:

- Prolonged periods of rainfall and flooding (the cause of most failures)
- Inadequate spillway capacity for extreme storms, which causes excess overtopping flows and erosion of the earth embankment.
- Internal erosion or erosions due to embankment or foundation leakage or piping
- Equipment malfunction, due to improper maintenance, improper design, or negligent operation
- Failure of upstream dams that results in large flows that overtop the dam.
- Landslides into reservoirs
- High winds
- Earthquakes

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7.3.1.2 History

The deadliest dam failure in U.S. history was in Johnstown, Pennsylvania, in 1889 when more than 2,209 people died. This failure was due to overtopping of the dam. The June 5, 1976 failure of the Teton Dam in Idaho, caused by piping, killed 11 people and caused approximately $1.0 billion in damages (FEMA, 1997).

In Arizona, two dam failure declarations (Presidential or Gubernatorial disaster or emergency declaration) and four additional undeclared dam failure events were identified. These resulted in an estimated 150 fatalities. The Walnut Grove Dam, located on the Hassayampa River, 30 miles south of Prescott Arizona, failed due to overtopping on February 22, 1890. About 150 people died in the waters released from the reservoir.

In 1915, Lyman dam, located south of St. Johns Arizona failed due to piping. Loss of life in this failure was eight.

The failure of Narrows Dam on Centennial Wash, located just west of Maricopa County in La Paz County, in September 1997 was due to piping through cracks in the embankment when the reservoir was filled during tropical storm Nora. Flooding from the failure extended into western Maricopa County.

Gillespie Dam failed in January 1993 in southwestern Maricopa County. Floodwaters and debris flows extended several miles downstream.

In Arizona, two dam failure declarations (Presidential or Gubernatorial disaster or emergency declaration) and four additional undeclared dam failure events were identified. These resulted in an estimated 150 fatalities. While none of these events occurred in Maricopa County, the 57 total dams present in the county today present a significant risk to lives and property. These dams are presented in Table 7-4.

7.3.1.3 Probability and Magnitude

The generally accepted safety standard for the design of dams is the Inflow Design Flood (IDF), which is the flood magnitude, selected on the basis of size and potential hazard classification of a dam for the emergency spillway design requirements. The PMF is the upper limit of the IDF. The Probable Maximum Flood (PMF), which is the estimated flood flow from the Probable Maximum Precipitation (PMP). The PMP is "… the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year" (US Department of Commerce and US Army Corps of Engineers, June 1988). In Maricopa County, the PMP is approximately 11 to 13 inches of rain in a 6-hour period. The probability of occurrence of a PMP is considered to be in the range of 1 in 10,000 to 1 in a million. There is historical record of only three storms of a magnitude exceeding 50% of the PMP in Arizona. The largest of these was the Labor Day storm of 1970, with 59%. No larger storms have been recorded. However, it must be noted that there are numerous dams in existence whose discharge capabilities were designed and built using methods that are now considered potentially unsafe.

The areas impacted by a dam failure are analyzed on the basis of "sunny day" failures and failures under flood condition. Typically, the dam-break inundation area or floodplain is more extensive than the floodplain used for land use development purposes and few communities consider upstream dams when permitting development. The potential severity of a full or partial dam failure is influenced by at least four factors: (1) the amount of water impounded, and (2) the density, type, and value of development and infrastructure downstream, (3) the amount of time available for warning and evacuation and (4) the quality of the warning and evacuation.

Currently, comprehensive and directly comparable information on the probability and magnitude of the impact of specific dam failures in Unincorporated Maricopa County is not available. However, preliminary analysis by the Arizona Department of Emergency Management (ADEM) indicates that dams on the Salt/Verde River, the Aqua Fria River, and the Gila River pose the greatest threat to the largest population centers within the county, due to the large amounts of water stored. For example, failure of any Bureau of Reclamation dams on the Salt/Verde River or the Aqua Fria River would cause massive flooding in Unincorporated Maricopa County. Failure of Coolidge Dam, a Bureau of Indian Affairs Dam on the Gila River could cause massive flooding in the Winkelman and Hayden areas of Gila County; Kearny, Florence and the Gila River Indian Reservation in Pinal County; and portions of Maricopa County. Failure of Painted Rock Dam, an Army Corps of Engineers dam, also on the Gila River system, could result

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in massive flooding of portions of Maricopa and Yuma Counties. (Arizona Division of Emergency Management, March 1998).

In addition, the following are two sources of information that provide an indication of the risk posed by specific dams in Maricopa County and the potential for their failure:

- National Inventory of Dams (NID): FEMA's Hazards US Multi-Hazard (HAZUS-MH) includes data on dams based on the National Inventory of Dams (NID) information. The HAZUS-MH/NID database contains information on approximately 77,000 dams in the 50 states and Puerto Rico, with approximately 30 characteristics for each dam, including name, owner, river, nearest community, length, height, average storage, max storage, hazard rating, Emergency Action Plan (EAP), latitude, and longitude. The NID database includes dams that meet the following criteria: if it is a high or significant hazard potential class dam or, if it is a low hazard potential class dam that exceeds 25 feet in height and 15 acre-feet storage, or if it is a low hazard potential class dam that exceeds 50 acre-feet storage and 6 feet height. There are 50 dams in the NID database that are located in Maricopa County (14 in the NID database only and 36 in both the NID and ADWR database), as shown in Table 7-4.
- Arizona Department of Water Resources (ADWR) Jurisdictional Dams: ADWR has jurisdiction over 43 dams in Maricopa County (7 in the ADWR database only and 36 in both the NID and ADWR databases), as shown in Table 7-4. The ADWR is responsible for the management of non-federal dams to reduce loss of life and damage to property, and conducts safety inspections of these dams.

Table 7-4: Identified Dams in Maricopa County, 2002

Jurisdiction	NID Only	ADWR Only	Both NID & ADWR	Total
Unincorporated Maricopa County	13	4	8	25
Total Maricopa County	14	7	36	57

Note: Dams may be contained within both the NID and ADWR databases. Categories for dams are not cumulative, but are independent of one another.

Source: NID / HAZUS-MH, ADWR, URS, December 2003

The NID and ADWR databases provide useful information on the potential hazard posed by dams in Maricopa County. Each dam in the NID is assigned one of the following three hazard potential classes based on the downstream potential for loss of life and damage to property should the dam fail (listed from best to worst): low, significant, or high. The hazard classes are determined by the anticipated consequences that may occur in the case of the failure or misoperation of the dam or related facilities, as shown in Table 7-5. It is important to note that the hazard potential classification is an assessment of the consequences of failure, but not an evaluation of the probability of failure.

Table 7-5: NID Downstream Hazard Potential Classes

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

Note: The hazard potential classification is an assessment of the consequences of failure, but not an evaluation of the probability of failure.

Source: National Inventory of Dams

ADWR jurisdiction dams are inspected regularly by ADWR according to NID hazard rating and ADWR safety rating. High hazard dams are inspected annually, significant hazard dams are inspected every three years, and low hazard

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dams are inspected every five years. After inspections ADWR assigns each dam one of the following four safety ratings (listed from best to worst): no deficiency, safety deficiency, unsafe non-emergency, or unsafe emergency. Note that at the time this analysis was prepared, no ADWR jurisdictional dams had a rating of "unsafe emergency" (the worst safety rating).

While it is not possible to predict the probability and magnitude of dam failure in Maricopa County, the NID hazard and ADWR safety ratings can be used to identify potentially hazardous dams in Maricopa County, as shown in Table 7-6 and Figure 7-1. Of the total 57 dams identified in Maricopa County, 38 have a "high hazard" rating, with concentrations of these dams in the central and eastern portions of the county. Only one dam had a safety rating of "unsafe non-emergency" from ADWR. Potentially the most hazardous dam in Maricopa County is the one "high hazard" dam that also has "unsafe non-emergency" safety rating. This dam is located at the base of the White Tank Park on the west side of the greater metropolitan area (Note: Design work currently in process to provide corrective construction planned in 2005).

In Unincorporated Maricopa County, a total of 25 NID and ADWR dams were identified, of which 12 are classified as High Hazard Dams and one classified as Unsafe Non-emergency by the NID. Located in the greater metropolitan area. The dam's classification as High Hazard is due to the significant consequences for both humans and property of a dam failure in such a highly populated region. In particular, five High Hazard dams exist in and around the Phoenix Mountains Preserve, which includes the distinctive North Mountain Preserve and Piestewa Peak areas. Draining to the south and west, this region is surrounded by homes for many miles in each direction. Various other High Hazard dams exist in the greater metropolitan area, especially in the eastern areas of Maricopa County where the many flood control structures associated with the Salt River Project exist. Collectively, this series of dams presents the greatest overall threat to the residents and property of Unincorporated Maricopa County due to their elevation and the large volumes of water that are retained. The only dam classified as Unsafe in the area is in an unincorporated area located north of Sun City West. No dams with both a High Hazard and Safety Deficiency rating were detected in Maricopa County.

Table 7-6: Potentially Hazardous Dams in Maricopa County, 2002

Jurisdiction	High Hazard Only	Unsafe Non-Emergency Only	Both High Hazard and Unsafe Non-Emergency	Total
Unincorporated Maricopa County	12	1	1	14
Total Maricopa County	38	1	1	40

Note: High Hazard Only dams from the National Inventory of Dams (NID) / HAZUS-MH and is an assessment of the consequences of failure on population (but not an evaluation of the probability of failure). Unsafe Non-Emergency Only dams from the Arizona Department of Water Resources (ADWR) and is an assessment of the safety of the dam that indicates a severe safety deficiency that could worsen to be come an unsafe condition which could result in failure of the dam. Both High Hazard and Unsafe Non-Emergency Dams meet both of these conditions and may be considered the most hazardous dams.

Source: NID / HAZUS-MH, ADWR, URS, December 2003.

7.3.1.4 Warning Time

The total time of failure of an earth dam is finite. The time of failure may range from a few minutes to usually less than an hour for overtopping and a few hours for piping failures. Studies indicate that loss of life due to dam failure flooding is significantly reduced when warning is in excess of 90 minutes. Historically, when warning time is less than 30 minutes, loss of life has been as high as 50% of the persons within the inundation area. Warning time is dependent upon early detection of a problem and the travel time from the dam to the population at risk. The factors that can cause dam failure are translated into high risks when people or properties are threatened. The National Weather Service (NWS) is responsible for most flood warning efforts in Maricopa County, including dam failure flood warnings.

All high hazard potential dams are required to prepare Emergency Action Plans (EAP) that includes inundation maps for various types of failures and floods. In many cases, inundation areas have also been defined for floods due to

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non-failure spillway flows that exceed the capacity of the channel below the dam. EAP's and inundation maps are filed with the Maricopa County Department of Emergency Management, the dam owner, and the ADWR. The city governments are generally responsible for the overall direction and control of emergency response operations within their jurisdictions to include warning, evacuation, and security of the evacuated areas.

For large river systems, hydrological models are used by River Forecast Centers (RFCS). For many—but not all—smaller streams, the NWS has developed an automated system called ALERT (Automated Local Evaluation in Real Time) that does not rely on volunteer observers. The ALERT system provides information on rainfall amounts, depth of stream flows and depth of water behind a dam. Many of the owners in Maricopa County participate in the ALERT system. However, some communities may still need to use volunteer observers to monitor water levels, the effectiveness of the levee system, or even to back up automated systems. It is always wise to confirm automated information with visual observations.

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Figure 7-1: Potentially Hazardous Dams, 2002

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The NWS has the responsibility for issuing forecasts and warnings to mitigate the loss of life and property associated with weather phenomena for the citizens of the United States. The NWS fulfills this mission with 121 Weather Forecast Offices (WFOs) nationwide that are responsible for collecting data, analyzing mathematical computer models of the atmosphere, and preparing and disseminating weather watches and warnings and disseminating river forecast and warnings. There are 13 River Forecast Centers (RFC) located throughout the United States that provide WFO locations with hydrologic forecasts to be used in the preparation of hydrologic watches and warnings. The NWS is also responsible for the preparation and issuance of public warnings and watches related to eminent or occurring dam failures. The WFOs are responsible for issuance within their appropriate county warning areas. All dams in danger of failing should be reported to the appropriate WFO as soon as possible. The WFOs in coordination with the RFCs will issue products informing the public of the dangers of a dam failure.

The NWS forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories). This office provides warnings with respect to extreme flash floods and to prolonged periods of flooding, both of which could potentially lead to dam failure. In general, the warning time for dam failure can vary from none to days, depending upon the nature of the dam failure. No warning time may be available due to the failure of a dam following a catastrophic earthquake, landslide, or terrorist attack. In the case of extreme flash flooding, the warning time may also be short, although could extend to hours. Periods of prolonged rainfall and associated flooding (e.g., from a tropical storm), the most common cause of dam failure, may have warning times as short as several hours, but more typically would extend to days.

7.3.2 Disease

7.3.2.1 Nature

A disease is a pathological (unhealthy or ill) condition of a living organism or part of the organism that is characterized by an identifiable group of symptoms or signs. Disease can affect any living organism, including people, animals, and plants. Disease can both directly (through infection) and indirectly (through secondary impacts) affect people, animals, and plants. Some diseases can directly affect both people and animals by infecting both. The major concern is an epidemic, a disease that affects numerous people, animals, or plants at one time.

Of great concern for human, animal and plant health are infectious diseases that are caused by the entry and growth of microorganisms in another living organism. Some, but not all, infectious diseases are contagious, that is communicable by coming into direct or even indirect contact with an organism infected with the disease, something it has touched, or another medium (e.g., water, air).

According to the Centers for Disease Control and Prevention (CDC), during the first half of the twentieth century, optimism grew as steady progress was made against infectious diseases in humans by improved water quality, sanitation, antibiotics, and inoculations (October 1998). The incidences and severity of infectious diseases such as tuberculosis, typhoid fever, smallpox, polio, whooping cough, and diphtheria were all significantly reduced during this period. This optimism proved premature, however, for a variety of reasons, including the following: antibiotics began to lose their effectiveness against infectious disease (e.g., Staphylococcus aureus); new strains of influenza emerged in China and spread rapidly around the globe; sexually transmitted diseases surged; new diseases were identified in the U.S. and elsewhere (e.g., Legionnaires's disease, Lyme disease, toxic shock syndrome, and Ebola hemorrhagic fever); acquired immunodeficiency syndrome (AIDS) appeared; and tuberculosis (including multidrug-resistant strains) reemerged (CDC, October 1998).

In a 1992 report titled *Emerging Infections: Microbial Threats to Health in the United States*, the Institute of Medicine (IOM) identified the growing links between U.S. and international health, and concluded that emerging infections are a major and growing threat to U.S. health. An emerging infectious disease is one whose incidence in humans has increased during the previous decades or threatens to increase in the near future. Emerging infectious diseases are a product of modern demographic and environmental conditions, such as global travel, globalization and centralized processing of the food supply, population growth and increased urbanization.

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In response to the threat of emerging infectious diseases, the CDC launched a national effort to protect the US public in a plan titled *Addressing Emerging Infectious Disease Threats*. Based on the CDC's plan, major improvements to the US health system have been implemented, including improvements in surveillance, applied research, public health infrastructure, and prevention of emerging infectious diseases (CDC, October 1998).

Despite these improvements, infectious diseases are the leading cause of death in humans worldwide and the third leading cause of death in humans in the U.S. (American Society for Microbiology, June 21, 1999). A recent follow-up report from the Institute of Medicine, titled *Microbial Threats to Health: Emergence, Detection, and Response*, notes that the impact of infectious diseases on the U.S. has only grown in the last ten years and that public health and medical communities remain inadequately prepared. Further improvements are necessary to prevent, detect, and control emerging, as well as resurging, microbial threats to health. The danger posed by infectious diseases are compounded by other important trends: the continuing increase in antimicrobial resistance; the US' diminished capacity to recognize and respond to microbial threats; and the intentional use of biological agents to do harm (Institute of Medicine, 2003).

The CDC has established a list of over 50 nationally notifiable diseases. A notifiable disease is one that, when diagnosed, health providers are required, usually by law, to report to State or local public health officials. Notifiable diseases are those of public interest by reason of their contagiousness, severity, or frequency. The long list includes such diseases as the following: AIDS; anthrax; botulism; cholera; diphtheria; encephalitis; gonorrhea; Hantavirus pulmonary syndrome; hepatitis (A, B, C); HIV (pediatric); Legionellosis; Lyme disease; malaria; measles; mumps; plague; polio (paralytic); rabies (animal and human); Rocky Mountain spotted fever; rubella (also congenital); Salmonellosis; SARS; Streptococcal disease (Group A); Streptococcal toxic-shock syndrome; *Streptococcus pneumoniae* (drug resistant); syphilis (also congenital); tetanus; Toxic-shock syndrome; Trichinosis, tuberculosis, Typhoid fever; and Yellow fever (Centers for Disease Control and Prevention, May 2, 2003).

In addition to diseases only in humans, there is also significant concern about diseases that affect both humans and animals, known as zoonotic diseases. There are approximately 40 zoonotic diseases, including the following: rabies; tuberculosis and brucellosis; trichinosis; ringworm; giardiasis; and Lyme disease (Will, April 2002).

In Maricopa County, the Department of Public Health seeks to prevent infectious diseases from entering the county and control those that are endemic or have already entered. Of particular concern to the Department of Public Health are new pandemic diseases, such as SARS, new strains of HIV, new influenza strains, botulism, and bio-terrorism pathogens such as anthrax, smallpox, or chemical attacks of sarin or VX gas. The Department of Public Health, Epidemiology & Data Services monitors and controls more than 70 infectious diseases of public health concern such as measles, rubella, pertussis and hepatitis B, diarrhea diseases and vomiting; excluding HIV/AIDS, which is addressed by the Office of HIV/AIDS.

Diseases affecting animals and plants, particularly livestock and agricultural products, are also of major concern, both the supply and quality of human food supplies, potential economic consequences, and impact on foreign trade. According to the National Animal Health Emergency Management System (NAHEMS), an animal health emergency is defined as the appearance of disease with the potential for a sudden negative impact through direct impact on productivity, real or perceived risk to public health, or real or perceived risk to a foreign country which imports from the U.S. (Lautner, April 18, 2002).

A division of the United States Department of Agriculture (USDA), the Animal and Plant Health Inspection Service (APHIS) is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. Major programs within APHIS relating to disease are Veterinary Services (VS) and Plant Protection and Quarantine (PPQ). Veterinary Services protects and improves the health, quality, and marketability of animals, animal products and veterinary biologics by (i) preventing, controlling and/or eliminating animal diseases, and (ii) monitoring and promoting animal health and productivity. Among other activities, Veterinary Services conducts surveillance on national animal diseases, foreign animal diseases, emerging animal diseases, and invasive plant species. Most of Veterinary Services efforts are targeted at diseases on the Organization Internationale des Epizooties (OIE) List A or List B.

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The OIE is the international standard setting body for animal health and international trade. OIE categorizes animal diseases in two classes: List A -- most serious; and List B -- less serious. List A contains transmissible diseases that have the potential for very serious and rapid spread, irrespective of national borders, that are of serious socio-economic or public health consequence, and that are of major importance in the international trade of animals and animal products. List A includes the following: Foot and mouth disease; lumpy skin disease; bluetongue; African horse sickness; classical swine fever; vesicular stomatitis; rinderpest; contagious bovine pleuropneumonia; Rift Valley fever; sheep pox and goat pox; African swine fever; and highly pathogenic avian influenza. The List B disease are transmissible diseases considered to be of socio-economic and/or public health importance within countries and that are significant in the international trade of animals and animal products, and number approximately 100 (Organization Internationale des Epizooties, January 9, 2003).

The Plant Protection and Quarantine (PPQ) program, also located within USDA's Animal and Plant Health Inspection Service (APHIS), safeguards agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds. Several thousand foreign plant and animal species have become established in the United States over the past 200 years, with approximately one in seven becoming invasive. An invasive species is an alien (i.e., non-native) species whose introduction does, or is likely to, cause economic or environmental harm or harm to human health. Invasive plants, animals, and pathogens have often reduced the economic productivity and ecological integrity of agriculture, forestry, and the US' other natural resources.

Common vertebrate invasive species in the continental US include nutria, house sparrows, European starlings, and commensal rodents (roof rat, Norway rat, and house mouse). In Hawaii and in some continental U.S. States, feral pigs, goats, and cats have severely impacted natural and environmental resources. Additionally, numerous invertebrate invasive species have become established in the United States, including zebra mussels, imported fire ants, Africanized honey bees, and Asian longhorned beetles (Animal and Plant Health Inspection Service, April 2003).

The Arizona Department of Agriculture (ADA) and Arizona Game and Fish Department (AGFD) are primarily concerned with plant, livestock and wild animal diseases and infections. They focus on diseases listed on the Office International des Epizooties (OIE) disease "A" list. The OIE develops standards and guidelines for use in protecting against incursions of diseases or pathogens during trade in animals and animal products. The agencies are concerned with animal-to-animal diseases, as well as diseases transmitted from animals or arthropod vectors to humans.

Many other hazards, such as floods, earthquakes or droughts, may create conditions that significantly increase the frequency and severity of diseases. These hazards can affect basic services (e.g., water supply and quality, wastewater disposal, electricity), the supply and quality of food, and the public and agricultural health system capacities. As a result, concentrations of diseases may result and grow rapidly, potentially leading to large losses of life and economic value.

In addition, since the anthrax attacks following the terrorist attacks on September 11, 2001, the threat of terrorism using disease to infest humans, animals, or plants, is of growing concern. This is particularly true of those capable of disrupting the human or animal food chain.

7.3.2.2 History

The influenza pandemic of 1918 and 1919, known as the Spanish Flu or Swine Flu, had the highest infectious disease mortality rate in recent history. More than 20 million persons were killed worldwide, some 500,000 of which were in the U.S. alone (Centers for Disease Control and Prevention, October 1998). More recent major infectious diseases affecting people in the U.S. include the following:

- West Nile Virus (WNV), a seasonal infection transmitted by mosquitoes, grew from an initial U.S. outbreak of 62 disease cases in 1999 to 4,156 reported cases, including 284 deaths, in 2002 (Centers for Disease Control and Prevention, July 8, 2003).

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- Severe acute respiratory syndrome (SARS), estimated to have killed 916 and infected 8,422 worldwide by mid-August 2003 (World Health Organization, August 15, 2003). In the U.S., there were 175 suspect cases and 36 probable cases, although no reported deaths (Centers for Disease Control and Prevention, July 17, 2003).
- Although most cases go unrecognized, Norwalk-like virus (NLV) is believed to affect over 20 million persons in the U.S. each year. NLV accounts for 96 percent of all non-bacterial outbreaks of gastroenteritis (Arizona Department of Health Services, March/April 2003).
- In Maricopa County in October and November of 2002 two five-year old children died after a private water system associated with the Rose Valley Company was contaminated.

Significant animal disease outbreaks that affected major U.S. trading partners, resulting in huge economic losses, include the following:

- The largest recent animal disease outbreak in the United States occurred in 1983-84, when avian influenza swept through Pennsylvania and neighboring States. Poultry prices for consumers jumped by $350 million. A 6-month eradication plan cost the Federal Government $63 million (Federal Emergency Management Agency, July 2002).
- In 1988, the value of British beef and beef products was estimated at US $880 million. After bovine spongiform encephalopathy (BSE, or "mad cow disease") emerged, its value dropped considerably. After a 1996 announcement of a probable link between consumption of BSE-affected meat and a new variant of Creutzfeld-Jakob disease in humans, the value fell to zero (Federal Emergency Management Agency, July 2002).
- The pig husbandry industry in the Netherlands was struck by a severe epidemic of Classical Swine Fever (CSF) in 1997, resulting in the killing of up to 1.1 million pigs (Bouma and Stegeman). Other countries affected by CSF include Haiti, the Dominican Republic, and the U.K. (Lautner, March 18, 2002).
- Approximately 1.1 million pigs were killed in Malaysia in the two years 1998 and 1999 in order to stop a major outbreak of the Nipah Virus. The virus also affects people and resulted in the death of at least 115 persons (Animal Production and Health Commission for Asia and the Pacific, January 2002).
- More than a million cattle and sheep were destroyed in the U.K. due to an outbreak of foot-and-mouth disease in 2001. Other countries affected by foot-and-mouth disease include Argentina, Brazil, Egypt, Taiwan, Korea, Japan, and South Africa (Lautner, March 18, 2002).

According to figures provided by Cornell University, invasive species cost the United States more than $138 billion each year (Animal and Plant Health Inspection Service, April 2003). The following are examples of the impacts of a number of invasive species in the U.S.:

- Boll weevils came to the United States from Mexico in 1892 and are the primary insect pest of cotton, costing U.S. farmers more than $200 million annually in control efforts and yield losses (Animal and Plant Health Inspection Service, April 2003).
- In 1970, leaf blight destroyed about $1 billion worth of corn in the United States. Between 1993 and 1998, fusarium head blight affected successive wheat harvests in the Dakotas, Minnesota, and Manitoba. The disease spread over 10 million acres, probably with the help of abnormally wet weather, and cost an estimated $1 billion in lost production (Federal Emergency Management Agency, July 2002).
- An invasive insect detected in California in the early 1990s, the glassy–winged sharpshooter carries the plant bacterium Xylella fastidiosa, which causes a variety of plant diseases, including Pierce's disease. This disease has already caused multi–million–dollar losses of California grape crops and continues to pose a major threat to the grape, raisin, and wine industries, and the tourism associated with them (Animal and Plant Health Inspection Service, April 2003).
- Tropical bont tick is present on the Caribbean Islands and is a pest of concern to the U.S. mainland due to frequent travel and commerce between the areas. It can carry a parasite that causes heartwater disease—a major threat to domestic livestock (Animal and Plant Health Inspection Service, April 2003).

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In Maricopa County, there have been 6 disaster declarations (Presidential, USDA, or Gubernatorial disaster or emergency declaration) due to disease and 7 additional undeclared events, as shown in Table 7-3. These events resulted in an identified 49 fatalities and 82 injuries. Major infectious disease outbreaks in Maricopa County that affected humans include the following:

- In 1918 the Spanish influenza pandemic entered Arizona resulting in a great number of deaths, although the exact number is undocumented.
- In 1952, large numbers of influenza cases were reported in the state, although no death statistics are available.
- In 2002, Arizona experienced two major outbreaks of the Norwalk-like virus (NLV). More than 70 persons were affected at a golf tournament held in Maricopa County resulting in the death of a teenage boy. Infected drinking water and ice was implicated at the golf tournament. (Arizona Department of Health Services, March/April 2003).

There have been relatively few reported incidents or concerns related to animal disease outbreaks in Arizona. Those reported include the following:

- On May 18, 2002 the Arizona Game and Fish Department placed an emergency ban on the importation of live hoofed animals (e.g., deer and elk) into Arizona due to a fear of Chronic Wasting Disease (CWD). CWD is a disease closely related to "mad cow disease" in cattle and scrapie in domestic sheep and goats but also affects deer and elk (Arizona Game and Fish).
- On January 8, 2003, the Arizona Department of Agriculture issued an Administrative Order implementing procedures to prevent the introduction of Exotic Newcastle Disease (END) into Arizona. END is a contagious and fatal viral disease affecting domestic, wild, and caged poultry and birds, and is one of the most infectious diseases of poultry in the world. On February 5, 2003, Governor Napolitano declared a state of emergency to contain END threatening Arizona's poultry. The US Secretary of Agriculture, Ann M. Veneman, signed declarations of extraordinary emergency with respect to END in Arizona on February 7, 2003 (United States Department of Agriculture, February 12, 2003).

Maricopa County has been subject to a number of major infestations, the largest of which is still affecting the state and region (pine bark beetle). Further details on these infestations are given below:

- On May 22, 2003, Governor Janet Napolitano declared a State disaster and a state of emergency due to the ravages of the pine bark beetle on the state's forests. An estimated 2.5 million ponderosa pines and 4 million pinon pines were killed by the pine bark beetle in Arizona in 2002-2003. The last significant bark beetle outbreak in Arizona occurred from 1951 to 1956. The bark beetles are killing so many trees for two reasons, first the forest has too many trees and second the trees are very dry. Overcrowded forest conditions coupled with drought lead to the high probability of beetle attack. The forests of Arizona have been able to survive in relatively dry conditions because in past centuries low intensity fires helped to maintain a low density of trees in the forest. In the past century, however, fires have been controlled allowing many forested areas to become overcrowded (DeGomez, April 23, 2003).
- Exotic and imported ants are listed on the Arizona Department of Agriculture website as "Arizona's Most Unwanted Pest". Some people are allergic to the sting and in some cases may cause death. Fire ants are also known to out compete and drive away local native ants (Arizona Department of Agriculture).
- Arizona periodically experiences major grasshopper infestations. Four infestations have resulted in State declarations of emergency in the last quarter century (Arizona Division of Emergency Management, March 6, 2003).
- A declared plant disease disaster involved the wheat disease—Karnal Bunt—in 1996. Other undeclared plant disease events include the citrus disease red scale in 1942 (Arizona Division of Emergency Management, March 6, 2003).

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7.3.2.3 Probability and Magnitude

The probability and magnitude of disease, particularly an epidemic, is difficult to evaluate due to the wide variation in disease characteristics, such as rate of spread, morbidity and mortality, detection and response time, and the availability of vaccines and other forms of prevention. A review of the historical record (see above) indicates that disease related disasters do occur in humans, animals, and plants with some regularity and severity. There is growing concern, however, about emerging infectious diseases as well as the possibility of a bioterrorism attack.

7.3.2.4 Warning Time

Due to the wide variation in disease characteristics, the warning time for a disease disaster can vary from immediate to months, depending upon the nature of the disease. No warning time may be available due to an extremely contagious disease, particularly if combined with a terrorist attack in a crowded environment. Balancing this are the numerous agencies and programs in place to prevent, detect, and respond to diseases, such as the Centers for Disease Control and Prevention, Arizona Department of Health Services, Maricopa County Department of Public Health, Organization Internationale des Epizooties, USDA Animal and Plant Health Inspection Service, USDA Plant Protection and Quarantine, and Arizona Department of Agriculture.

Maricopa County Public Health has in place a continuous mechanism for all health care professionals within Maricopa County to report any public health concern or observation. All cities and towns in the County rely on their health care professions to utilize this system (Mare Schumacher, Epidemiology Deputy Director Maricopa County Public Health).

7.3.3 Drought

7.3.3.1 Nature

Drought is a normal part of virtually every climate on the planet, including areas of high and low rainfall. It is different from normal aridity, which is a permanent characteristic of the climate in areas of low rainfall. Drought is the result of a natural decline in the expected precipitation over an extended period of time, typically one or more seasons in length. The severity of drought can be aggravated by other climatic factors, such as prolonged high winds and low relative humidity (FEMA, 1997).

Drought is a complex natural hazard which is reflected in the following four definitions commonly used to describe it:

- Meteorological drought is defined solely on the degree of dryness, expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
- Hydrological drought is related to the effects of precipitation shortfalls on streamflows and reservoir, lake, and groundwater levels.
- Agricultural drought is defined principally in terms of soil moisture deficiencies relative to water demands of plant life, usually crops.
- Socioeconomic drought associates the supply and demand of economic goods or services with elements of meteorological, hydrologic, and agricultural drought. Socioeconomic drought occurs when the demand for water exceeds the supply as a result of weather-related supply shortfall. It may also be called a water management drought.

A drought's severity depends on numerous factors, including duration, intensity, and geographic extent as well as regional water supply demands by humans and vegetation. Due to its multi-dimensional nature, drought is difficult to define in exact terms and also poses difficulties in terms of comprehensive risk assessments.

Drought differs from other natural hazards in three ways. First, the onset and end of a drought are difficult to determine due to the slow accumulation and lingering effects of an event after its apparent end. Second, the lack of an exact and universally accepted definition adds to the confusion of its existence and severity. Third, in contrast with other natural hazards, the impact of drought is less obvious and may be spread over a larger geographic area. These characteristics have hindered the preparation of drought contingency or mitigation plans by many governments.

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Droughts may cause a shortage of water for human and industrial consumption, hydroelectric power, recreation, and navigation. Water quality may also decline and the number and severity of wildfires may increase. Severe droughts may result in the loss of agricultural crops and forest products, undernourished wildlife and livestock, lower land values, and higher unemployment.

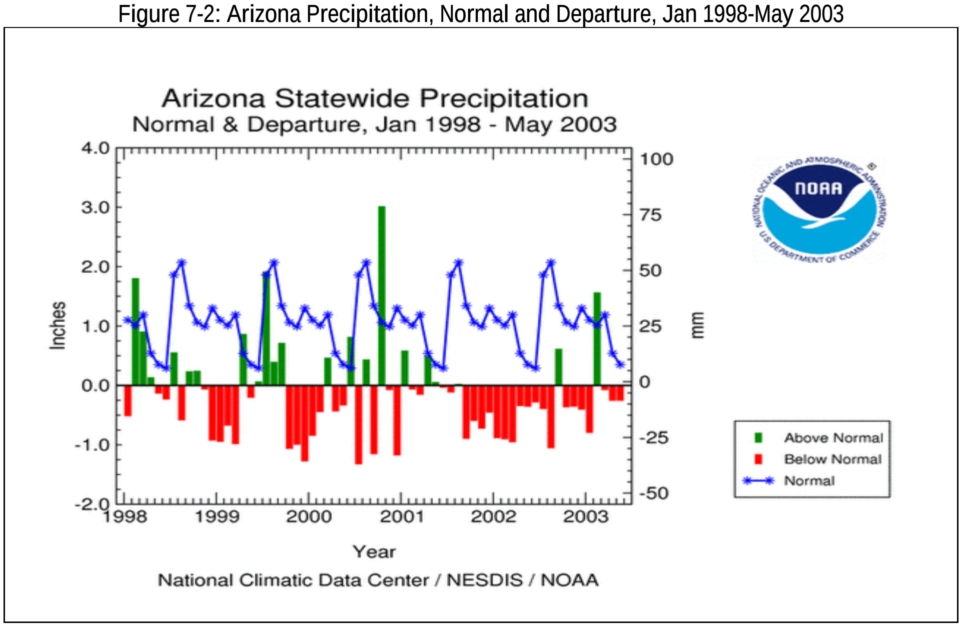
7.3.3.2 History

During the 20th century, nine notable droughts have occurred in the United States. While damage estimates are not available for most, estimates suggest that the Great Plains Drought of the 1930's, precipitating the Oklahoma Dust Bowl, and lasting approximately a decade, cost $475 million in federal funds. However, not figured into this cost is the loss of at least five inches of topsoil from nearly 10 million acres and by 1938 nearly 10% of the State of Oklahoma's population had left. In 1976-1977 drought again hit the Great Plains, the Upper Midwest, and the far western portion of the United States causing direct losses of $10-15 billion. Furthermore, the drought in the Central and Eastern States during 1987-89 caused an estimated $39 billion in damages (FEMA, 1997, Oklahoma Department of Libraries, State of Oklahoma History and Culture).

Maricopa County has identified the years between 1941 through 1965 as specific dates when drought conditions were evident and described as a prolonged dry period with no spill releases in the Salt River. Additionally, 1951 and again in 1991, are the only two times in Salt River Project's 100-year history that it has rationed water.

It is also important to note that in addition to affecting people, drought may severely affect livestock and pets. Such events may require emergency watering/feeding, shelter, evacuation, and possible increase in event-caused deaths and burying of animals, such as during the statewide droughts in the 1990's. Range animals were affected resulting in range closures and the institution of dry-milk programs (Lanman, May 27, 2003).

Figure 7-2: Arizona Precipitation, Normal and Departure, Jan 1998-May 2003



Source: NOAA, May 2003.

Maricopa County has experienced 12 droughts that were declared disasters/emergencies and 86 drought events (droughts affect multiple years are recorded as a distinct event for each year affected), as shown in Table 7-3. In Maricopa County, the most prolonged period of drought conditions in the past 300 years was between 1849 and 1905 (NOAA, July 29, 2003). Another period of prolonged drought occurred during the period 1941 to 1965, during

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which time there were no spill releases into the Salt River (Arizona Division of Emergency Management, December 2001). Data collected by the National Climatic Data Center, as shown in Figure 7-2, shows that between 1998 and 2003 there have been more months with a below normal amount of precipitation than months with above normal precipitation. Especially from mid-2001 to mid-2002, there has been a continuous below normal amount of precipitation.

At the time of this writing, Maricopa County was experiencing drought conditions. Much of Maricopa County is in its fourth consecutive year of below average rainfall, and is below average for six out of the last seven years. Surface water flows and reservoir storage levels are the lowest ever recorded in many areas. Rural areas are most affected due to heavy reliance on dwindling ground water supplies and lack of alternatives. Maricopa County and its surrounding communities are less affected thanks to supplies from the Central Arizona Project (CAP), the Salt River Project (SRP), significant investments in recharge systems, and ground water sources (Jacobs and Morehouse, June 11-13, 2003).

7.3.3.3 Probability and Magnitude

No commonly accepted approach exists to assessing risks associated with drought. The Palmer Drought Severity Index (PSDI) is a commonly used index that measures the severity of drought for agriculture and water resource management. It is calculated from observed temperature and precipitation values and estimates soil moisture. However, the Palmer Index is not considered to be consistent enough to characterize the risk of drought on a nationwide basis (FEMA, 1997).

The principal objective of the *National Study of Water Management During Drought* was to develop strategies for improving water management to reduce the nation's vulnerability to drought (USACE, September 1995). An outcome of this study was the *National Drought Atlas*, which was managed by the United States Army Corps of Engineers and is the first nationwide study of drought frequency. The *Atlas* provides a useful tool for answering questions about the likely duration, timing, and severity of drought in a region (Willeke et al, 1994). It is based on precipitation, stream flow, and Palmer Drought Severity Index data from 1,119 sites (grouped into 111 regions) in the National Climate Data Center's Historical Climate Network (with an average record length of 85 years).

While there is no commonly accepted return period or non-exceedance probability for defining the risk from hydrological drought (such as the 100-year or 1 percent annual chance of flood), as noted above, the *National Drought Atlas* can be used to answer questions on drought at the regional level (FEMA, 1997). Figure 7-3 shows July-to-January mean stream flow in cubic feet per second per square mile with a 5-percent chance of non-exceedance (meaning that stream flow will be less than this value once in every twenty years). The map indicates that Maricopa County, including all of the communities in the greater metropolitan area, will be subject to a drought every twenty years in which mean streamflows are 0.1 cubic feet per second per square mile or less. According to ADEM's *State of Arizona Hazard Identification Study - Draft* (March 1998), the entire state is susceptible to a drought at any time, though the drought season tends to be from January through May.

It is notable that temperatures in the Western U.S. rose 2-5°F during the 20th century. While this increase was accompanied by precipitation increases of up to 50 percent in some areas of the West, some places have become drier and experienced more droughts (including Arizona). The two major climate change models, the Canadian Model and the Hadley Model, both forecast continued temperature increases in the West of 5-11°F during the 21st century, including Arizona. However, both models also forecast significant increases in rainfall in much of the West, with the increase on the order of 75-100 percent across much of Arizona. These increases may lead to elevated water supplies, although current reservoir systems may be inadequate to control earlier spring runoff and to maintain supplies for the summer (National Assessment Synthesis Team, May 2001).

When attempting to evaluate the probability and magnitude of drought in Maricopa County, it is helpful to remember that potable water in Maricopa County is derived from both surface water and groundwater. Surface water to Maricopa County users comes from two sources, the Colorado River, (through the Central Arizona Project (CAP) Canal, which transports it from the Colorado River), and in-state rivers (including streams and lakes). This surface water is a major renewable resource for the county, but can vary dramatically between years, seasons, and locations

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due to the state's desert climate. In order to lessen the impact of such variations, water storage reservoirs and delivery systems have been constructed throughout the county, the largest of which are located on the Salt River, Verde River, Gila River, and Agua Fria River.

The other major source of water is groundwater. This water has been pumped out of natural reservoirs beneath the surface known as aquifers, which have been created over millions of years. While a significant supply of water remains stored in aquifers, groundwater has historically been pumped out much more rapidly than it is replenished, thereby creating a condition known as overdraft leading to limits to its availability by location, depth, and quality. In 1980, Arizona implemented the Groundwater Management Code in order to promote conservation and long-range planning of water resources, including reducing reliance on groundwater supplies.

Reclaimed water, or effluent, is the only increasing source of water in the county, although it constitutes only a small amount of the overall water used. As the regional population grows; however, increasing amounts of reclaimed water will be available for purposes such as agriculture, golf courses, parks, industrial cooling, and maintenance of wildlife areas.

Much of Maricopa County, particularly the greater metropolitan area, is in a rather unique position. While located in a region subject to hydrological drought, a large supply of water is available via the Central Arizona Project (CAP) Canal. The CAP Canal is a 336-mile long system of aqueducts, tunnels, pumping plants, and pipelines running from the Colorado River on the Arizona-California border eastward to metropolitan Maricopa County and then southeast to the Tucson area. The CAP Canal supplies approximately 1.5 million acre-feet of water annually to Maricopa, Pinal, and Pima Counties and is the largest single source of renewable water supply in the state. The CAP Canal has more than 80 major customers, approximately 75 percent of which are municipal and industrial users, 13 percent are irrigation districts, and 12 percent are Indian communities (Arizona Department of Water Resources; Central Arizona Project).

7.3.3.4 Warning Time

The U.S. Drought Outlook forecasts the drought outlook for the U.S. for the remaining part of the month of issue plus the next three months. This report is prepared monthly by the National Weather Service's Climate Prediction Center (CPC). Tools used in preparing the drought outlook include the following: the official CPC long-lead precipitation outlook for the next 90 days; the Palmer Drought Index probability projections for the next 3 months; various medium and short-range forecasts and models, such as the 6-10 day and 8-14 day forecasts and the 2-week soil moisture forecast; and the constructed analogue from soil moisture forecasts (National Weather Service, Climate Prediction Center).

A more short-term drought outlook is the U.S. Drought Monitor, which provides a weekly summary of the extent and intensity of current drought conditions across the U.S. It is a joint effort product from the Climate Prediction Center (CPC) and National Climatic Data Center (NCDC), the U.S. Department of Agriculture, and the National Drought Mitigation Center (NDMC). Tools used to prepare the U.S. Drought Monitor include the following: climate outlooks; seasonal U.S. drought outlook; stream flow forecast; forecast Palmer Drought Index; and soil moisture forecasts (National Drought Mitigation Center).

Droughts typically take months or even years to occur and be identified, and may also persist for years. As noted above, the U.S. Drought Outlook provides some warning time, perhaps months about the occurrence of a drought. The U.S. Drought Monitor provides information on the extent and severity of existing drought conditions. The information from both of these may provide warning time on the order of months which will be used to plan for future or existing drought conditions.

Despite the on-going drought, Arizona is one of 15 states nationwide that lack a statewide drought plan. However, the State is taking action to address this shortfall. On March 20, 2003, Governor Janet Napolitano signed Executive Order 2003-12 directing the establishment of the Arizona Drought Task Force. The Task Force is lead by the Department of Water Resources and is comprised of State agencies and elected officials. The task force is charged with creating work groups to address problems in: municipal and industrial water supply, agriculture, wildlife and

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wildlife habitat, conservation education, and fire suppression. In February of 2000 the City of Phoenix approved and adopted an updated Drought Management Plan, which replaced an earlier version that was adopted in 1990.

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Figure 7-3: Hydrologic Drought

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7.3.4 Earthquake

7.3.4.1 Nature

An earthquake is "…a sudden motion or trembling caused by an abrupt release of accumulated strain on the tectonic plates that comprise the earth's crust." These rigid tectonic plates are some 50 to 60 miles in thickness and move slowly and continuously over the earth's interior. The plates meet along their edges, where they move away, past or under each other at rates varying from less than a fraction of an inch up to five inches per year. While this sounds small, at a rate of two inches per year, a distance of 30 miles would be covered in approximately one million years (FEMA, 1997).

The tectonic plates continually bump, slide, catch, and hold as they move past each other which causes stress that accumulates along faults. When this stress exceeds the elastic limit of the rock, an earthquake occurs, immediately causing sudden ground motion and seismic activity. Secondary hazards may also occur, such as surface faulting, ground failure, and tsunamis. While the majority of earthquakes occur near the edges of the tectonic plates, earthquakes may also occur in the interior of plates.

The vibration or shaking of the ground during an earthquake is described by ground motion. The severity of ground motion generally increases with the amount of energy released and decreases with distance from the fault or epicenter of the earthquake. Ground motion causes waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves. The following are the two kinds of seismic waves:

- P (primary) waves are longitudinal or compressional waves similar in character to sound waves that cause back-and-forth oscillation along the direction of travel (vertical motion), with particle motion in the same direction as wave travel. They move through the earth at approximately 15,000 mph.
- S (secondary) waves, also known as shear waves, are slower than P waves and cause structures to vibrate from side-to-side (horizontal motion) due to particle motion at right-angles to the direction of wave travel. Unreinforced buildings are more easily damaged by S waves.

There are also two kinds of surface waves, Raleigh waves and Love waves. These waves travel more slowly and typically are significantly less damaging than seismic waves.

Seismic activity is commonly described in terms of magnitude and intensity. Magnitude (M) describes the total energy released and intensity (I) subjectively describes the effects at a particular location. Although an earthquake has only one magnitude, its intensity varies by location. Magnitude is the measure of the amplitude of the seismic wave and is expressed by the Richter scale. The Richter scale is a logarithmic measurement, where an increase in the scale by one whole number represents a tenfold increase in measured amplitude of the earthquake. Intensity is a measure of how strong the shock is felt at a particular location, expressed by the Modified Mercalli Intensity (MMI) scale.

Another way of expressing an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. If an object is dropped while standing on the surface of the earth (ignoring wind resistance), it will fall towards earth and accelerate faster and faster until reaching terminal velocity. The acceleration due to gravity is often called "g" and is equal to 9.8 meters per second squared (980 cm/sec/sec). This means that every second something falls towards earth, it's velocity increases by 9.8 meters per second. Peak ground acceleration (PGA) measures the rate of change of motion relative to the rate of acceleration due to gravity. For example, acceleration of the ground surface of 244 cm/sec/sec equals a PGA of 25.0 percent.

It is possible to approximate the relationship between PGA, the Richter scale, and the MMI, as shown in Table 7-7. The relationships are, at best, approximate, and also depend upon such specifics as the distance from the epicenter and depth of the epicenter. An earthquake with 10.0 percent PGA would roughly correspond to an MMI intensity of V or VI, described as being felt by everyone, overturning unstable objects, or moving heavy furniture.

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Table 7-7: Earthquake PGA, Magnitude and Intensity Comparison			
PGA (%g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.
0.17 - 1.4	3.0 - 3.9	II - III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
1.4 - 9.2	4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rock noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
9.2 - 34	5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
34 - 124	6.0 - 6.9	VII - IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
>124	7.0 and higher	VIII or higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Wald, Quitoriano, Heaton, and Kanamori, 1999.

One of the secondary hazards from earthquakes is surface faulting, the differential movement of two sides of a fault at the earth's surface. Linear structures built across active surface faults, such as railways, highways, pipelines, and tunnels, are at high risk to damage from earthquakes. Displacement along faults, both in terms of length and width, varies but can be significant (e.g., up to 20 feet), as can the length of the surface rupture (e.g., up to 200 miles).

Earthquake-related ground failure, due to liquefaction, is another secondary hazard. Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Pore-water pressure may also increase sufficiently to cause the soil to behave like a fluid (rather than a soil) for a brief period and causing deformations. Liquefaction causes lateral spreads (horizontal movement commonly 10-15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to 12 miles), and loss of bearing strength (soil deformations causing structures to settle or tip).

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7.3.4.2 History

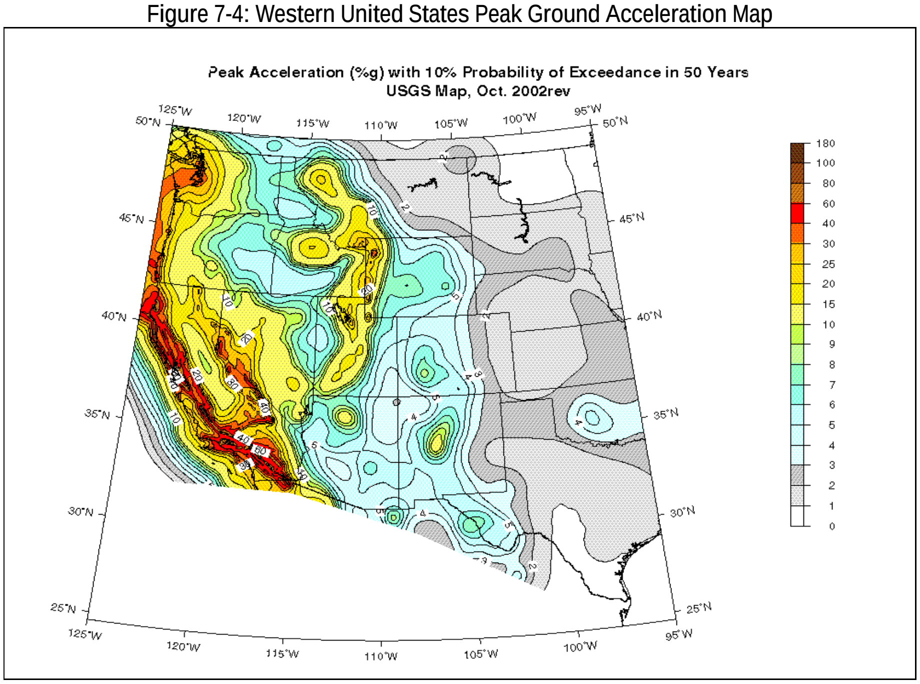
No federal or state emergency declarations pertaining to earthquake events have occurred in Maricopa County, as shown in Table 7-3, and only one earthquake event has been recorded in the county. On December 20, 1974, a MMI scale VI earthquake struck near Cave Creek. No fatalities, injuries, or damages were recorded in association with this event.

7.3.4.3 Probability and Magnitude

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps measure the probability of exceeding a certain ground motion, expressed as peak ground acceleration (PGA), over a specified period of years. For example, Figure 7-4 displays the probability of exceeding a certain ground motion, expressed as PGA, in 50 years in the Western United States. This is a common earthquake measurement that shows three things: the geographic area affected, all colored areas on the map; the probability of an earthquake of each level of severity, 10.0 percent chance in 50 years; and the severity, the PGA as indicated by color.

The Arizona Geological Survey (AZGS) has prepared a map displaying the intensity of historical earthquakes that have affected Maricopa County using the Modified Mercalli Intensity (MMI) scale, as shown in Figure 7-5. With intensity ranges defined through Table 7-7, Maricopa County demonstrates MMI scale levels of V in the vast majority of the County, progressing to less than V levels in the upper central-west region and finally demonstrating intensity levels of VI in the central-eastern portion of the County. In general, these MMI levels indicate earthquake damage in Maricopa County that would be expected to be comparatively minor.

Figure 7-4: Western United States Peak Ground Acceleration Map



Source: United States Geological Survey, April 2003

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Figure 7-5: Maximum Intensity Ground Shaking and Earthquake Damage, 1887-1999

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Note that this map expresses a 10.0 percent probability of exceedance and, therefore, there is a 90.0 percent chance that the peak ground acceleration displayed will not be exceeded during 50 years. The use of a 50-year period to characterize the percent chance of exceedance is arbitrary and does not imply the structures are thought to have a useful life of only 50 years. Similar maps exist for other measures of acceleration, probabilities, and time periods.

It is useful to note that, according to the USGS, a PGA of approximately 10.0 percent gravity is the approximate threshold of damage to older (pre-1965) dwellings or dwellings not made resistant to earthquakes. The 10 pg measure was chosen because, on average, it corresponds to the Modified Mercalli Intensities of VI to VII levels of threshold damage in California within 25 km of an earthquake epicenter. The earthquake hazard maps combine near and distant ground motions indiscriminately and should not be used for particular buildings (USGS, February 7, 2003).

Figure 7-6 provides a more detailed view of the PGA map for Unincorporated Maricopa County. In this map, the probability of exceedance has been reduced to 2.0 percent, while the period has been kept constant at 50 years. Most of Unincorporated Maricopa County has a PGA of about 4.0 to 5.0 percent gravity (pg), with the north portion and the far east portion of the County having a PGA of 7 pg. Additionally, the southwest section demonstrates PGA between 7 to 15 pg. The majority of the County presents values that are low in comparison with other counties within the State. As such, FEMA's Earthquakes Hazard Reduction Program has designated Arizona a "high risk" state for earthquakes due to other counties within the State having a propensity for a higher magnitude and frequency (Bausch and Brumbaugh, May 23, 1996).

In general the risk of seismic hazard in the greater metropolitan area of Maricopa County is generally low, with PGA zones of 4-5 pg in most of the metropolitan area. The southwestern corner of the county has elevated seismic risk where the PGA level increase up to 15 pg, although this region is largely uninhabited. As illustrated through Figure 7-6, Maricopa County demonstrates a range of peak ground acceleration zones of 4, 5, and 7 percent in the inhabited area of the County. The seismic risk to Unincorporated Maricopa County is elevated, however, due to the large and growing population, existence of some high rise buildings, predominance of unreinforced masonry buildings, and the lack of earthquake awareness among its population (Bausch and Brumbaugh, June 13, 1994).

The rate of seismicity in Unincorporated Maricopa County has historically been low, with the area's most recent quakes originating in Cave Creek in 1974 (M 2.5 and M 3.0). However, the area has been influenced by major quakes in southern California and northern Mexico, including the 1887 Sonoran quake (M 7.2) which caused ground shaking and triggered rock falls in the greater metropolitan area. The largest impact of an earthquake on the metropolitan area would be the economic impact from a catastrophic southern California earthquake, which would disrupt approximately 60.0 percent of Arizona's fuel and 90.0 percent of Arizona's food goods. The greater metropolitan area could also be significantly affected by a major quake in the Yuma or Northern Arizona Seismic Belt (NASB). A repeat of the 1887 earthquake would result in significant damage to Arizona's population centers, particularly where development is located on alluvial plains and steep slopes, which is the case in much of region. The Sugarloaf and Horseshoe faults are the nearest mapped potentially active faults, both approximately 40 miles northeast of the Phoenix area. A M 6.75 is the largest credible earthquake that could occur on these faults which would result in rock falls, dam failure, liquefaction, destructive resonance in reinforced concrete buildings three to four stories in height, and ground motion sufficient to cause damage in other structures (Bausch and Brumbaugh, June 13, 1994).

It should also be noted that although the small earthquakes that occur in Maricopa County are of low seismic risk to buildings, the repeated shaking could eventually cause structural damage. Small earthquakes may also trigger, in unstable areas, landslides and boulders rolling off mountain slopes (Jenny and Reynolds, 1989).

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Figure 7-6: Peak Acceleration Map

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7.3.4.4 Warning Time

Earthquake forecasts are similar to weather forecasts in that earthquake forecasts declare that a temblor of a specified magnitude has a certain probability of occurring within a given time, not that one will definitely strike. Because quakes tend to occur in clusters that strike the same area within a limited time period, scientists are able to make earthquake forecasts. The largest quake in a cluster is called the mainshock, those before it are called foreshocks, and those after it are called aftershocks (USGS, 1995).

Predicting earthquakes days in advance is not expected to be possible anytime soon. However, an early warning system that will alert southern California residents seconds before a temblor begins is under development. The system, Earthquake Alarm System (ElarmS), could use an existing system (TriNet) in southern California to issue a warning a few to tens of seconds ahead of damaging ground motion. Elarms use the frequency content of the P-wave arrival to determine earthquake magnitude, which allows magnitude estimation and could provide a warning tens of seconds before damaging ground motion occurs. This could be sufficient time for people to take cover beneath a table or shut off gas lines and water mains (Allen and Kanamori, May 5, 2003).

While advance prediction of earthquakes may not immediately be possible, there are three major networks in the U.S. to monitor earthquakes, each operated largely by the United States Geological Survey:

- The Advanced National Seismic System (ANSS) will be a nationwide network of at least 7,000 shaking measurement system on the ground and on buildings. The system will make it possible to provide emergency response personnel with real-time earthquake information, engineers with information about building and site response, and scientists with high-quality data to understand earthquakes (USGS, May 2000).
- The United States National Seismic Network (USNSN) provides uniform coverage of the U.S. and integrates data from its own stations and the more than 2,500 seismograph stations in regional networks of the United States. Regional networks provide information about earthquakes to the USGS National Earthquake Information Center (NEIC) in Colorado, which serves as a national point of contact for distributing earthquake information (USGS, March 14, 2003).
- The National Strong-Motion Program (NSMP) has the primary federal responsibility for recording damaging earthquakes in the United States on the ground and in man-made structures in densely urbanized areas in order to improve public earthquake safety. The program maintains a national cooperative instrumentation network, a national data center, and a supporting strong-motion data analyses and research center in support of this responsibility (USGS, November 14, 2002).

7.3.5 Extreme Heat

7.3.5.1 Nature

Extreme summer heat is the combination of very high temperatures and exceptionally humid conditions. If such conditions persist for an extended period of time, it is called a heat wave (FEMA, 1997). The National Weather Service Phoenix Weather Forecast Office, with the technical support of the University of Maryland, designed a science-based, customized, Extreme Heat derivation technique developed specifically for the metropolitan region. It is based upon the mortality rates in relation to air-mass temperature, humidity, sunshine, and the persistence of these elements. It has long been recognized by both health agencies and the National Weather Service that the "Heat Index" (HI) or similar "humidity indices" commonly used in the eastern 2/3rds of the nation are not an accurate model for the desert southwest. Arizona Department of Health Services is a partner with the National Weather Service Phoenix Weather Forecast Office in this program and has endorsed it since 2000.

The major human risks associated with extreme heat are as follows:

- Heatstroke: Considered a medical emergency, heatstroke is often fatal. It occurs when the body's responses to heat stress are insufficient to prevent a substantial rise in the body's core temperature. While no standard diagnosis exists, a medical heatstroke condition is usually diagnosed when the body's

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temperature exceeds 105°F due to environmental temperatures. Rapid cooling is necessary to prevent death, with an average fatality rate of 15 percent even with treatment.

- Heat Exhaustion: While much less serious than heatstroke, heat exhaustion victims may complain of dizziness, weakness, or fatigue. Body temperatures may be normal or slightly to moderately elevated. The prognosis is usually good with fluid treatment.
- Heat Syncope: This refers to sudden loss of consciousness and is typically associated with people exercising who are not acclimated to warm temperatures. Causes little or no harm to the individual.
- Heat Cramps: May occur in people unaccustomed to exercising in the heat and generally ceases to be a problem after acclimatization.

In addition to affecting people, severe heat places significant stress on plants and animals. The effects of severe heat on agricultural products, such as cotton, may include reduced yields and even loss of crops (Brown and Zeiher, 1997). Similarly, cows may become overheated, leading to reduced milk production and other problems. (Garcia, September 2002).

7.3.5.2 History

Extreme summer heat occurs with some regularity in the U.S. and in other countries. Major historic events have included the following:

- In 1980, summer temperatures reached all time highs in Central and Southern States, with over 1,700 deaths identified as heat related (FEMA, 1997).
- In July and August 2003, a heat wave across Europe caused thousands of deaths, including at least 11,000 in France alone. Again, a high proportion of the victims were elderly (Brock, September 14, 2003).

While summer temperatures in Maricopa County regularly reach levels that would be considered extreme in many parts of the country, a total of only 10 extreme heat events affecting Maricopa County were identified, as shown in Table 7-3, none of which resulted in a disaster/emergency declaration. No fatalities, injuries, or damages for specific events were recorded, although Maricopa County has on average 24 deaths annually from heat related illnesses (Timothy J. Flood, M.D., Arizona Department of Health Services Bureau of Public Health Statistics average taken from 1998-2002). The record high temperature in the area was set on June 26, 1990 at Sky Harbor Airport, which reached 122°F, forcing closure of the airport for several hours. Triple digit temperatures (100+°F) are regularly experienced in Maricopa County and have been recorded in the months of March to October, as shown in Figure 7-8. While the record temperature in the area was recorded at 122°F, apparent temperatures of 115-120 are also common in the region.

Over the past two decades, as the metropolitan area has grown dramatically in size, the "urban heat island" effect has developed, which has caused temperatures in the center of the metropolitan area to become much warmer than those on the outskirts of the valley. The concrete and asphalt of the greater metropolitan area retains the heat of the day, and releases it slowly as compared to the surrounding desert terrain, which cools much quicker at night. The ASOS weather sensor has always been located near the Sky Harbor runway complex, and as the heat island effect intensifies, the nighttime lows keep rising every year. The summer of 2003 saw the all time record high minimum temperature (93 degrees) shattered as a new mark of 96 degrees was established. Several times during the summer the old mark of 93 was tied or broken, as well.

The thermal imagery map of the greater metropolitan area, Figure 7-7, indicates the hottest temperatures in urbanized Maricopa County occur at the Sky Harbor Airport runway complex, clearly shown by the bright yellow colors at the top center of map. The most significant concentration of asphalt in the metropolitan area occurs at the runway complex, and shown by the yellow stripes in the IR imagery, which correspond to the east-west runways at Sky Harbor. With the weather sensor located very close to this location, it is clear why the area has been seeing increasingly warm mornings over the past decade. As time goes by, it is possible that this region will see a morning where the temperature never drops below 100 degrees.

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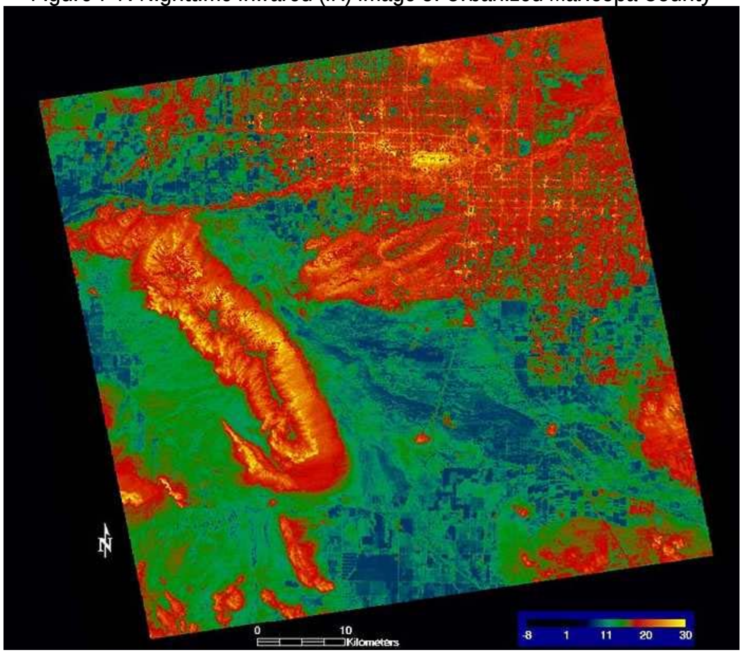
Figure 7-7: Nighttime Infrared (IR) Image of Urbanized Maricopa County



(NWS Forecast Office, Phoenix and Arizona Weather History, image provided by http://www.wrh.noaa.gov/Phoenix/general/history/ASU Geological Remote Sensing Laboratory)

7.3.5.3 Probability and Magnitude

The probability and frequency of heat hazards may be characterized by a heat index using temperature and humidity readings. Such an index has been developed for the entire U.S., and Unincorporated Maricopa County portion is shown in Figure 7-8. The map was prepared using hourly readings between 2 PM and 5 PM for June, July, and August (based on the assumption that the annual maximum temperature and relative humidity occurs during summer afternoons). The data was used to conduct a frequency analysis from which the heat index map was prepared (with a 5.0 percent chance of exceedance in any given year). As illustrated through this figure, most of Maricopa County has a very high probability of reaching temperatures that are classified as dangerous or even extremely dangerous.

7.3.5.4 Warning Time

It is a well-known fact that Maricopa County, including Unincorporated Maricopa County, regularly experiences months of high summer temperatures and relatively high humidity levels (caused largely by the late summer monsoons). As a result, extreme summer temperatures are hardly surprising and the warning time could be considered on the order of months.

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories). The fact that unusual and potentially deadly hot weather events occur in Maricopa County led to the launch of a heat warning service in 2001. The service is a joint effort by the National Weather Service (NWS), Arizona Department of Health Services (ADHS), Salt River Project (SRP), and Arizona Department of Commerce (ADOC). The service will warn the public of danger up to 2 ½ days in advance via press releases and will remind people to take precautions to prevent heat-related illnesses (Arizona Department of Health Services, June 18, 2001).

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Figure 7-8: Summer Heat Severity

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7.3.6 Flood

7.3.6.1 Nature

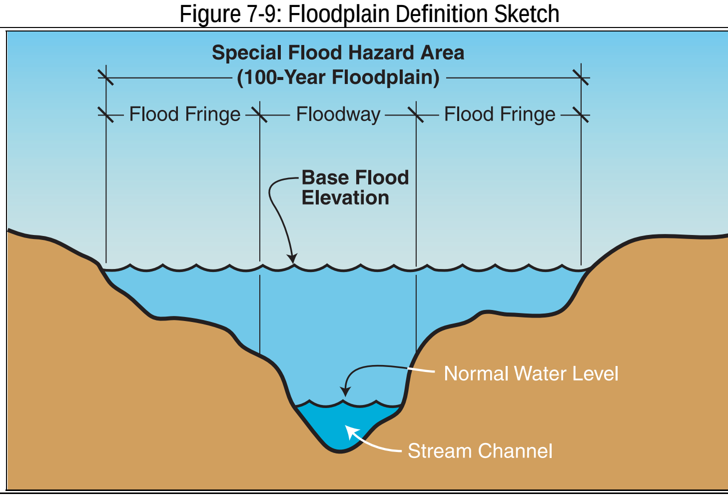
Flooding is the accumulation of water where there usually isn't any or the overflow of excess water from a stream, river, lake, reservoir, etc. onto adjacent floodplains. As illustrated in Figure 7-9, floodplains are lowlands, adjacent to water bodies that are subject to recurring floods. Floods are natural events that are considered hazards only when people and property are affected. Nationwide, hundreds of floods occur each year, making it one of the most common hazards in all 50 states and U.S. territories (FEMA, 1997).

There are a number of categories of floods in the U.S., including the following:

- Riverine flooding, including overflow from a river channel, flash floods, alluvial fan floods, ice-jam floods, and dam break floods
- Local drainage or high groundwater levels
- Fluctuating lake levels
- Coastal flooding, including storm surges
- Debris flows
- Subsidence

The most common type of flooding event is riverine flooding, also known as overbank flooding. Riverine floodplains range from narrow, confined channels in the steep valleys of mountainous and hilly regions, to wide, flat areas in plains and coastal regions. The amount of water in the floodplain is a function of the size and topography of the contributing watershed, the regional and local climate, and land use characteristics. In steep valleys, flooding is usually rapid and deep, but of short duration, while flooding in flat areas is typically slow, relatively shallow, and may last for long periods of time.

Figure 7-9: Floodplain Definition Sketch



Source: FEMA, August 2001.

The cause of flooding in large rivers is typically prolonged periods of rainfall from weather systems covering large areas (e.g., tropical storms). These systems may saturate the ground and overload the rivers and reservoirs in numerous smaller basins that drain into larger rivers. Localized weather systems (e.g., thunderstorms), may cause intense rainfall over smaller areas, leading to flooding in smaller rivers and streams. Annual spring floods, due to the melting of snowpack, may affect both large and small rivers and areas.

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While there is no sharp distinction between riverine floods, flash floods, alluvial fan floods, ice jam floods, and dam-break floods, these types of floods are widely recognized and may be helpful in considering the range of flood risk and appropriate responses:

- Flash flood is a term in wide use by experts and the general population, but there is no single definition or clear means of distinguishing flash floods from other riverine floods. Flash floods involve a rapid rise in water level, high velocity, and large amounts of debris, which can lead to significant damage that includes the tearing out of trees, undermining of buildings and bridges, and scouring new channels. The intensity of flash flooding is a function of the intensity and duration of rainfall, steepness of the watershed, stream gradients, watershed vegetation, natural and artificial flood storage areas, and configuration of the streambed and floodplain. Dam failure and ice jams may also lead to flash flooding. Urban areas are increasingly subject to flash flooding due to the removal of vegetation, covering of ground cover with impermeable surfaces, and construction of drainage systems. Flash floods are a significant hazard in Arizona.
- As indicated by the name, alluvial fan floods occur in the deposits of rock and soil that have eroded from mountainsides and accumulated on valley floors in the pattern of a fan. Alluvial fan floods often cause greater damage than straightforward riverine flooding due to the high velocity of the flow, amount of debris, and broad area affected. Alluvial fan flooding is most prevalent in arid western states, such as Arizona. Human activities may exacerbate flooding and erosion on alluvial fans via increased velocity along roadway acting as temporary drainage channels or changes to natural drainage channels from fill, grading, and structures. Alluvial fan floods are a significant hazard in Arizona, particularly in urbanized areas. Floods on alluvial fans are dangerous because they are unpredictable. Channels may migrate quickly, for example, and the water flow often travels at high velocity–much higher than usually found in rivers or streams. This velocity is usually much more of a problem than the depth of the flow. Such action on alluvial fans is often characterized as “sheet flow” because of the high speed and shallow depth. In contrast to other flood hazards (i.e. riverine situations), FEMA puts an average velocity on the Flood Insurance Rate Map (FIRM) when mapping an alluvial fan to draw attention to the additional hazard posed by velocity.
- Ice jam floods are primarily a function of the weather and are most likely to occur where the channel slope naturally decreases, culverts freeze solid, reservoir headwaters, natural channel constructions (e.g., bends and bridges), and along shallows. Ice jam floods are not considered a significant hazard in Arizona.

Dam break floods may occur due to structural failures (e.g., progressive erosion), overtopping or breach from flooding, or earthquakes. Dam breaks or failures are examined in detail in Section 7.3.1. The risk from dam failures is a significant hazard in Maricopa County.

Local drainage floods may occur outside of recognized drainage channels or delineated floodplains due to a combination of locally heavy precipitation, a lack of infiltration, inadequate facilities for drainage and stormwater conveyance, and increased surface runoff. Such events frequently occur in flat areas, particularly during winter and spring in areas with frozen ground, and also in urbanized areas with large impermeable surfaces. High groundwater flooding is a seasonal occurrence in some areas, but may occur in other areas after prolonged periods of above-average precipitation. Losses associated with local drainage are most significant when they occur with other hazards described in this document, such as widespread flooding and thunderstorms; therefore, they are not analyzed as a distinct hazard.

Many urban areas that have historically been flood prone have been removed from the floodplain through the application of three construction types: (1) flood control dams, which reduce peak discharges, (2) levees, and (3) open-channel projects, of which the last two redirect flood waters away from areas that would otherwise be inundated. Much of the metropolitan area, for example, is protected by these systems.

7.3.6.2 History

Floods occur in all 50 US states and territories, with an estimated 4 percent of the total area of the United States subject to the 1-percent annual chance floodplain. An estimated nine million US households and $390 billion in property are at risk within the 1-percent annual chance floodplain. Nationwide damage from flooding has increased

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from $902 billion annually during the period 1916-1950 to $2.15 billion annually, an increase of almost two-and-a-half times. The worst flood disaster in US history was caused by a series of storms from April to September of 1993 in the Upper Mississippi Basin. Nationwide there were 38 to 47 flood-related deaths and damage was estimated at $12 to $16 billion, including $4 to $5 billion in agricultural losses (FEMA, 1997).

Flash floods are the top weather-related killer in the United States, resulting in about 150 deaths every year. Most, if not all, of these fatalities could have been avoided if those involved would have recognized the dangers of flash floods and taken a few simple actions to protect themselves (National Weather Service, Flagstaff).

As shown in Table 7-3, Maricopa County has experienced 10 flooding incidents of sufficient magnitude to prompt Presidential or Gubernatorial disaster declarations, which is second only to drought in the number of declarations that have been made for Maricopa County. In addition, there were 25 undeclared significant flood events. The combined flood total of 35 declared flood and undeclared events are reported to have killed 21 persons and injured 116. Furthermore, these events are reported to have caused nearly $1.3 billion dollars in damages, by far the most of any hazard in Maricopa County. No part of the county is free from the threat of flooding, as shown in Figure 7-10. A close correlation is evident between the locations of significant floods and urbanized areas of the county.

Flooding is clearly a major hazard in the region, where the following three seasonal atmospheric conditions tend to trigger flooding events:

- Tropical Storm Remnants: The worst flooding tends to occur when the remnants of a tropical storm enter the state. These events occur infrequently (i.e. every ten ears or so), mostly in the early autumn, but when they do occur the storms bring intense precipitation over large regions causing severe flooding
- Winter Rains: Winter brings the threat of low intensity; but long duration rains covering large areas that cause extensive flooding and erosion, particularly when combined with snowmelt.
- Summer Monsoons: A third atmospheric condition that brings flooding to Maricopa County is the annual summer monsoon. In mid to late summer the monsoon winds bring humid subtropical air into the state. Solar heating triggers afternoon thunderstorms that can be devastating. As a result of too much rain, in too small an area, in too short a time, flash flooding may result.

Maricopa County has been subject to multiple examples of each of the above flood types. The following are a few representative examples:

- The summer of 1990 brought some of the worst and most extensive flooding experienced in Maricopa County, due primarily to a series of flash flooding events. Between July 8 and 24, 1990, Arizona experienced a series of severe thunderstorms caused by an unusually strong monsoon season that exceeded annual and individual storm event average, resulting in heavy rain, high winds, flash flooding and damage. On July 27, 1990, Governor Rose Mofford declared a state of emergency. Sky Harbor International Airport in Phoenix reported over seven inches of rain by the end of the monsoon season, more than two inches above average. Other reporting stations experienced even greater precipitation amounts, sometimes falling in extreme bursts.
- During January and February 1993, winter rain flooding damage occurred from winter storms associated with the El Nino phenomenon. These storms flooded watersheds throughout Arizona by dumping excessive rainfall amounts that saturated soils and increased runoff. Warm temperature snowmelt exacerbated the situation over large areas. Erosion caused tremendous damage and some communities, along normally dry washes, were devastated. Stream flow discharges and runoff volumes exceeded historic highs. Many flood prevention channels and retention reservoirs were filled to capacity, so water was diverted to the emergency spillways or the reservoirs were breached, causing extensive damage in some cases (e.g., Painted Rock Reservoir spillway). Ultimately, the President declared a major federal disaster that freed federal funds for both public and private property losses statewide. Damages were widespread and significant, impacting over 100 communities. Total public and private damages exceeded $400 million, and eight deaths and 112 injuries were reported to the Red Cross (FEMA, April 1, 1993; ADEM, March, 1998).

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Figure 7-10: Significant Floods

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It is also important to note that in addition to affecting people, floods may severely affect livestock and pets. Such events may require the emergency watering/feeding, shelter, evacuation, and a possible increase in event-caused deaths and burying of animals, such as during the floods in Maricopa County in the 1980's (Lanman, May 27, 2003).

A measure of the seriousness and location of floods in Maricopa County is the number of National Flood Insurance Program (NFIP) losses and payments. During the period 1978 to 2002, there were 1,750 losses and nearly $9.0 million in payments in the county. As shown in Table 7-8, Unincorporated Maricopa County had losses and payments of 267 for a total of $ 1,818,893.98 in payments.

In 1968, Congress created the NFIP in response to the rising cost of taxpayer funded disaster relief for flood victims and the increasing amount of damage caused by floods. The Mitigation Division, a component of the Federal Emergency Management Agency (FEMA) manages the NFIP, and oversees the floodplain management and mapping components of the Program.

Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities.

The NFIP Community Rating System (CRS) was implemented in 1990 as a program to recognize and encourage community floodplain management activities that exceed minimum NFIP standards. The National Flood Insurance Reform Act of 1994 codified the CRS in the NFIP. Under the CRS, flood insurance premium rates are adjusted to reflect the reduced flood risk resulting from community activities that meet the three goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote the awareness of flood insurance.

Table 7-8: National Flood Insurance Program (NFIP) Loss Statistics, 1978-2002

Jurisdiction	Losses	Payments
Unincorporated Maricopa County	267	1,818,893.98
Maricopa County Total	1,750	$8,877,559.13

Source: FEMA, May 16, 2003; URS, October 2003.

Nationally, flood damage is reduced by nearly $1 billion a year through partnerships with NFIP and CRS communities, the insurance industry, and the lending industry. Buildings constructed in compliance with NFIP building standards also suffer approximately 80 percent less damage annually than those not built in compliance. Further, every $3 paid in flood insurance claims saves $1 in disaster assistance payments.

The NFIP is self-supporting for the average historical loss year, which means that operating expenses and flood insurance claims are not paid for by the taxpayer, but through premiums collected for flood insurance policies. The Program has borrowing authority from the U.S. Treasury for times when losses were heavy, however, these loans have been paid back with interest.

To obtain secured financing to buy, build, or improve structures in Special Flood Hazard Areas (SFHAs), flood insurance must be purchased. Lending institutions that are federally regulated or federally insured must determine if the structure is located in a SFHA and must provide written notice requiring flood insurance.

Flood insurance is available to any property owner located in a community participating in the NFIP. All areas are susceptible to flooding, although to varying degrees. In fact, 25 percent of all flood claims occur in low-to-moderate risk areas. (FEMA, 2003)

Currently, 15,771 eligible homeowners in Maricopa County have taken advantage of the NFIP program, as shown through Table 7-9. Within this region Unincorporated Maricopa County included 1,464 homeowners who purchased NFIP insurance. It should be noted that only a minority of property owners in floodplains actually purchase flood insurance, therefore the actual financial loss experienced locally is probably much greater than indicated here.

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Table 7-9: National Flood Insurance Program (NFIP) Policy Holders, 2002	
Jurisdiction	Policies In Force
Unincorporated Maricopa County	1,464
Maricopa County Total	15,771

Source: FEMA, May 16, 2003; URS, December 2003.

According to FEMA records, there were 120 identified Repetitive Loss (RL) properties in Maricopa County, with a total of $3.9 million in associated total payments (building and contents value), as shown in Table 7-10 and displayed by location in Figure 7-11. Unincorporated Maricopa County represents a large proportion of the county with 27 repetitive loss properties and $865,080.00 in total payments.

Table 7-10: Flood Repetitive Losses			
Jurisdiction	No. of Properties	Losses	Payments
Unincorporated Maricopa County	27	60	$865,080.00
Maricopa County Total	120	354	$3,919,901.05

Source: FEMA, May 7, 2003; URS, October 2003.

7.3.6.3 Probability and Magnitude

Floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and the related probability of occurrence. Flood studies use historical records to determine the probability of occurrence for different extents of flooding. The probability of occurrence is expressed in percentages as the chance of a flood of a specific magnitude occurring in any given year.

The most widely adopted design and regulatory standard for floods in the United States is the 1-percent annual chance flood and this is the standard formally adopted by FEMA. The 1-percent annual flood, also known as the base flood, has a 1 percent chance of occurring in any particular year. It is also often referred to as the "100-year flood" since its probability of occurrence suggests it should only reoccur once every 100 years (although this is not the case in practice). Experiencing a 100-year flood does not mean a similar flood cannot happen for the next 99 years; rather it reflects the probability that over a long period of time, a flood of that magnitude should only occur in 1 percent of all years.

Smaller floods occur more often than larger (deeper and more widespread) floods. Thus, a "10-year" flood has a greater likelihood of occurring than a "100-year" flood. Table 7-11 shows a range of flood recurrence intervals and their probabilities of occurrence.

Table 7-11: Flood Probability Terms	
Flood Recurrence Intervals	Percent Chance of Occurrence Annually
10 year	10.0%
50 year	2.0%
100 year	1.0%
500 year	0.2%

Source: FEMA, August 2001.

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Figure 7-11: Repetitive Loss Properties

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Figure 7-12 displays the 100-Year 24-hour Probable Maximum Precipitation (PMP) in Unincorporated Maricopa County. Note that this map displays an event with a 1 percent chance of being exceeded in any year, not an event that is expected to occur once every 100 years. The map was developed using multiple methods, including judgments based on record storms and related meteorological processes, with the results of the studies considered estimates because changes are likely to occur as understanding increases. The studies assumed that storm records for the preceding 80 years were representative and no allowance was made for climate change.

Figure 7-13 highlights the known 100-year flood plain areas within most of Unincorporated Maricopa County as determined by FEMA. The total area within the 100-year floodplain is shown by jurisdiction in Table 7-12, as well as the amount within urban boundaries. As illustrated through these figures, Unincorporated Maricopa County contains 361 square miles of identified floodplains. This figure represents 4.9% of the 7,358 total square miles that comprise Unincorporated Maricopa County. Many of the floodprone areas within the County are associated with the Salt River, the Agua Fria River, New River, Verde River, Centennial Wash, Cave Creek, Gila River and the Hassayampa River (the greatest impact being the Salt River which flows into the Gila River through the center of the County.) Other floodplains in Unincorporated Maricopa County are also created through roads and canals that interrupt the natural flow of the water coming out of the east. Ponding along these structures is the result of the interruption of this natural flow.

Table 7-12: 100-Year Floodplains

Jurisdiction	Total Area in Square Miles	Area Within 100-Year Floodplain	
		Total	
		Sq. Mi.	Percent
Unincorporated Maricopa County	7,358	361	4.9%
Total Maricopa County	9,222	518.48	8.1%

Note: Floods may still occur outside of identified flood prone areas.

Source: FEMA, April 22, 2003; URS, October, 2003.

In the desert basins of central and southern Arizona, runoff channels are not well defined. Additionally, the Flood Control District of Maricopa County has approximately 6,000 to 8,000 linear miles of watercourses that have yet to be mapped. Because of these topographic phenomena the probability of floods occurring in Maricopa County unincorporated communities is relatively high. Contributing to this dispersion type is an urbanization and sprawl pattern that has spread development onto the washes and sediment piedmonts. In addition, runoff from thunderstorms can quickly overtop a wash, thereby flooding adjacent areas (FEMA, January 1991; DEMA, March 1998).

By contrast to its northern Arizona counterparts, Maricopa County communities are susceptible to the hazards of heavy rains due to differences in topography, vegetation, and urbanization. However, heavy rainfall occurrences accompanying tropical storms and other severe storms can quickly inundate areas statewide, causing flooding. Frequently, low-intensity, long-duration rains cover large areas of Maricopa County, particularly in the winter. When combined with snowmelt, heavy winter rains may also cause extensive flooding and erosion (National Weather Service – Phoenix, May 11, 2003).

Temperatures in the Western U.S. rose 2-5°F during the 20th century. This increase was accompanied by precipitation increases of up to 50 percent in some areas of the West, although some places (including Maricopa County) become drier and experience more droughts. The two major climate change models, the Canadian Model and the Hadley Model, both forecast continued temperature increases in the West of 5-11°F during the 21st century, including Arizona. Both models also forecast significant increases in rainfall in much of the West, with the increase on the order of 75-100 percent across much of Arizona. These increases may lead to amplified water supplies, although current reservoir systems may be inadequate to control earlier spring runoff and to maintain supplies for the summer (National Assessment Synthesis Team, May 2001). Simply stated, such increases in precipitation could lead to increased flooding in Maricopa County and elsewhere in the West.

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Figure 7-12: 100-Year 24-Hour Probable Maximum Precipitation

Figure 7-13: 100-Year Flood Hazard Zones

7.3.6.4 Warning Time

Unfortunately, there is no universal answer for every rainfall event. Flood warning times vary based on storm location, direction, intensity, duration, and the topography and size of the drainage area. Depending upon the type of flooding event and the location, the warning time available for a flood can vary from seconds to days. A flash flood or dam break, for example, can cause flooding within minutes, while a tropical storm may precede flooding by days.

Before severe weather watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Often, forecasters begin issuing severe weather statements, advisories, or bulletins on hurricanes and winter storms three or four days before the storm hits. However, forecasters cannot issue alerts for the danger of severe thunderstorms, tornadoes and flash floods that far in advance. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Maricopa County originate from NWS offices in Tucson, Phoenix, Flagstaff, or Las Vegas, Nevada.

A flood watch is issued by the National Weather Service (NWS) to inform the public and cooperating agencies that current and developing weather is such that there is a threat of rapid flooding (e.g., flash flooding). The occurrence of flooding is, however, neither certain nor imminent. Persons in the watch area are advised to check flood action plans, keep informed, and be ready to take necessary actions if a warning is issued or flooding is observed. A flood watch may also be issued for a dam break. Flood watches are issued as needed to inform the public of conditions that may cause flooding in the next one to two days. A flood watch indicates that there is threat of flooding, but the occurrence is neither certain nor imminent. Flood watches may cover large geographic areas and will be updated with flood statements.

A flood watch is issued if the following conditions occur during the first 48 hours of the forecast period:

- Meteorological, soil, and/or hydrologic conditions indicate a flood is possible but not certain
- The geographical area covered by a pre-existing flood watch increases or decreases
- A dam or levee may fail threatening lives or property, but the threat is not deemed imminent

The flood watch notification will contain:

- The counties or geographical area covered by the watch (this should be described in terms of well-known river basins, counties, or portions of states)
- The effective time of the watch expressed in terms of hours or in general terms, such as this evening
- The extent of the hazardous condition expected, i.e., localized or widespread
- The severity of the hazardous condition expected when this can be done with sufficient degree of confidence
- Call to action statements

A flood warning is a statement issued by the NWS that flash flooding has occurred or is imminent. A flood warning is issued as needed when flooding is expected to threaten life and property within 6 hours of the onset of heavy rain, ice jams, reservoir releases or excessive snow melt. Flood warnings may be in effect for days or even weeks depending on weather and soil conditions, land topography, and the size of the river basin. Updated information will be issued in flood statements. Flood warnings will be re-issued if the river forecast changes significantly.

For communities in Maricopa County, where roughly 60 percent of the State's population resides, warning times for floods depend on the size of the wash, stream, or river. The times can vary from minutes for small washes to days for the larger streams and rivers, and are issued by the NWS in coordination with the United States Army Corps of Engineers (USACE), Bureau of Reclamation (BOR), and other applicable agencies, as well as the Salt River Project, which manages many of the dams, canals, and levees that affect all of Maricopa County.

For the communities in the region the Flood Control District of Maricopa County operates a flood threat recognition system called ALERT (Automated Local Evaluation in Real Time). This data is collected by rain and stream gauges. Currently, the system has nearly 282 stream and rain gauges throughout the County and in neighboring areas. The

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gauge data is sent by radio waves back to the base station at the District. District staff is able to relay the gauge readings to the NWS, Maricopa County Department of Emergency Management, and local dam operators. These agencies use this information to issue the appropriate warnings and, if necessary, prepare for evacuations.

The Maricopa County Department of Emergency Management (MCDEM) maintains emergency call lists of properties in certain locations that have experienced repeated flooding in the past. Residents on these call lists are notified when streamflow or rainfall gauges upstream of their location indicate that flooding is imminent.

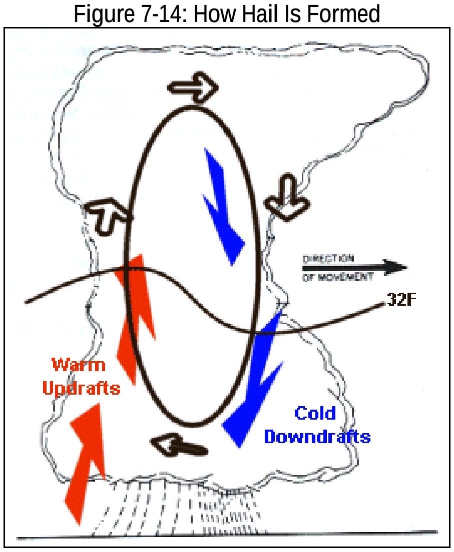
7.3.7 Hail

7.3.7.1 Nature

Hail is an outgrowth of severe thunderstorms and develops within a low-pressure front as warm air rises rapidly in to the upper atmosphere and is subsequently cooled, as shown in Figure 7-14, leading to the formation of ice crystals. These are bounced about by high velocity updraft winds and accumulate into frozen droplets, falling as precipitation after developing enough weight (FEMA, 1997).

The size of hailstones varies and is a direct consequence of the severity and size of the thunderstorm. The higher the temperatures at the Earth's surface, the greater the strength of the updrafts, and the greater the amount of time the hailstones are suspended, the larger the size of the hailstones. Hailstones vary widely in size, as shown in Table 7-13. Note that hail penny size (3/4 inches in diameter) or larger is considered severe.

Figure 7-14: How Hail Is Formed



Source: NWS, January 10, 2003

The National Weather Service (NWS) defines severe thunderstorms as those with downdraft winds in excess of 58 miles an hour and/or hail 3/4 inches in diameter or greater. While only about 10 percent of thunderstorms are classified as severe, all thunderstorms are dangerous because they produce numerous dangerous conditions, including one or more of the following: hail, strong winds, lightning, tornadoes, and flash flooding (National Weather Service – Flagstaff).

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Table 7-13: Estimating Hail Size	
Size	Inches in Diameter
Pea	1/4 inch
Marble/mothball	1/2 inch
Dime/Penny	3/4 inch
Nickel	7/8 inch
Quarter	1 inch
Ping-Pong Ball	1 1/2 inch
Golf Ball	1 3/4 inches
Tennis Ball	2 1/2 inches
Baseball	2 3/4 inches
Tea cup	3 inches
Grapefruit	4 inches
Softball	4 1/2 inches

Source: NWS, January 10, 2003.

Hailstorms occur most frequently during the late spring and early summer, when the jet stream moves northward across the Great Plains. During this period, extreme temperature changes occur from the surface up to the jet stream, resulting in the strong updrafts required for hail formation.

7.3.7.2 History

Hail causes $1 billion in damage to crops and property each year in the United States. The costliest hailstorm in the United States was in Denver in July 1990 with reported damage of $625 million. The largest hailstone ever recorded, which fell in Coffeyville, Kansas on September 3, 1970, measured over 5.6 inches in diameter and weighed almost 2 pounds (NWS, January 10, 2003).

Four significant hail events have occurred in Maricopa County, as shown in Table 7-3. None of these events prompted a disaster declaration, although 3 injuries were recorded and roughly $500,000 in damage, most of which was caused by one event that affected the central and northwest portions of the metropolitan area. Specifically, on October 7, 2002, there were numerous reports of large hail throughout the West Valley, including Sun City, Peoria, and Phoenix. Winds reached over 60 mph, damaged homes, blew down power poles, and uprooted trees. Streets were also flooded in the West Valley as rain totals were as much as 1.85 inches. Arizona Public Service and Salt River Project estimated over 11,000 customers were without power. The storm caused an estimated $200,000 in property damage (NCDC, Storm Event Database, January 2003).

Based on past occurrences, Maricopa County is far more likely to receive hailstorms with hailstones less than 2 inches in diameter. Table 7-14 also displays the average number of days with thunderstorms and average number of days with hail in Maricopa County by month between 1896 and 1995. Based on these data, Maricopa County is far more likely to receive thunderstorms in July and August when compared to the other months of the year. Despite the predominance of thunderstorms during the monsoon months of July, August, and September, however, thunderstorms with hail are less likely to occur during this portion of the year.

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Table 7-14: Average Number Of Days With Thunderstorms And Average Number Of Days With Hail In Maricopa County By Month (1896-1995)												
	J	F	M	A	M	J	J	A	S	O	N	D
Thunderstorms	.03	.07	.09	.09	1.1	1.2	6.6	7.9	3.5	1.2	.06	.04
Thunderstorms w/Hail	.01	.02	.02	.01	.01	*	*	*	.01	.01	*	.01
* Denotes a frequency of less than .05												

Source: NWS

7.3.7.3 Probability and Magnitude

Figure 7-15 and Table 7-14 illustrate the frequency of hailstorms in Maricopa County. Note that the map originally dates from 1991, with no more recent frequency map available. Most hail in Maricopa County is less than 2 inches in diameter, however the NWS does not typically report hailstone sizes of less than 0.75" in diameter. Despite this, it has been noted that between 1996 and 2003 Maricopa County averaged 4.75 hailstorm events per year with hailstones $\geq$ 0.75 inches in diameter. Severe thunderstorms can occur in any month of the year, but the months of July, August and September account for most of the severe thunderstorm occurrences (National Weather Service – Flagstaff). The real extent and severity of hailstorms is somewhat similar to that for maximum thunderstorm and tornado activity. Severe thunderstorms are likely to generate concurrent effects, such as severe winds, tornadoes, and hail.

7.3.7.4 Warning Time

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories).

Hail is a consequence of severe thunderstorms. The NWS issues a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms. The local NWS office considers a thunderstorm severe if it produces hail at least 3/4-inch in diameter and/or winds of 58 mph or higher. When a watch is issued for a region, residents are encouraged to continue normal activities but should remain alert for signs of approaching storms, and continue to listen for weather forecasts and statements from the local NWS office. When a severe thunderstorm has been detected by weather radar or one has been reported by trained storm spotters, the local NWS office will issue a severe thunderstorm warning. A severe thunderstorm warning is an urgent message to the affected counties that a severe thunderstorm is imminent. The warning time provided by a severe thunderstorm watch may be on the order of hours, while a severe thunderstorm warning typically provides warning time in the range of an hour or less.

Unfortunately, there is no universal answer for every storm event. Warning times vary based on storm location, direction, intensity, duration, and the topography and size of the drainage area. Before watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Often, forecasters begin issuing severe weather statements, advisories, or bulletins on hurricanes and winter storms three or four days before the storm hits. However, forecasters cannot issue alerts for the danger of severe thunderstorms, tornadoes and flash floods that far ahead. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Arizona originate from NWS offices in Tucson, Phoenix, Flagstaff, and Las Vegas, Nevada.

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Figure 7-15: Annual Frequency of Hailstorms

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7.3.8 Hazardous Material (HAZMAT) Event

7.3.8.1 Nature

Hazardous materials (HAZMAT) may include hundreds of substances that pose a significant risk to humans. These substances may be highly toxic, reactive, corrosive, flammable, radioactive or infectious. They are present in nearly every community in the U.S., where they may be manufactured, used, stored, transported, or disposed. Because of their nearly ubiquitous presence, there are hundreds of HAZMAT release events annually in the U.S. that contaminate air, soil, and groundwater resources, potentially triggering millions of dollars in clean-up costs, human and wildlife injuries, and occasionally cause human deaths (FEMA, 1997).

Hazardous material releases may occur from any of the following:

- Fixed site facilities (e.g., refineries, chemical plants, storage facilities, manufacturing, warehouses, wastewater treatment plants, swimming pools, dry cleaners, automotive sales/repair, gas stations)
- Highway and rail transportation (e.g., tanker trucks, chemical trucks, railroad tankers)
- Marine transportation (e.g., bulk liquefied gas carriers, oil tankers, tank barges)
- Air transportation (e.g., cargo packages)
- Pipeline transportation (liquid petroleum, natural gas, other chemicals)

In response to concerns over the environmental and safety hazards posed by the storage and handling of toxic chemicals in the U.S., Congress passed Emergency Planning and Community Right to Know Act (EPCRA) in 1986. These concerns were triggered by the 1984 disaster in Bhopal, India, in which more than 2,000 people died or were seriously injured from the accidental release of methyl isocyanate from an American owned Union Carbide plant. To reduce the likelihood of such a disaster in the U.S., EPCRA established specific requirements on federal, state and local governments, Indian tribes, and industry to plan for hazardous materials emergencies.

EPCRA's Community Right-to-Know provisions help increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities working with facilities can use the information to improve chemical safety and protect public health and the environment (EPA, May 2003). Under EPCRA, hazardous materials must be reported to the Environmental Protection Agency (EPA), even if they do not result in human exposure. Such releases may include the following:

- Air emissions (e.g., pressure relief valves, smokestacks, broken pipes, water or ground emissions with vapors)
- Discharges into bodies of water (e.g., outflows to sewers, spills on land, water runoff, contaminated groundwater)
- Discharges onto land
- Solid waste disposals in onsite landfills
- Transfer of wastewater to public sewage plants
- Transfers of waste to offsite facilities for treatment or storage

In addition to accidental human-caused hazardous material events, such as an unintended release from a pressure valve or a transportation accident, natural hazards may cause the release of hazardous materials and complicate response activities. The impact of earthquakes on fixed facilities may be particularly bad due to the impairment of the physical integrity or even failure of containment facilities. The threat of any hazardous material event may be magnified due to restricted access, reduced fire suppression and spill containment, and even complete cut-off of response personnel and equipment. In addition, the risk of terrorism involving hazardous materials is considered a major threat due to the location of hazardous material facilities and transport routes throughout communities and the frequently limited anti-terrorism security at these facilities.

Due to the high level of risk posed by hazardous materials, numerous federal, state and local agencies are involved in their regulation, including the U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation

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(DOT), National Fire Protection Association (NFPA), Federal Emergency Management Agency (FEMA), U.S. Army, and the International Maritime Organization.

Unless exempted, facilities that use, manufacture, or store hazardous materials in the U.S. fall under the regulatory requirements of EPCRA, enacted as Title III of the federal Superfund Amendments and Reauthorization Act ((SARA) 42 U.S.C. §§11001-11050 (1988)), and under Arizona Revised Statutes §26-350. EPCRA has four major provisions:

- Emergency Planning (Section 301-303) is designed to help communities prepare for and respond to emergencies involving hazardous substances. It requires every community in the United States to be part of a comprehensive emergency response plan.
- The Governor of Arizona has designated a SERC responsible for implementing EPCRA provisions within Arizona. The SERC oversees fifteen countywide Local Emergency Planning Committee (LEPC) districts (Maricopa County Department of Emergency Management, May 2003). Emergency Release Notification (Section 304) includes a list of chemicals that if spilled must be reported, including Extremely Hazardous Substances (EHS). The SERC supervises and coordinates activities of each LEPC, establishes procedures for receiving and processing public requests for information collected under EPCRA, and reviews LEPC developed local emergency response plans. Facilities holding an Extremely Hazardous Substance (EHS) at quantities exceeding the Threshold Planning Quantities (TPQ) must notify the SERC and LEPC and provide a representative to participate in the county emergency planning process.
- Hazardous chemical storage reporting requirements (Sections 311-312) that requires facilities possessing a threshold reporting quantity of a hazardous material under EPCRA (Section 311/312, 40 CFR Part 370) to submit an annual chemical inventory report (Tier II Hazardous Chemical Inventory Form) to the SERC, LEPC and local fire department by March 1 of each year; and
- Toxic chemical release inventory (Section 313).

Of the hundreds of hazardous materials, under the EPCRA regulatory scheme, those hazardous materials that pose the greatest risk for causing catastrophic emergencies are identified as an Extremely Hazardous Substance (EHS). As noted above, the presence of EHSs in quantities at or above Threshold Planning Quantities (TPQ) require additional emergency planning and mitigation activities. These chemicals are identified by the US EPA in the *List of Lists – Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act (EPCRA) and Section 112 of the Clean Air Act* (EPA, October 2001).

Releases of EHSs can occur during transport and from fixed facilities, with transported EHSs exposed to greater risk of release due to the inherently greater risk of transport. Transportation related releases are generally more troublesome because they may occur anywhere, including close to human populations, critical facilities, or sensitive environmental areas. Transportation related EHS releases are also more difficult to mitigate due to the variability of locations and distance from response resources.

It should be noted that while comprehensive and readily accessible information is available on hazardous material release and facilities subject to EPCRA, there are numerous other sources of information on hazardous material facilities and incidents that are beyond the scope of this plan. According to the Arizona Department of Environmental Quality (ADEQ), a complete analysis of potential hazardous material events would include all of the following:

- Risk Management Plan (RMP) facilities
- Tier II Hazardous Chemical Inventory Form facilities
- Toxic Release Inventory (TRI) facilities
- Pipelines and related facilities
- Railroad transportation facilities
- Explosive storage, sales, use, and manufacturing facilities
- Hazardous Materials Management Plan (HMMP) permit and Hazardous Materials Inventory Statement (HMIS) facilities
- Hazardous waste facilities (RCRA information and RMS databases)

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- Arizona Department of Environmental Quality (ADEQ) Material Incident Logbook
- National Response Center Incident Database
- U.S. Department of Transportation (DOT) Incident Database
- Arizona Department of Transportation (ADOT)
- Trucking terminal facilities
- U.S. Office of Occupational Safety and Health Administration (OSHA) Injury, Illness, and Fatality Database
- 911 regional dispatch centers (e.g., Phoenix)
- Environmental Protection Agency (EPA) Envirofacts and Window to My Environment
- EPA Enforcement and Compliance History Online (ECHO)
- EPA Central Data Exchange. (ADEQ, April 3, 2003)

7.3.8.2 History

Some of the worst hazardous material events have occurred outside of the U.S., such the 1984 incident in Bhophal, India, which killed or seriously injured more than 2,000 people. The following is a summary of hazardous material events by type in the U.S.:

- The National Response Center (NRC) reported an average of 280 hazardous material releases and spills occurred at fixed sites annually during the period 1987-1990.
- The US Department of Transportation reported an average of 6,774 hazardous material events annually during the period 1982-1991, with highways accounting for 81.4 percent, railroads 14.7 percent, and other events 6.6 percent. Additionally, highway transportation hazardous material events have caused more than 100 deaths, 2,800 injuries, and $22.4 million in damages (FEMA, 1997).

Hazardous Material (HAZMAT) releases are a major concern for communities in Maricopa County. The Arizona Division of Emergency Management (ADEM) provided information on the declared hazardous material events, while information on nearly all of the undeclared events came from the National Response Center (NRC). In addition, hazardous material release reports were gathered from the NRC for the period 1990-2002 and screened to include only releases reported to the NRC of Extremely Hazardous Substances (EHSs) that met the Reportable Quantity (RQ) test under Section 304 of EPCRA (see *EPA List of Lists,* Section 304 EHS RQ). These materials pose the greatest risk for causing catastrophic emergencies.

- A total of 39 significant HAZMAT events in Maricopa County were identified, 4 of which prompted a disaster declaration by the Governor, as shown in Table 7-3. Among the Maricopa County events that did not prompt a state or federal disaster declaration, 5 occurred within Unincorporated Maricopa County. The following two incidents were listed due to the possibility of fuel leakage and munitions being carried: March 26, 1999 F-16 fighter jet suffered engine failure, which forced the pilot to eject. The aircraft crashed 22 miles southwest of Luke AFB, Arizona. All Luke AFB F-16s were subsequently grounded as the result of the crash until all engines could be inspected. Cracks were found in 63 other F-16 P&W 220 engines augmentor ducts. Cracks in the afterburner resulted in an earlier F-16 crash on February 3, 1999. The aircraft was on a training mission with practice munitions.
- April 26, 1999 F-16 fighter jet crashed 20 miles northwest of Luke AFB on White Tank Mt. Range at 18:05 hours. The cockpit landing gear lights indicated an unsafe undercarriage. While attempting to resolve the problem, the aircraft ran out of fuel. The instructor pilot and a German exchange pilot were recovered safely.

Maricopa County experienced 34 EHS incidents that were reported to the NRC between 1990 and 2002. This figure represents nearly half of the 71 total incidents in Arizona during that time. This is not surprising given the overall level of development in Maricopa County, particularly with respect to the concentration of industry and major infrastructure in the region. In general the greatest intensity of EHS facilities exists in the urbanized areas of the county, and along its primary transportation corridors.

The location of EHS incidents within Maricopa County is reflected in Table 7-15 and Figure 7-16. As shown by these figures, among the 34 Maricopa County incidents reported to the NRC, 5 occurred within Unincorporated Maricopa County.

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Table 7-15: National Response Center (NRC) Extremely Hazardous Substances, 1990-2002		
Jurisdiction	Incidents	Percent
Unincorporated Maricopa County	5	14.7%
Total	34	100.0%

Note: Includes only releases reported to the National Response Center (NRC) of Extremely Hazardous Substances (EHSs) that met the Reportable Quantity (RQ) test under Section 304 of EPCRA (see *EPA List of Lists*, Section 304 EHS RQ).

Source: NRC, May 2003; URS, October 2003.

7.3.8.3 Probability and Magnitude

Comprehensive information on the probability and magnitude of hazardous material events across all types of sources (e.g., fixed facility, transport vehicle) is not available. Wide variations in the characteristics of hazardous material sources and between the materials themselves make such an evaluation very difficult.

The US Department of Transportation's Hazardous Materials Transportation Program is one of the most advanced probability and magnitude estimation programs. The program collects information on unintentional releases of hazardous materials, including the consequences, and analyzes them. One of the major efforts of the program is to identify low probability, high consequence events (which may not be apparent from incident data) and provide appropriate levels of protection (DOT, September 2003).

While it is beyond the scope of this plan to evaluate the probability and magnitude of hazardous material events in Unincorporated Maricopa County in detail, it is possible to determine the exposure of population, buildings, and critical facilities should such an event occur. Of the facilities that were required to file an annual Tier II Material Inventory Report (under EPCRA) in Maricopa County because of the presence of hazardous materials, 684 were identified as having Extremely Hazardous Substance (EHS), as shown in Table 7-16 and Figure 7-17. Within this population of facilities 85 existed in Unincorporated Maricopa County, a figure which represents 12.4% of the total facilities in Maricopa County. As noted above, EHSs pose the greatest risk for causing catastrophic emergencies. Therefore, facilities with EHSs are considered a greater threat than situations where Hazardous Materials, as compared to Extremely Hazardous Substances, are involved.

Table 7-16: Extremely Hazardous Substance (EHS) Facilities in Unincorporated Maricopa County, 2002		
Jurisdiction	Facilities	Percent
Unincorporated Maricopa County	85	12.4%
Maricopa County Total	684	100.0%

Note: Includes only facilities with Extremely Hazardous Substances (EHSs). Based on Arizona Online Tier II Reporting System FY2002.

Source: Arizona Emergency Response Commission, April 6, 2003.

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Figure 7-16: Extremely Hazardous Substances (EHS) Releases, 1990-2002

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Figure 7-17: Extremely Hazardous Substance Facilities, 2002

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7.3.8.4 Warning Time

The amount of warning time for a hazardous material (HAZMAT) event varies widely by type and size of event. The release of a small amount of non-gaseous hazardous material onto land that is immediately contained may allow significant warning time to nearby people (perhaps hours, not to mention the fact that such an event presents a relatively low level of immediate risk). By contrast, the release of a large amount of a gaseous Extremely Hazardous Substance (EHS) may provide no warning time (potentially seriously injuring or killing those nearby and effectively delaying the detection of and response to such an event).

7.3.9 Lightning

7.3.9.1 Nature

Lightning typically occurs as a by-product of a thunderstorm. The action of rising and descending air in a thunderstorm separates positive and negative charges, with lightning the result of the buildup and discharge of energy between positive and negative charge areas. Water and ice particles may also affect the distribution of the electrical charge. In only a few millionths of a second, the air near a lightning strike is heated to 50,000°F, a temperature hotter than the surface of the sun. Thunder is the result of the very rapid heating and cooling of air near the lightning that causes a shock wave.

The hazard posed by lightning is significantly underrated. High winds, rainfall, and a darkening cloud cover are the warning signs for possible cloud-to-ground lightning strikes. While many lightning casualties happen at the beginning of an approaching storm, more than half of lightning deaths occur after a thunderstorm has passed. The lightning threat diminishes after the last sound of thunder, but may persist for more than 30 minutes. When thunderstorms are in the area, but not overhead, the lightning threat can exist when skies are clear. Lightning has been known to strike more than 10 miles from the storm in an area with clear sky above.

According to the National Oceanic and Atmospheric Administration (NOAA), there are an average of 20 million cloud-to-ground flashes detected every year in the continental US. About half of all flashes have more than one ground strike point, so at least 30 million points on the ground are struck on the average each year. In addition, there are roughly 5 to 10 times as many cloud-to-cloud flashes as there are to cloud-to-ground flashes (NOAA, July 7, 2003).

Lightning is the most dangerous and frequently encountered weather hazard that most people in the US experience annually. Lightning is the second most frequent killer in the US, behind floods/flash floods, with nearly 100 deaths and 500 injuries annually. These numbers are likely to underestimate the actual number of casualties because of the under reporting of suspected lightning deaths and injuries.

Cloud-to-ground lightning can kill or injure people by either direct or indirect means. The lightning current can branch off to strike a person from a tree, fence, pole, or other tall object. It is not known if all people are killed who are directly struck by the flash itself. In addition, their current may be conducted through the ground to a person after lightning strikes a nearby tree, antenna, or other tall object. The current also may travel through power or telephone lines, or plumbing pipes to a person who is in contact with an electric appliance, telephone, or plumbing fixture. Lightning may use similar processes to damage property or cause fires.

7.3.9.2 History

Nationally, lightning strikes rank second only to flash floods in weather-related deaths. Annually, lightning causes around 100 deaths in the U.S. NOAA undertook a major study of lightning-related fatality, injury, and damage reports in the US for the period 1954-1994, with the following findings (October 1998):

- There were 3,239 deaths, 9,818 injuries, and 19,814 property-damage reports from lightning. The number of lightning-caused casualty and damage events was less variable from year to year than other weather causes. For this reason, lightning is the most constant and widespread threat to people and property during the thunderstorm season.

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- Florida led the nation in the actual number of deaths and injuries, while the largest number of damage reports came from Pennsylvania.
- Taking population into account, there were large variations among decades in casualties and damages, with New Mexico and Wyoming leading the nation in death, injury, and casualty rates. High casualty rates tended to be in Florida, the Rocky Mountains (including Arizona), plains, southeast, and New England. The highest rates of population-weighted damage reports were on the plains.

Similarly, the Centers for Disease Control (CDC) and Prevention studied lightning mortality and morbidity in the U.S. during the period 1980-1995, with the following findings:

- A total of 1,318 deaths were attributed to lightning, equating to an average of 82 deaths per year.
- The greatest number of deaths attributable to lightning occurred in Florida and Texas (145 and 91, respectively).
- Accounting for population, New Mexico, Arizona, Arkansas, and Mississippi had the highest lightning death rates, respectively, with 10.0, 9.0, 9.0, and 9.0 per 10.0 million population (CDC, October 5, 1998).

Using the NOAA Storm Event Database, a total of 22 significant lightning events in Maricopa County were identified, none of which prompted a disaster declaration, as shown in Table 7-3. Significant events include those with at least one death, one injury, or $50,000 worth of damage, or that were severe enough to have been identified in historical records. The 22 undeclared events resulted in 4 fatalities, 22 injuries, and $5,459,000 in damages. Among these 22 significant events only 1 was recorded in Unincorporated Maricopa County. This event resulted in 1 injury and 1 fatality.

- August 19, 1995, 1 fatality, 1 injury. Two boys and a dog walking outside during a storm were struck by lightning. One of the boys died within a couple of days of being struck. The dog was killed immediately.

7.3.9.3 Probability and Magnitude

The mean annual lightning strike density in Maricopa County is shown in Figure 7-18. In general most of urbanized Maricopa County is subject to 0.2 to 0.8 lightning strikes per square mile annually. Unincorporated Maricopa County reflects this density range, and also includes pockets in the County's southeast and northeast regions that reflect average annual lightning densities of 0.8 to 1.5 strikes per square mile. The real extent and density of lightning strikes is somewhat similar to that for maximum thunderstorm and tornado activity. Severe thunderstorms are likely to generate concurrent effects, such as severe winds, tornadoes, and hail.

7.3.9.4 Warning Time

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories).

Unfortunately, there is no universal answer for every storm event. Warning times vary based on storm location, direction, intensity, duration, and the topography and size of the drainage area. Before watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Often, forecasters begin issuing severe weather statements, advisories, or bulletins on hurricanes and winter storms three or four days before the storm hits. Forecasters can't issue alerts for the danger of severe thunderstorms, tornadoes and flash floods that far ahead. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Arizona emanate from NWS offices in Tucson, Phoenix, Flagstaff, and Las Vegas, Nevada.

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Figure 7-18: Lightning Flash Density, 1996-2000

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Lightning is a consequence of severe thunderstorms. The NWS issues a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms. The local NWS office considers a thunderstorm severe if it produces hail at least 3/4-inch in diameter, wind of 58 mph or higher, or tornadoes. When a watch is issued for a region, residents are encouraged to continue normal activities but should remain alert for signs of approaching storms, and continue to listen for weather forecasts and statements from the local NWS office. When a severe thunderstorm has been detected by weather radar or one has been reported by trained storm spotters, the local NWS office will issue a severe thunderstorm warning. A severe thunderstorm warning is an urgent message to the affected counties that a severe thunderstorm is imminent. The warning time provided by a severe thunderstorm watch may be on the order of hours, while a severe thunderstorm warning typically provides warning time in the range of an hour or less.

A severe thunderstorm watch may be issued by a NWS office to give advanced notice that severe thunderstorms are possible in an area, providing time to make preliminary plans for moving to a safe location if a severe thunderstorm warning is issued. A NWS office may issue a severe thunderstorm warning in order to urgently announce that a severe thunderstorm has been reported or is imminent in the area and that people should take immediate cover. The warning time provided by a severe thunderstorm watch may be on the order of hours, while a severe thunderstorm warning typically provides warning time in the range of an hour or less.

As noted previously, lightning strikes may occur in areas with clear skies, up to 10 miles from thunderstorms and before or after thunderstorm activity. Lightning strikes occur in millionths of a second.

7.3.10 Severe Winds

7.3.10.1 Nature

Wind is the motion of air relative to the surface of the earth. The most significant aspects of wind are the horizontal flow and the near-surface phenomena. Severe winds, also known as extreme winds or windstorms, are associated with tropical cyclones, winter cyclones, and severe thunderstorms and accompanying events, such as tornadoes, downbursts, and microbursts. Wind speeds vary from near zero at ground level to 200 miles per hour (mph) in the jet stream approximately six to eight miles above the earth (FEMA, 1997).

Wind speed is measured in many ways, such as peak gusts, fastest mile wind speed, 1-minute wind speed, 10-minute wind speed, sustained wind speed, and gradient wind speed. The main factors in all wind speed measures are the following:

- Duration: The shorter the period over which the wind is measured, the higher the wind speed due to the affect of gusts
- Altitude: Wind speed increases with altitude to a certain extent, after which wind speed becomes constant. The height over which the wind speed increases is called the boundary layer, with gradient wind speed measured above the boundary layer.
- Terrain: Wind speeds over smooth surfaces (e.g., fields, water) are much higher than over rough surfaces (e.g., cities, rough terrain).

In the mainland US, the mean annual wind speed is 8 to 12 mph, with frequent wind speeds of 50 mph, and occasional speeds of more than 70 mph. Tropical cyclone winds on the East and Gulf Coast may exceed 100 mph. Foehn-type winds are regional down slope winds in mountainous regions (e.g., Rocky Mountains, Southern California) that may exceed 100 mph in small areas and for short periods. In addition, severe thunderstorms often produce wind downbursts, microbursts, and tornadoes. These events are often interrelated, making it difficult to separate the individual wind components that cause damage.

Near-surface winds and their associated pressure effects (positive and negative) exert pressure on structural components, such as the walls, doors, windows, and roofs. Positive wind pressure directly pushes the components inward, while negative pressure indirectly creates lift and suction forces that pull the components outward and upward. The upper levels of multi-story structures are subject to magnified effects. In addition to the pressure effects,

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internal building pressures rise and result in the failure of roof or leeward structural components. In addition, debris carried by extreme winds causes additional damage to structures and people.

7.3.10.2 History

The entire U.S. is vulnerable to the hazards of windstorms, including hurricanes, severe thunderstorms, tornadoes, downbursts, and microbursts. In 1998, a calm year according to experts, wind related storms resulted in more than $5.5 billion in damages, and at least 186 fatalities (ASCE, May 9, 2003).

A total of 5 distinct severe wind events in Maricopa County were identified, none of which prompted a disaster declaration, as shown in Table 7-3. No severe wind events were reported within Unincorporated Maricopa County. It is important to recognize the interrelated nature of severe winds in conjunction with other significant severe weather events that Maricopa County experiences in high numbers. For example, a combined total of 103 thunderstorm, tornado, and tropical storm events were recorded, with a combined total of 27 fatalities, 139 injuries, and $811,956,000 million in damages, as shown in as shown in Table 7-3.

The five undeclared distinct severe wind events in Maricopa County resulted in one reported fatality and $30,000 in damages.

7.3.10.3 Probability and Magnitude

There are various methods of measuring and displaying the probability and magnitude of wind speeds. These measures are used by organizations to make recommendations concerning the minimum building code standards in areas subject to varying wind speeds in order to reduce the potential for damage to structures and injuries to people.

A traditional wind speed measure is the fastest mile wind speed, which measures the highest wind speed measured at an altitude of 33-feet in open terrain. Technically speaking, it is the period of time required for one mile of wind to pass the anemometer, an instrument for measuring wind force and velocity. The measure is made over smooth terrain (e.g., flat open country and grasslands), with an annual probability of 2.0 percent (equivalent to a return period of 50-years).

The fastest mile speed has more recently been replaced by the 3-second wind gust speeds which is considered by the American Society of Civil Engineers (ASCE) to more accurately measure the potential for damage to structures. According to this measure, the 3-second gust wind speed for most of the US is 90 mph, with 3-second gust wind speeds for the East and Gulf Coast areas, including an area of 150-165 mph at the southern tip of Florida (ASCE, 1999).

All of the communities located in Maricopa County experience a 3-second gust wind speed of 85-90 mph, indicating relatively low levels of risk from severe winds alone. Likewise, FEMA identifies most of Maricopa County in design wind speed Zone I. In this zone, a design wind speed of 130 mph is recommended for the design and construction of community shelters. (FEMA, July 2000).

7.3.10.4 Warning Time

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories).

Unfortunately, there is no universal answer for every storm event. Warning times vary based on storm location, direction, intensity, duration, and the topography and size of the drainage area. Before watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Forecasters can't issue alerts for the danger of severe thunderstorms, tornadoes and flash floods days in advance, as they are able to for a hurricane or winter storm. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Arizona emanate from NWS offices in Tucson, Phoenix, Flagstaff, and Las Vegas, Nevada.

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Severe winds are typically a consequence of tropical cyclones, winter cyclones, severe thunderstorms and accompanying events, such as tornadoes, downbursts, and microbursts. The NWS issues a watch when conditions are favorable for the development of severe weather conditions. When a watch is issued for a region, residents are encouraged to continue normal activities but should remain alert for signs of approaching storms, and continue to listen for weather forecasts and statements from the local NWS office. A warning is an urgent message to the affected counties that severe weather is imminent. The forecast office will be specific with the type of severe weather event or events expected. The warning time provided by a watch may be on the order of hours, while a warning typically provides warning time in the range of an hour or less.

7.3.11 Subsidence

7.3.11.1 Nature

Land subsidence is the loss of surface elevation and affects nearly every U.S. state. Land subsidence has numerous causes, although the primary causes are underground coal mining, groundwater and petroleum withdrawal, and the drainage of organic soils. Due to the diversity of causes and wide range of impacts, land subsidence has been analyzed primarily by federal, state, and local agencies independently, with comparatively little focus nationally (FEMA, 1997).

Land subsidence is caused by numerous human activities and natural processes including the following: mining of coal, metallic ores, limestone, salt, and sulfur; withdrawal of groundwater, petroleum, and geothermal fluids; dewatering of organic soils; wetting of dry, low-density deposits known as hydrocompaction; natural sediment compaction; melting of permafrost; liquefaction; and crustal deformation. Land subsidence takes three major forms:

- Collapse Into Voids: The collapse of surface materials into underground voids is the most dramatic form of land subsidence and is most frequently caused by coal mining. While typically collapses are human-caused, some cavities may be natural, such as in limestone or halite. Catastrophic subsidence is most commonly caused by lowering of the water table, rapid water table fluctuation, diversion of surface water, construction, use of explosives, or impoundment of water.
- Sediment Compaction: Typically causing broad regional subsidence or a few millimeters per year, total subsidence due to sediment compaction may reach several meters over decades. Sediment compaction is the result of underground fluid withdrawal, natural compaction, or hydrocompaction,
- Drainage of Organic Soils: The draining of organic soils, such as peat and muck, causes a series of processes that reduce the volume of soil. This primarily affects large wetlands or river delta areas.

Subsidence is primarily an economic hazard, threatening buildings and infrastructure, as opposed to a threat to life. It may also lead to cracks in the earth's surface called fissures, which themselves are also hazardous.

7.3.11.2 History

Land subsidence is estimated to affect parts of at least 45 states. More than 17,000 square miles of land has been lowered due to subsidence, an area roughly the size of New Hampshire and Vermont combined. More than 80 percent of the identified subsidence nationally has been due to the removal of underground water. In 1991, the National Research Council (NRC) estimated that the cost of flooding and structural damage from land subsidence in the U.S. exceeded $125 million annually. The estimation of less direct or hidden costs is complicated by difficulties identifying and mapping affected areas, establishing cause and affect relationships, assigning economic values to environmental resources, and inherent legal system conflicts. As a result, the annual total cost of subsidence is probably significantly larger (USGS, 1999).

In 1991, the NRC estimated cumulative damages from subsidence by type for U.S. states. While broad ranges were used for these estimates, they provide an indication of the relative hazard level posed by different types of subsidence. According to the NRC, underground fluvial withdrawal (i.e., withdrawal of underground water) is clearly the largest subsidence hazard in Arizona, with $10-100 million in estimated cumulative damages in 1991, as shown in Table 7-17. Relatively minor subsidence damage was posed by mining and hydrocompaction, with $0-1 million in cumulative damages each.

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In south-central Arizona the combination of low rates of precipitation (3-20 inches per year) and high rates of evapotransportation (60+ inches per year) has historically led to high rates of groundwater withdrawal. Groundwater withdrawal in Arizona began before 1900 and was used largely for irrigation. By the 1960's, increasing development and declining groundwater levels led to the approval of the Central Arizona Project (CAP) Canal, which provided approximately 12 percent of Arizona's water in 1994. That same year, however, groundwater accounted for 44 percent of water used in Arizona.

Table 7-17: Estimated Cumulative Damage From Subsidence by Type in Arizona, 1991

Subsidence Type	Cumulative Damage (mill.)
Mining	$0-1
Sinkholes	$0
Underground Fluid Withdrawal	$10-100
Hydrocompaction	$0-1
Organic Soils	$0

Note: Costs not converted into constant dollars. Figures can be used as a general measure of risk associated with land subsidence, but do not indicate probability or magnitude of land subsidence.

Source: FEMA, 1997 (from National Research Council, 1991).

The withdrawal of groundwater is the primary cause of land subsidence and earth fissures that affect significant portions of Maricopa County. The areas of greatest subsidence correspond to the areas of greatest groundwater level decline (USGS, 1999). One subsidence hazard event has been identified for Maricopa County that led to damages, as shown in Table 7-3:

- On Luke Air Force base in Glendale, Maricopa County, up to 18 feet of subsidence and related earth fissures have been recorded. This led to a significant increase in local flooding and the flow reversal of the Dysart Drain, an engineered flood control device. On September 20, 1992, a rainstorm caused 4 inches of surface runoff that closed the base for 3 days. The Dysart Drain spilled over due to sluggish flow, flooding the runways and 100 homes, resulting in approximately $3 million worth of damages (USGS, 1999).
- Subsidence near McMicken Dam at the base of the White Tank Mountains as resulted in earth fissures. While there has not been a breach or damage yet, to protect life and the surrounding property, the dam must be repaired. Repair, rebuild or replacement of large segments of the dam is estimated in the millions.

In addition, areas affected by subsidence in Unincorporated Maricopa County have been identified by the USGS, and are shown in Table 7-19. As illustrated through this figure, more than half of Unincorporated Maricopa County is not exposed to subsidence due to either water-level decline that exceeds 100 feet or historically. However, a band across the central region of the County is affected by water-level decline greater than 100 feet with an area in the center of the County and two areas east of center that have historically been affected by subsidence. Earth fissures, long linear cracks at the surface that have little or no vertical offset, often occur in alluvial valley sediments in areas of subsidence in Maricopa County. Fissures may start out only fractions of an inch wide and several hundred feet long. However, they may increase to 30 feet wide, thousands of feet long, and more than 30 feet deep. The most studied fissure in Arizona is the Picacho earth fissure. This fissure has caused damage to Interstate 10, caused a change to the route of the CAP Canal, and exposed a natural gas pipeline.

The Arizona Department of Water Resources (ADWR) is working with the Center for Space Research at the University of Texas, Austin, to research land subsidence in Arizona. The research uses radar interferometry to measure land subsidence in Phoenix, Arizona and Houston, Texas. Radar interferometry is a technique where radar data, usually recorded from satellite, are used to map the elevation (topography) or the deformation of the ground - such as in earthquakes or subsidence. The research is sponsored by the following: NASA's Earth Science Enterprise, Solid Earth and Natural Hazards program; European Space Agency; Western North America InSAR Consortium; and ADWR.

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Figure 7-19: Areas Historically Affected by Subsidence

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The use of several interferograms spanning different time periods provides information about the spatial and temporal progression of subsidence in these regions. From this work, it is possible to identify those areas in central Arizona that are experiencing subsidence at a rate of 0.5 cm/year or more. As shown in Table 7-19, Maricopa County has two major areas of subsidence, one in the northwest and one in the northeast. The northwest subsidence area is centered on Sun City, but also affects parts of El Mirage, Glendale, Peoria, Phoenix, Surprise, and Youngtown. In the northeast, portions of Phoenix and Scottsdale area affected.

7.3.11.3 Probability and Magnitude

Procedures to determine the probability and magnitude of land subsidence have not been recommended. However, the major areas of subsidence in Arizona identified by the USGS shown in Table 7-19 have historically been subject to subsidence and may be considered to be susceptible to subsidence in the future. The magnitude of subsidence is difficult to determine in advance, although it may be reasonable to expect that those areas shown via interferograms to be subsiding at a rate of 0.5 cm/year or more will continue to do so in the future.

7.3.11.4 Warning Time

Subsidence is a hazard that typically happens slowly, over a period of months, years or decades. As such, significant warning time should be available to prepare for, and ever avoid, subsidence.

These warnings may come from the National Geodetic Survey (NGS) which develops and maintains a national system of positioning data needed for transportation, navigation, and communication systems; land record systems; mapping and charting efforts; and defense operations. The foundation of the system is the National Spatial Reference System (NSRS), which is a national coordinate system that defines position (latitude, longitude and elevation), distances and directions between points, strength of gravitational pull, and how these change over time. This system includes work on a set of models that predict geophysical processes such as land subsidence (sinking) and uplift, movement of the Earth's crust, and other phenomena affecting spatial measurements. The radar interferometry research of the ADWR and Center for Space Research described above may also provide such warnings.

7.3.12 Thunderstorm

7.3.12.1 Nature

A thunderstorm, also known as a thunder event, is a local storm that produces lightning, thunder, and rainfall. A thunderstorm may consist of a single cumulonimbus cloud, a cluster of clouds, or a line of clouds, which is formed when moist, unstable air near the surface is lifted, as may occur due to strong surface heating, upward terrain, or the convergence of surface winds. The duration of a thunderstorm is measured as the time between the first peal of thunder, caused by lightning, and the last peal of thunder, with most storms lasting from 15 minutes to several hours. Compared with other atmospheric hazards, such as tropical storms and winter storms, most thunderstorms are relatively small (15 miles in diameter) and last for a short time at a single location (30 minutes). However, thunderstorms may intensify into severe thunderstorms capable of causing significant damage and able to travel significant distances (FEMA, 1997).

Thunderstorms typically have a three-stage life cycle, as illustrated in Figure 7-20. In the first state, known as the cumulus stage, warm, moist air rises and water vapor condenses, releasing latent heat, which enhances the upward convection and the growth of the cloud. As the cloud rises and cools, it eventually passes above the freezing level, where super-cooled water droplets and ice crystals coexist. In the second stage, the mature stage, both updrafts and downs-drafts exist within the cloud. Falling precipitation initiates downdrafts, although precipitation may evaporate before reaching the ground. Cloud to ground lightning usually begins when precipitation first falls from the base of the cloud. An anvil, or overhang of the top of the cloud may be visible at this stage. Finally, in the third or decaying stage, downdrafts dominate the cloud. Here the cloud has lost updrafts due to the release of latent heat and most of the water vapor has crystallized into frozen droplets that the cloud is no longer able to support. Precipitation may be heavy at this stage.

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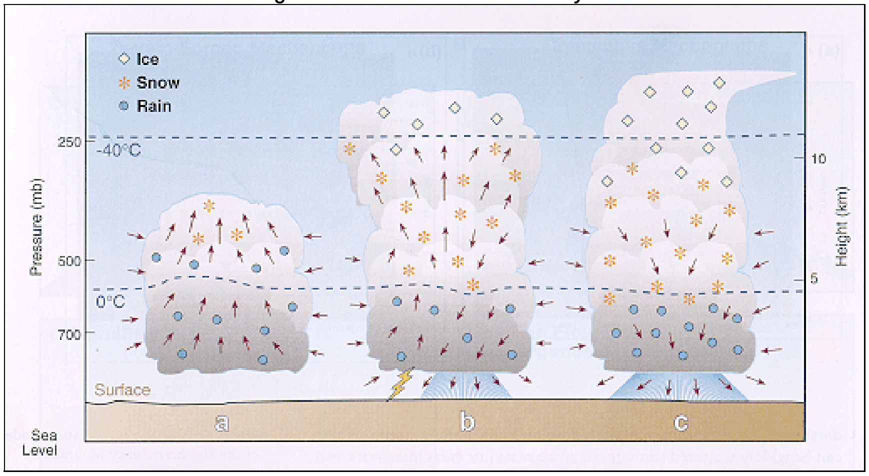
Figure 7-20: Thunderstorm Life Cycle



Source: National Weather Service Flagstaff.

Thunderstorms are categorized as ordinary and severe, with the latter meeting one of the following National Weather Service (NWS) criteria: winds reaching or exceeding 58 mph; production of a tornado; or hail at least 0.75 inches in diameter. Severe thunderstorms may also produce heavy precipitation, flash flooding, downbursts, and microbursts. Downbursts are strong, straight-line winds created by falling rain and sinking air that may reach speeds of 125 mph. Microbursts are more concentrated than downbursts, with speeds reaching up to 150 mph. Both downbursts and microbursts typically last only 5-7 minutes, but can cause severe damage and pose a major hazard to aircraft departures/landings due to the wind shear and detection difficulties (FEMA, 1997).

Dangerous and damaging effects of severe thunderstorms include lightning, tornadoes, hail, flash flooding, and severe winds. In addition to the information presented on these effects in this section, each is addressed in more detail in other sections contained in this document.

7.3.12.2 History

Since 1986, severe thunderstorm winds have killed over 300 people and injured over 4,000 nationwide. Of the estimated 100,000 thunderstorms that occur each year in the United States, only about 10 percent are classified as severe (NWS Flagstaff).

A total of 79 significant thunderstorm events were identified in Maricopa County, 11 of which prompted a disaster declaration, as shown in Table 7-3. These events caused at least one injury, one death, $50,000 worth of damage, or were severe enough to be identified in historical records. This is the second highest number of significant events, behind wildfires. It should be noted that the events detailed in this section are all associated with thunderstorms in some fashion, but may also appear as a significant event in another hazard profile. For example, the microburst that occurred on August 14, 1996 involved various documented severe weather events including damage caused by high wind, flooding, and hail. Specific event histories of these hazards are provided throughout the various chapters of this document. Most of the significant thunderstorm events were identified using the National Climate Center (NCDC) Storm Event Database, which has a large number of well-recorded events from approximately 1970 forward. For all 79 events in Maricopa County, 4 deaths, 82 injuries, and nearly $397 million in damages were recorded. Among these events, the 7 or more significant thunderstorms that have affected Unincorporated Maricopa County, include the following:

- July 29, 1985 12 injuries. National Climate Data Center, January 2003, Storm Event Database.
- June 26, 1986 1 injury. National Climate Data Center, January 2003, Storm Event Database.
- October 29, 1987 4 injuries. National Climate Data Center, January 2003, Storm Event Database.

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- July 10, 1988 1 fatality, 6 injuries. National Climate Data Center, January 2003, Storm Event Database.
- July 28, 1988 1 injury. National Climate Data Center, January 2003, Storm Event Database.
- July 29, 1988 1 injury. National Climate Data Center, January 2003, Storm Event Database.
- August 17, 1989 1 injury. National Climate Data Center, January 2003, Storm Event Database.

7.3.12.3 Probability and Magnitude

Thunderstorms occur throughout the year in Maricopa County, but most commonly during the monsoon season, the seasonal wind shift that brings a dramatic increase in moisture. Severe thunderstorms produce heavy rain, flash flooding, severe winds, hail, and lightning, all of which are addressed in detail elsewhere within this document. Rainfall is the most recognizable attendant feature of thunderstorms, with normal annual precipitation rates varying somewhat across the county and posing a significant flash flooding hazard. Severe thunderstorms may also produce hail. Another hazardous feature of severe thunderstorms is tornadoes, which are generally rare in Maricopa County, but may cause damage and are most common in the summer months. Lightning is a hazard wherever and whenever thunderstorms occur, but can be particularly hazardous in those parts of the State highly susceptible to wildland fires.

One thunderstorm feature, microbursts, generate localized, straight-line winds reaching from 60 to over 80 mph. Microbursts are quite common in Maricopa County and may cause significant damage. On rare occasions thunderstorms can develop much larger "macroburst" winds that have an affected outflow area of at least 2.5 miles wide and peak winds lasting between 5 and 20 minutes. Intense macrobursts may cause tornado-like damages (NWS Phoenix).

The probability of a severe thunderstorm occurring increases as the average duration and number of thunderstorm events increases. The National Weather Service (NWS) collects information on the number of thunder days (days with a thunder clap), number and duration of thunder events, and lightning strike density. An analysis of this data, collected for the period 1948-1977, provides an indication of the areal extent and frequency thunderstorm severity. With a minimum average duration between 120 minutes in the north to 80 minutes in the south for thunderstorms in Maricopa County, the standard length of such storms in the county is among the longest in the nation.

Indicators of potential thunderstorm severity and frequency for Unincorporated Maricopa County provide specific probability and magnitude estimates for storm events in the County. Figure 7-21 indicates the thunderstorm severity for Unincorporated Maricopa County based upon the average duration of these events between 1949-1977. This figure suggests that the greater metropolitan area to include Wickenburg and Aguila but not north Phoenix, north Fountain Hills, Carefree, Cave Creek and the community of Anthem experience an average thunderstorm that lasts 100-110 minutes, while the northernmost portion as well as the south and northwest portions of the County experiences slightly shorter storms. Figure 7-22, reflecting the average number of thunder events, indicates that Unincorporated Maricopa County averaged 50-60 thunder events in the east, 60-70 in the center and 70-80 in the west portions of the County per year during the same period. Figure 7-23 illustrates the average density of lightning strikes in Unincorporated Maricopa County between 1947-1977. This figure indicates that most of the County experienced an average of 2-4 lightning flashes per square mile between 1947-1977, while the southeast corners average 6-8 and the northwest corner averaging 4-6 such events.

7.3.12.4 Warning Time

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories). Unfortunately, there is no universal answer for every severe weather event. Warning times vary based on storm location, direction, intensity, and duration. Before watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Forecasters can't issue alerts for the danger of severe thunderstorms, tornadoes and flash floods days in advance, as they are able to for a hurricane or winter storm. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Unincorporated Maricopa County originate from NWS offices in Tucson, Phoenix, Flagstaff, or Las Vegas, Nevada.

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The NWS issues a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms. The local NWS office considers a thunderstorm severe if it produces hail at least 3/4-inch in diameter, wind of 58 mph or higher, or tornadoes. When a watch is issued for a region, residents are encouraged to continue normal activities but should remain alert for signs of approaching storms, and continue to listen for weather forecasts and statements from the local NWS office. When a severe thunderstorm has been detected by weather radar or one has been reported by trained storm spotters, the local NWS office will issue a severe thunderstorm warning. A severe thunderstorm warning is an urgent message to the affected counties that a severe thunderstorm is imminent. The warning time provided by a severe thunderstorm watch may be on the order of hours, while a severe thunderstorm warning typically provides warning time in the range of an hour or less.

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Figure 7-21: Thunderstorm Hazard Severity Based on Average Duration, 1949-1977

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Figure 7-22: Thunderstorm Hazard Severity Based on Average Number of Thunder Events, 1949-1977

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Figure 7-23: Thunderstorm Hazard Severity Based on Lightning Strike Density, 1949-1977

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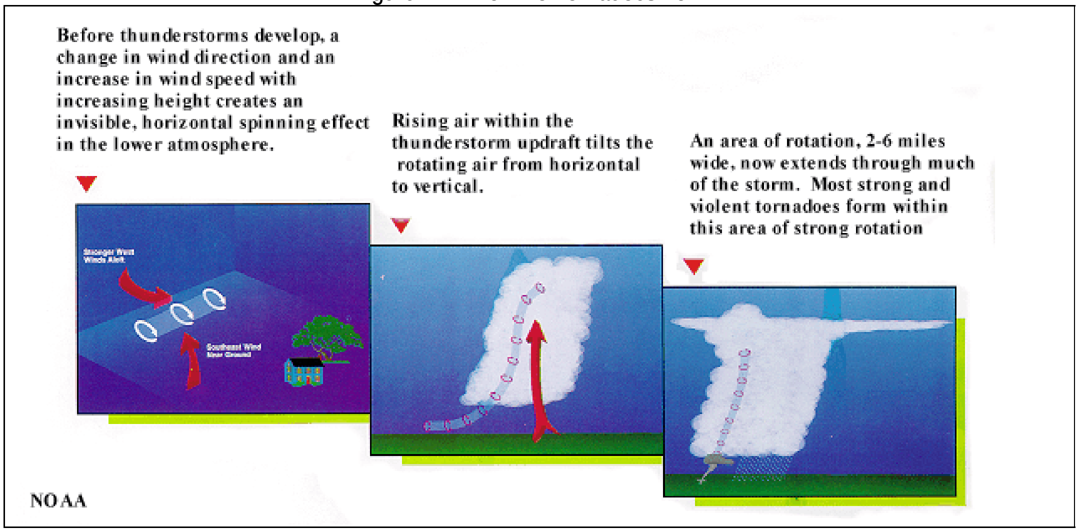
7.3.13 Tornado

7.3.13.1 Nature

A tornado is a rapidly rotating funnel (or vortex) of air that extends toward the ground from a cumulonimbus cloud. Most funnel clouds do not touch the ground, but when the lower tip of the funnel cloud touches the earth, it becomes a tornado and can cause extensive damage. Funnel Clouds often form in convective cells, such as thunderstorms or at the front of hurricanes. Tornadoes may also result from earthquake induced fires, wildfires, or atomic bombs (FEMA, 1997). The formation of tornadoes from thunderstorms is explained in Figure 7-24.

Figure 7-24: How Do Tornadoes Form?



Source: NWS Phoenix.

Tornado damage severity is measured by the Fujita Tornado Scale, which assigns a numerical value of 0 to 5 based on wind speeds, as shown in Table 7-18. The letter F may precede the number (e.g., FO, F1, F2). Most tornadoes last less than 30 minutes, but some last for over an hour. The path of a tornado can range from a few hundred feet to miles. The width of a tornado may range from tens of yards to more than a quarter of a mile.

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Table 7-18: Fujita Tornado Scale		
Category	Wind Speed	Description of Damage
F0	40-72 mph	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
F1	73-112 mph	Moderate damage. The lower limit is the beginning of hurricane speed. Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158-206 mph	Severe damage. Roofs and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
F4	207-260 mph	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	261-318 mph	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100-yards; trees debarked.

Source: FEMA, 1997.

7.3.13.2 History

In an average year, 800-1200 tornadoes are reported nationwide, resulting in approximately 80 deaths and 1,500 injuries. Nearly 75 percent of tornado damage is relatively minor, with the associated tornadoes rated F0 or F1. However, some tornadoes are capable of tremendous destruction, particularly to densely populated areas (NWS Flagstaff, McCarthy 2003).

A total of 16 significant tornadoes affecting Maricopa County were identified, as shown in Table 7-3, none of which resulted in a disaster/emergency declaration. Most of the significant tornado events were identified using the National Climate Center (NCDC) Storm Event Database, which has a large number of well-recorded events from approximately 1970 forward. A total of 57 injuries were recorded and $34.3 million in damages was caused by these tornado events. Of the total events, 14 occurred in unspecified, possibly unincorporated areas of Maricopa County. These events include the following:

- On August 4, 1957, an F3 tornado was identified in Maricopa County, with no reported injuries or damages (NCDC Storm Event Database).
- On August 30, 1970, an F2 tornado in Maricopa County caused 41 injuries (NCDC Storm Event Database).

7.3.13.3 Probability and Magnitude

Most Maricopa County tornadoes occur from July through September, with nearly all being category F0 and F1 on the Fujita scale and only two F3 tornadoes reported in Arizona since 1950. Compared to Oklahoma, which receives on average 7.5 tornadoes annually, the highest state rate of occurrence per 10,000 state square miles, tornadoes are rare in Arizona, occurring at a rate of 0.3 annually per 10,000 state square miles.

Arizona ranks number 34 in comparison with other states for frequency of tornadoes, 31 for number of deaths, 32 for injuries and 32 for cost of damages. When compared to other states in terms of square miles, Arizona ranks number 45 for frequency of tornadoes, number 35 for fatalities per square mile, number 38 for injuries per square mile, and number 39 for costs per square mile (Disaster Center).

7.3.13.4 Warning Time

The National Weather Service (NWS) forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories).

The NWS issues a tornado watch to give advanced notice that tornadoes are possible in an area. This gives people time to make preliminary plans for moving to a safe location if a tornado warning is issued. A tornado warning is an urgent announcement that a tornado has been reported or is imminent and warns people to take immediate cover. The warning time provided by a tornado watch may be on the order of hours as a watch warning is to advise that a significant event is likely to occur. While a tornado warning typically is an announcement that the event is occurring or is imminent therefore the warning time is in the range of minutes.

Before severe weather watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Often, forecasters begin issuing severe weather statements, advisories, or bulletins on hurricanes and winter storms three or four days before the storm hits. Forecasters can't issue alerts for the danger of severe thunderstorms, tornadoes and flash floods that far ahead. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Arizona emanate from NWS offices in Tucson, Phoenix, Flagstaff, and Las Vegas, Nevada.

7.3.14 Tropical Cyclone

7.3.14.1 Nature

A tropical cyclone is a low-pressure area of closed circulation winds that originates over tropical waters, with winds that rotate counterclockwise in the Northern Hemisphere. Tropical cyclones may range from 100 to 500 miles in diameter, with the storm rotating around an area of low barometric pressure, known as the eye, which may be 10 to 30 miles in diameter. Tropical cyclones cause damage through a variety of associated phenomena, including severe winds, storm surge flooding, high waves, coastal erosion, extreme rainfall, thunderstorms, lightning, and tornadoes (most of these are addressed more fully elsewhere in this document). Hurricanes are among the most destructive forces on the planet and are the focus of significant monitoring and mitigation efforts. Because tropical cyclones, themselves, cannot make landfall in Maricopa County and rarely retain the qualities of an organized tropical system by the time they reach the area, mitigation planning that is associated with this phenomena is focused on accompanying hazards such as extreme rainfall, flooding, high wind, and lightning.

Tropical cyclones start as a tropical depression, with winds speeds below 39 mph, that may intensify into a tropical storm and may go on to become a hurricane or typhoon. Eventually the storm weakens as it travels over land or colder waters. The classification criteria for tropical storms are shown in Table 7-19. Hurricanes are further classified based on the Safir/Simpson scale, as shown in Table 7-20.

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Table 7-19: Classification Criteria for Tropical, Subtropical, and Extratropical Cyclones	
Development Stage	Criteria
Tropical Depression (development)	The formative stages of a tropical cyclone in which the maximum sustained (1-min mean) surface wind speed is <39 mph (<18 m/s).
Tropical Storm	A warm core tropical cyclone in which the maximum sustained surface wind speed (1-min mean) ranges from 39 to <74 mph (18 to <33 m/s).
Hurricane	A warm core tropical cyclone in which the maximum sustained surface wind speed (1-min mean) is at least 74 mph (33 m/s).
Tropical Depression (dissipation)	The decaying stages of a tropical cyclone in which the maximum sustained surface wind speed (1-min mean) have dropped below 39 mph (18 m/s).
Extratropical Cyclone	Tropical cyclones modified by interaction with nontropical environment. There are no wind speed criteria, and maximum winds may exceed hurricane force.
Subtropical Depression	A subtropical cyclone in which the maximum sustained surface wind speed (1-min mean) is below 39 mph (18 m/s).
Subtropical Storm	A subtropical cyclone in which the maximum sustained surface wind speed (1-min mean) is at least 39 mph (18 m/s).

Source: FEMA, 1997; modified from Neumann and others, 1993.

Table 7-20: Saffir/Simpson Hurricane Scale Ranges					
Scale Number (Category)	Central Pressure (mbar)	(inches)	Wind Speed (mph)	Storm Surge (feet)	Potential Damage
1	980+	28.94+	74 – 95	4 – 5	Minimal
2	965 – 979	28.50 – 28.91	96 – 110	6 – 8	Moderate
3	945 – 964	27.91 – 28.47	111 – 130	9 – 12	Extensive
4	920 – 944	27.17 – 27.88	131 – 155	13 – 18	Extreme
5	<920	<27.17	>155	>18	Catastrophic

Source: FEMA, 1997; Herbert and others, 1995.

7.3.14.2 History

Tropical cyclones approaching the western U.S. from the Pacific Ocean tend to weaken quickly, but their remnants are capable of delivering large amounts of rainfall to California, Nevada, Arizona, and New Mexico. The remnants of tropical cyclones affect Arizona infrequently, but are responsible for some of the most intense rainfall and flooding events in Arizona. Sometimes moisture associated with eastern Pacific hurricanes and tropical storms gets pulled north by the monsoon flow. When this occurs, continuous heavy rains can persist for 24 to 48 hours or longer, causing serious flooding.

A total of 8 tropical cyclones have affected Maricopa County, as shown in Table 7-3, only one of which resulted in a disaster/emergency declaration. A total of 23 fatalities were recorded and $380.8 million in damages, most of which were due to flooding associated with the tropical cyclones. These events affected both incorporated and unincorporated areas of Maricopa County and include the following:

- In late September 1983, Arizona was struck by a particularly strong tropical low. Flooding killed eight persons, reportedly injured 975, and caused $226.5 million in damages in the state. (FEMA, January 1991).
- In September 1997, Tropical Storm Nora reached the level of a category four hurricane before making landfall in California. Nora caused enormous flooding and $375 million in damages in Arizona, leading to a Presidential disaster declaration. The calculated 24-hour, 100-year rainfall amount in NW Maricopa County was exceeded at six Automated Local Evaluation in Real Time (ALERT) measuring sites. Yuma observed a 2-minute sustained wind of 45 mph during Nora's passage, a rarity in the United States for eastern Pacific

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tropical cyclones. Peak gusts of 54 mph, and 52 mph were also observed (ADEM, December 2001; NCDC, Storm Event Database; Maricopa County Flood Control District, September 2003; NWS).

7.3.14.3 Probability and Magnitude

Tropical cyclone probability is generally derived from coastal flooding caused by storm surge or by the frequency of tropical cyclones as determined by the number of landfall events over a given period of time for specific geographic areas. Maricopa County is not located in a coastal region and, as such, has experienced few tropical cyclones. Because of this, the probability and magnitude of tropical cyclone events has not been estimated for the county. However, as indicated by the historic data above, Maricopa County has been affected by 8 identified tropical cyclone events during the years 1962-2000, several of which caused massive damage, primarily via flooding. This suggests a low probability, but potentially high magnitude for tropical cyclones in the area.

7.3.14.4 Warning Time

Before watches and warnings are issued, the NWS, private forecasters, newspapers, radio and television normally try to alert the public to potential weather dangers. Often, forecasters begin issuing severe weather statements, advisories, or bulletins on hurricanes and winter storms three or four days before the storm hits. Usually, the NWS Storm Prediction Center sends out alerts the day before dangerous weather is likely. Most television weathercasters highlight these alerts on the evening news the day before threatening weather. All severe weather broadcasts covering Maricopa County originate from the NWS offices in Tucson, Phoenix, Flagstaff, or Las Vegas, Nevada.

A part of the NWS, the Tropical Prediction Center (TPC) issues watches, warnings, forecasts, and analyses of hazardous weather conditions in the tropics. The National Hurricane Center (NHC), a part of the TPC, maintains a continuous watch on tropical cyclones over the Atlantic, Caribbean, Gulf of Mexico, and the Eastern Pacific from 15 May through November 30. A hurricane watch indicates the possibility that hurricane conditions are expected within 36 hours. A watch should trigger disaster plans and protective measures, especially those actions that require extra time such as securing a boat, leaving a barrier island, etc. A hurricane warning indicates that sustained winds of at least 74 mph are expected within 24 hours or less. Once a warning has been issued, protective actions should be complete and movement to the safest location during the storm underway.

The NWS forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories). The warning time provided by a hurricane watch is on the order of days, while a hurricane warning typically provides warning time of 24 hours. This time should be sufficient for people to move to safety, although damage from a hurricane may still be significant. Given the historically small impact hurricane systems have had on Maricopa County communities an elaborate system to effectively provide advance notice for hurricane events may not be necessary. Instead, advance-warning techniques are most appropriate for specific hazards that are associated with the hurricane system, including flash floods, high winds, and lightning.

Unfortunately, there is no universal answer for every rainfall event. Warning times vary based on storm location, direction, intensity, duration, and the topography and size of the drainage area.

7.3.15 Wildfire

7.3.15.1 Nature

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. They often begin unnoticed, spread quickly, and are usually signaled by dense smoke that may fill the area for miles around. Wildfires can be human-caused through acts such as arson or campfires, or can be caused by natural events such as lightning. Wildfires can be categorized into four types:

- **Wildland fires** occur mainly in areas under federal control, such as national forests and parks, and are fueled primarily by natural vegetation.
- **Interface or intermix fires** occur in areas where both vegetation and structures provide fuel. These are also referred to as urban-wildland interface fires.

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- **Firestorms** occur during extreme weather (e.g., high temperatures, low humidity, and high winds) with such intensity that fire suppression is virtually impossible. These events typically burn until the conditions change or the fuel is exhausted.
- **Prescribed fires and prescribed natural fires** are intentionally set or natural fires that are allowed to burn for beneficial purposes.

The following three factors contribute significantly to wildfire behavior and, as detailed more fully later, they can be used to identify wildfire hazard areas:

- **Topography**: As slope increases, that is the divergence of the terrain from horizontal, the rate of wildfire spread increases. South facing slopes are also subject to greater solar radiation, making them drier and thereby intensifying wildfire behavior. However, ridgetops may mark the end of wildfire spread, since fire spreads more slowly or may even be unable to spread downhill.
- **Fuel**: Weight or volume are the two methods of classifying fuel, with volume also referred to as fuel loading (measured in tons of vegetative material per acre). Each fuel is assigned a burn index (the estimated amount of potential energy released during a fire), an estimate of the effort required to contain a wildfire, and an expected flame length. The fuel's continuity is also an important factor, both horizontally and vertically.
- **Weather**: The most variable factor affecting wildfire behavior is weather. Important weather variables are temperature, humidity, wind, and lightning. Weather events ranging in scale from localized thunderstorms to large fronts can have major effects on wildfire occurrence and behavior. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildfire activity. By contrast, cooling and higher humidity often signals reduced wildfire occurrence and easier containment.

The frequency and severity of wildfires is also dependent upon other hazards, such as lightning, drought, and infestations (e.g., Pine Bark Beetle). In Arizona, these hazards combine with the three other wildfire contributors noted above (topography, fuel, weather) to present an on-going and significant hazard across much of Arizona.

If not promptly controlled, wildfires may grow into an emergency or disaster. Even small fires can threaten lives, resources, and destroy improved properties. It is also important to note that in addition to affecting people, wildfires may severely affect livestock and pets. Such events may require the emergency watering/feeding, shelter, evacuation, and increased event-caused deaths and burying of animals.

The indirect effects of wildfires can also be catastrophic. In addition to stripping the land of vegetation and destroying forest resources, large, intense fires can harm the soil, waterways and the land itself. Soil exposed to intense heat may lose its capability to absorb moisture and support life. Exposed soils erode quickly and enhance siltation of rivers and streams thereby enhancing flood potential, harming aquatic life and degrading water quality. Lands stripped of vegetation are also subject to increased landslide hazards.

7.3.15.2 History

Historically, wildfires have burned thousands of acres in Maricopa County, as shown in Figure 7-25. On average, 58 percent of these wildfires are human caused, while 42 percent are lightning caused. Information on the location and size of wildfire events in Maricopa County were collected from a variety of sources. Most of the information came from the following two sources:

- The USDA Forest Service has published a study titled *Development of Coarse-Scale Spatial Data for Wildland Fire and Fuel Management* (April 2002). This study describes and makes available seven coarse-scale (1 square kilometer) resolution spatial data layers for the contiguous U.S. to support national-level fire planning and risk assessments. One of the layers, National Fire Occurrence, 1986 to 1996, contains information on Federal and non-Federal wildfire occurrence, including date, location, area burned, and cause. Information for wildfires in Arizona was retrieved from this layer. These events were screened to include only fires 100+ acres in size.
- The Arizona State Land Department's wildfire dispatcher working database of wildfire incidents in Arizona from 1994 to 2002 (Pearlberg, April 3, 2003). This database included information on the date, location, area

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burned, and cause of wildfires. In order to avoid overlap, information from this database was used for the period 1997 to 2002. These events were screened to include only fires 100+ acres in size

A total of 83 significant wildfires in Maricopa County were identified during the period 1968-2002, as shown in Table 7-3, which is second only to drought among the highest number of hazard events identified in Maricopa County across all hazard categories. These events were at least 100 acres in size or were severe enough to be identified in historical records. A disaster/emergency declaration was made for 16 wildfires. The following are some of the largest wildfires in Maricopa County's history:

- In July 1979, lightning caused the Verde Fire, which spread over 35,678 acres of Tonto National Forest land about 40 miles northeast of Phoenix. Also, the Castle Fire was caused by a lightning strike about 50 miles northwest of Phoenix in the Bradshaw Mountains, with the fire burning 28,600 acres in the Prescott National Forest (Arizona Republic, June 20, 2003).
- In 1994, the Perkins Fire burned 25,946 acres of Bureau of Land Management land near Phoenix (Arizona Republic, June 30, 2003).
- On April 27, 1996, the Lone Fire was started by campers in the Tonto National Forest near Roosevelt Lake and eventually burned 61,370 acres of canyons and scrub-covered mountains (Arizona Republic, June 20, 2003).
- March 30, 2004, The Citris Fire located west of Gila Bend burned over 5,700 acres along the Gila River included State, Private and Federal lands.

The location of significant wildfires (100+ acres) in Maricopa County is shown in Figure 7-25, with the number of wildfires per jurisdiction tabulated in Table 7-21. As illustrated through Figure 7-25, many of the wildfires Maricopa County has endured over the past 34 years have occurred near the greater metropolitan area. This region of the county, with a localized resident base that continues to expand at a significant rate, is projected to experience a growing number of wildfire events that affect this growing population. This may occur because many of Maricopa County's new residents will choose to live in areas that have been relatively protected from loss caused by wildfire events. This has been the circumstance because Maricopa County's development patterns have not necessitated the development of infrastructure needed to facilitate new construction in forested and other non-urban areas. If current development trends in the county continue, however, this circumstance may change. In particular, if the burgeoning metropolitan region surrounding Phoenix grows near vulnerable natural features, this threat is expected to become more and more pervasive. As shown in Table 7-21 in conjunction with Figure 7-25, it is demonstrated that there have been numerous wildfires throughout the County. Table 7-21 has data limitations in that it is only able to record those fires that can be accurately geo-coded. Figure 7-25 indicates that Unincorporated Maricopa County, itself, has experienced approximately 32 significant wildfires between 1968-2002, with 28 affecting between 100-499 acres, 2 damaging an area 500-999 acres, and one engulfing over 1,000 acres in size.

Table 7-21: Significant Wildfires, 1968-2002

Jurisdiction	Wildfire Size			
	100-499 acres	500-999 acres	1,000+ acres	Total
Unincorporated Maricopa County	0	0	0	0
Maricopa County Total	11	1	1	13

Note: Only those wildfires that could be accurately located (geocoded) are counted above.

Source: USDA Forest Service, April 2001; Arizona State Land Department; URS, October 2003.

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Figure 7-25: Significant Wildfires, 1968-2002

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7.3.15.3 Probability and Magnitude

Depending upon the needs of the user and the availability of data, there are many different approaches to fire modeling. However, nationally accepted or utilized wildfire models have not been developed for the evaluation of wildfire risk or conducting vulnerability analysis. In addition, most wildfire modeling conducted to date has been focused on wildfire behavior, not true probability and magnitude modeling. This is because the probability of ignition and the probable wildfire size has generally not been considered. In addition, there have been major limitations in terms of software systems, data availability, and data coverage/resolution.

These limitations aside, with improving Geographic Information Systems (GIS) programs and data availability, there are a growing number of wildfire hazard assessment models. In addition, as a part of the National Fire Plan, communities have also been identified across the U.S. that are at risk to wildfires. Finally, using an approach utilized by the International Fire Code Institute (IFCI), FEMA has a suggested approach to identify wildfire hazard areas. These are each addressed below, with specific information on Arizona identified where available.

In the absence of a statewide wildfire risk assessment model for Maricopa County, the approach specified by FEMA in *How-To #2: Understanding Your Risks -Identifying Hazards and Estimating Losses* for the identification of wildfire hazard areas have been followed, with a number of adjustments taken to account for Arizona specific factors. The FEMA methodology is the same as that specified from the International Fire Code Institute (IFCI) in the *Urban-Wildland Fire Interface Code 2000*.

To determine the risk of wildfire in Maricopa County it was necessary to determine what areas are the most susceptible and exposed to the greatest risk of wildfires. The *Urban-Wildland Interface Code* model relies on the relationship between the three primary fire potential factors to estimate fire hazard severity: topography, critical fire weather, and fuel availability. The relationship between these three factors and wildfire susceptibility is shown in Table 7-22.

Table 7-22: FEMA/IFCI Wildfire Susceptibility Matrix

Fuel Class	Critical Fire Weather Frequency								
	<1 day per year			2-7 days per year			8+ days per year		
	Slope %			Slope %			Slope %		
	<40	41-40	61+	<40	41-40	61+	<40	41-40	61+
Light	M	M	M	M	M	M	M	M	H
Medium	M	M	H	H	H	H	E	E	E
Heavy	H	H	H	H	E	E	E	E	E

Note: M = Medium, H = High, E = Extreme.
Source: International Fire Code Institute, January 2000

The first factor, topography, was obtained from the State Digital Elevation Model (DEM). Steeper slopes generally increase fire velocity. The FEMA/IFCI model breaks slope into three broad classes: ≤ 40 percent, 41-60 percent, ≥ 61 percent. The U.S. Geological Survey Digital Elevation Model, 75meter/250 feet cell size was used to determine slope in Arizona. As shown in Figure 7-26, the majority of Maricopa County and the majority of Unincorporated Maricopa County topography present slopes of less than 40 percent slope. However, Unincorporated Maricopa County does exhibit slopes between 41%-60% and, in some areas, slopes exceeding 61% are evident. As expected, these regions of the County include slopes found in and around South Mountain, within the North Mountain Preserve, Phoenix Mountain Preserve—including Piestewa Peak and Camelback Mountain—and with greater density in the eastern portion of the County around Apache Lake and Canyon Lake.

The second factor, critical fire weather frequency, proved more difficult to evaluate due to the apparent unavailability of long-term GIS coverage/data for the state. Discussions with the Maricopa County Hazard Mitigation Plan Team indicated that it was reasonable to assume that the county experiences 35 to 60 very high or extremely high critical fire weather days per year during the summer months.

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Figure 7-26: Slope Model

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For the third factor, as recommended by FEMA, the US Forest Service's National Fire Danger Rating System (NFDRS) fuel model dated July 1999 was used. The NFDR fuel models have been mapped in raster format across the lower 48 states at 1 km resolution, derived from satellite imagery and ground sampling that can be converted into GIS format.

The NFDRS fuel models describe twenty regional vegetative biomes which are assigned a model letter (e.g., A, B, C). Not all 20 NFDRS models were mapped. Fuel model E (hardwoods after leaf fall) was not used. Only model R was used for hardwoods because the live load can be transferred between the live and dead vegetation classes as a function of changes in vegetation greenness as observed from satellites. The slash fuel models (I, J, and K) were not used because the location, extent and condition of activity fuels changes relatively quickly.

Each NFDRS fuel model was then classified as heavy, medium or light fuel based upon availability, moisture content, and continuity. The classification scheme is contained in *FEMA's How-To #3: Understanding Your Risks*.

In addition, the NFDRS fuel model does not identify or exclude areas that are urbanized. In order to avoid overstating the wildfire danger in highly urbanized areas, two additional screens were conducted:

- Detailed existing land use layers for Maricopa County was obtained. Only polygons greater than 10 acres in size with the following land uses were included: vacant; parks and recreation; and forests. All other existing land use polygons were identified as urban.

By combining the three factors, topography, critical fire weather frequency, and fuel using the matrix in Table 7-22, it was possible to produce the wildfire hazard areas map shown in Figure 7-28. The map shows a close correspondence between the heavy fuel model and the areas of extreme wildfire susceptibility.

7.3.15.4 Warning Time

The warning time provided by wildfire warnings is typically on the order of days, providing sufficient time for people to evacuate potential hazard areas. Major wildfire warning services are provided by the Wildland Fire Assessment System (WFAS) and the National Weather Service (NWS).

National Fire Danger Rating System (NFDRS): Every day during the fire season, national maps of selected fire weather and fire danger components of the National Fire Danger Rating System (NFDRS) are produced by the Wildland Fire Assessment System (WFAS) at the USDA Forest Service Rocky Mountain Research Station in Missoula, Montana. The maps characterize fire danger by evaluating the approximate upper limit of fire behavior in a fire danger rating area during a 24-hour period. The NFDRS uses computer programs and algorithms based on fuels, topography and weather to estimate short-term (today and tomorrow) fire danger for a given rating area. NFDRS fire danger is rated by evaluating the approximate upper limit of fire behavior in a fire danger rating area during a 24-hour period. The ratings are for the potential growth and behavior of a wildfire. They are used to guide presuppression activities and the selection of appropriate level of initial response to a reported wildfire (in lieu of detailed, site- and time-specific information). In essence, the ratings link an organization's readiness level (or pre-planned fire suppression actions) to the fire problems of the day (NWS).

Note that the NFDRS relates only to the potential of an initiating fire, one that spreads without crowning or spotting, through uniform fuels on a continuous slope. It measures fire only from a containment standpoint as opposed to full extinction. In addition, the NFDRS represents near worst-case conditions measured at exposed locations at or near the peak of the normal burning period. Also note that the NFDRS is a broad scale rating, approximately for 100,000 acres. Besides the basic fire danger ratings of low, moderate, high, very high and extreme, the NFDRS calculates parameters to aid agencies in determining staffing levels, how hot a fire will burn and spread, ignition component and flame length. One possible outcome of a high fire danger is an agency may have to ban campfires or prescribed burning on federal lands.

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Figure 7-27: Modified National Fire Danger Rating System Fuel Model

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Figure 7-28: Wildfire Hazard Areas

In addition to the NFDRS warnings, the NWS prepares fire weather warnings for localized areas. The NWS forecast office in Phoenix provides a wide range of weather related information, including current conditions, regional weather forecasts, and storm information (e.g., watches, warnings, statements, or advisories). These offices may issue the following wildfire warnings:

- Fire Weather Zones: Complete fire weather forecasts for states or forecast regions. These forecasts are prepared twice daily during fire weather season, and once daily during the off-season. This forecast is used for day-to-day planning of land management operations and for determining general weather trends that might impact fire behavior.
- Fire Weather Spot Forecasts: Special point fire weather forecasts made for controlled burns or wildfires. Spot forecasts are special, non-routine forecasts prepared upon request from user agencies that need site-specific weather forecasts in order to control the spread of wildfire, plan and manage prescribed fires, or other specialized forest management activities.
- Fire Weather Statements, Watches and Warnings: During periods in which critical fire weather conditions are expected or are imminent, the NWS will issue statements, watches and warnings to describe the level of urgency to the appropriate user agencies and the public. These are coordinated with the land management agencies.
- Red Flag Warning / Event: Special forecast issued when red flag conditions exist or are highly probable and the forecast time of onset is less than 24 hours. A Red Flag Event occurs when critical weather conditions develop which could lead to extensive wildfire occurrences or to extreme fire behavior. Red Flag Events represent a hazard to life and property and may adversely impact fire fighting personnel and resources. Critical weather conditions include combinations of the following: strong, gusty wind, very low relative humidity, highly unstable atmosphere, significant wind shifts or lightning. Typically, these weather conditions must be coupled with very low fuel moistures.
- Fire Danger Statements and Blow-Up Alerts: When fire danger or fire occurrence is high and is coupled with critical weather conditions, the U.S. Forest Service or state land management agencies may request that the NWS issue a Fire Danger Statement or Blow-Up Alert.

It should also be noted that longer-term forecasts are also made, typically prior to the fire season. An example is the *Long-Range Fire Risk Assessment, Southwest Geographic Area, 2003 Fire Season* (Heckman et al, April 30, 2003).

7.4 Asset Inventory

The third step in the risk assessment process is the identification of assets that may be affected by hazard events. The inventory of assets is divided into the following five major categories, each of which is analyzed in detail below:

- Population
- Buildings
- Critical facilities and infrastructure

Assets include any type of structure or critical facility such as hospitals, schools, museums, apartment buildings, and public infrastructure. An inventory of existing and proposed assets within Unincorporated Maricopa County was generated. The assets were then mapped to show their locations and to determine their vulnerability to each hazard type. The Plan also evaluates proposed structures, including planned and approved developments, based upon a review of the Maricopa County General Plan Land Use Element.

7.4.1 Population

Historic and projected population for Maricopa County and Unincorporated Maricopa County was provided in Section 6. This information was from a variety of sources, including the Arizona Department of Commerce, Arizona Department of Economic Security, and the US Census Bureau.

Similar information is provided here on population, with all information from FEMA's program, Hazards US Multi-Hazard (HAZUS) which is based on US Census Bureau data. Information shown includes the following:

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- Total population
- Total number of households
- Number of persons <19 years old (potentially vulnerable population group)
- Number of persons 65+ years old (potentially vulnerable population group)
- Number of households with income <$20,000 income (potentially vulnerable population group)

Overall, Unincorporated Maricopa County includes both a moderate number and proportion of its population that is vulnerable to hazards. As shown in Table 7-23, in 2000 approximately 30% of Maricopa County's residents, including those residing in cities and towns in the County, were under the age of 19, and 12% were over the age of 65. By contrast, only 4% of the residents of Unincorporated Maricopa County were under the age of 19, and 23% were over the age of 65. This comparison indicates that the residents located outside of cities and towns in Maricopa County are somewhat older than those living in incorporated areas. In addition, Unincorporated Maricopa County's household income levels are markedly higher than those countywide, with only 1% of its households earning under $25,000 annually, compared to 24% countywide. This marked improvement over countywide performance for this indicator may be attributable to the high number of master planned communities located in Unincorporated Maricopa County. By comparison to the region, residents of Unincorporated Maricopa County tend to own their homes instead of renting, with a ratio of owners to renters of 7.8:1.0. As shown in Table 7-24, this number contrasts to a countywide ratio of 2.1:1.0. Unincorporated Maricopa County's housing units are comparatively new, with only 16% being built before 1970, compared to 21% for the County as a whole.

Table 7-23: Populations Potentially Vulnerable to Hazards, 2000

Jurisdiction	Population			Households	
	Total	<19 years	65+ years	Total	Income <$25,000
Maricopa County	3,072,149	913,187	358,834	1,133,048	274,821
Unincorporated Maricopa County	204,018	35,964	82,033	91,287	27,111

Source: US Census Bureau.

Table 7-24: Dwelling Units Potentially Vulnerable to Hazards, 2000

Jurisdiction	Homeownership-Owners Vs. Renters		Housing Units	
	Homeowners	Renters	Total	Built <1970
Maricopa County	764,563	368,323	1,250,231	262,325
Unincorporated Maricopa County	82,799	10,576	107,643	17,386

Source: US Census Bureau.

Table 7-25: Population of Maricopa County Communities, 2000-2030					
Municipal Planning Area (MPA)	Total Resident Population 2000	Total Resident Population 2010	Total Resident Population 2020	Total Resident Population 2025	Total Resident Population 2030
Avondale	37,800	82,100	122,500	141,600	161,400
Buckeye	16,700	58,600	153,400	275,500	380,600
Carefree	3,000	4,000	4,800	4,800	4,900
Cave Creek	3,900	5,100	5,800	9,800	12,900
Chandler	185,300	260,000	286,600	287,000	288,600
County Areas	85,300	92,900	109,900	124,600	138,000
El Mirage	8,700	29,700	31,400	32,200	33,100
Fountain Hills	20,500	24,700	30,400	30,400	30,700
Gila Bend	2,300	2,800	6,000	12,500	17,800
Gila River *	2,700	3,200	4,200	4,700	5,200
Gilbert	119,200	202,800	280,300	281,900	290,500
Glendale	230,300	290,400	308,100	309,800	312,200
Goodyear	21,200	61,300	161,100	247,400	330,400
Guadalupe	5,200	5,200	5,500	5,500	5,600
Litchfield Park	3,800	7,000	13,700	13,700	14,200
Mesa	441,800	537,900	617,800	630,300	647,800
Paradise Valley	14,100	15,200	15,700	15,800	15,900
Peoria*	114,100	160,800	206,600	232,200	253,400
Phoenix	1,350,500	1,700,300	2,022,500	2,101,600	2,187,500
Queen Creek*	7,400	18,900	58,300	73,100	88,100
Salt River	6,500	7,400	7,500	7,500	7,500
Scottsdale	204,300	253,100	287,300	289,600	292,700
Surprise	37,700	115,200	213,300	312,300	395,500
Tempe	158,900	176,400	189,200	192,700	196,700
Tolleson	5,000	6,100	6,200	6,200	6,300
Wickenburg	7,400	7,700	10,000	14,800	16,000
Youngtown	3,000	5,400	6,200	6,300	6,600
TOTAL	3,096,600	4,134,400	5,164,100	5,664,000	6,140,000

Source: Maricopa Association of Governments, Interim Projections, June 25, 2003

Total resident population includes resident population in households and resident population in group quarters (dorms, nursing homes, prisons and military establishments). MPA numbers are rounded to the nearest 100. County numbers may not add due to rounding.

*These projections include the Maricopa County portion of the community only.

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7.4.2 Buildings

HAZUS-MH includes an inventory of buildings and their estimated values. Of particular interest for hazard mitigation planning are the numbers of residential and commercial buildings. The concentration of population in Maricopa County (noted above) is the source of the large number and value of buildings in the area, as shown in Table 7-26.

Table 7-26: Buildings in Maricopa County, 2000

Jurisdiction	Residential Buildings	Commercial Buildings	Total Buildings
Avondale	9,781	25	9,806
Buckeye	1,804	2	1,806
Carefree	2,322	15	2,337
Cave Creek	1,742	21	1,763
Chandler	58,060	398	58,458
El Mirage	2,508	3	2,511
Fort McDowell Yavapai Nation	280	1	281
Fountain Hills	8,983	46	9,029
Gila Bend	586	-	586
Gilbert	36,773	140	36,913
Glendale	61,448	499	61,947
Goodyear	6,439	44	6,483
Guadalupe	990	2	992
Litchfield Park	2,006	3	2,009
Mesa	132,429	1,100	133,529
Paradise Valley	8,079	20	8,099
Peoria	39,396	134	39,530
Phoenix	356,542	4,877	361,419
Queen Creek	1,270	6	1,276
Salt River Pima- Maricopa Native Comm.	2,423	39	2,462
Scottsdale	90,638	1,250	91,888
Surprise	14,187	22	14,209
Tempe	44,071	1,111	45,182
Tolleson	1,183	20	1,203
Unincorporated Maricopa County	96,814	364	97,178
Wickenburg	1,999	35	2,034
Youngtown	1,190	14	1,204
Total	984,192	10,191	994,383

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7.4.3 Critical Facilities and Infrastructure

Critical facilities are systems or facilities whose incapacity or destruction would have a debilitating impact on the defense or economic security of the nation, include the following:

- Airport Facilities
- Bridges
- Broadcast Facilities
- Bus Facilities
- Electric Facilities
- Emergency Facilities
- Gas Facilities
- Government Facilities
- Hospital Facilities
- Oil Facilities
- Rail Facilities
- School Facilities
- Potable and Wastewater Facilities

Specific abbreviations that apply to the critical facilities in Maricopa County have been identified in Table 7-27 on the following page. HAZUS-MH includes an inventory and estimated property values for these facilities that have been used for all of Arizona, except Maricopa County. In Maricopa County, the HAZUS-MH database has been supplemented with information from the Maricopa County Department of Emergency Management (MCDEM). This inventory was also reviewed and updated by most of the local jurisdictions in Maricopa County ,with default HAZUS-MH estimated values (property only, not contents) used.

Again, due to the large population noted above, many of these facilities are concentrated in Maricopa County greater metropolitan communities, as shown in tables 7-28 through 7-41.

Table 7-27: Abbreviations for Jurisdiction Critical Facilities	
AIR	Airport Facilities
BRG	Bridges
BRT	Broadcast Facilities
BUS	Bus Facilities
ELEC	Electric Facilities
EMER	Emergency Facilities
GAS	Gas Facilities
GOVT	Government Facilities
HOSP	Hospital Facilities
OIL	Oil Facilities
RAIL	Rail Facilities
SCH	School Facilities
WTR	Potable and Wastewater Facilities

This section of Unincorporated Maricopa County Hazard Mitigation Plan is intended to identify the type and number of buildings, infrastructure, and other critical facilities at risk from the hazards identified in the previous sections and to estimate the potential dollar losses resulting from each. For the purpose of this plan, critical facilities have been classified using the key described in Table 7-27.

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Beginning with Table 7-28: Inventory of Potential Exposure to Critical Facilities from All Hazards, and continuing through Table 7-41: Potential Exposure to Critical Facilities from Wildfire Hazard (Extreme and Medium Risks Combined), the critical facilities located within both Unincorporated Maricopa County and Maricopa County as a whole are summarized, and their losses estimated. Table 7-28 shows the total number of critical facilities in Unincorporated Maricopa County and in Maricopa County addressed in this plan by type. In all, there are 3,011 critical facilities in Maricopa County, with 713 found in Unincorporated Maricopa County. Within this population, Maricopa County is exposed to over $6.4 billion in exposed losses from these facilities, with nearly $972.4 million worth of critical facilities located within Unincorporated Maricopa County. The single facility class that presents the greatest potential from loss in Unincorporated Maricopa County is Bridges, where this facility type, with a potential cumulative loss of $568.1 million, represents 514 of the 713 total Unincorporated Maricopa County critical facilities.

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Table 7-28: Inventory of Potential Exposure to Critical Facilities from All Hazards															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	28	514	9	0	1	45	1	1	2	1	0	21	90	713
	Exposure (x$1000)	140,000	568,084	855	0	104,500	67,500	1,036	1,000	10,000	95	0	10,500	68,800	972,370
Total Number		47	1,415	64	4	17	264	1	27	36	6	10	543	577	3,011
Total Exposure (x$1000)		235,000	2,873,025	6,080	4,142	1,776,500	396,000	1,036	27,000	180,000	570	20,710	271,500	635,700	6,427,263

Table 7-29: Potential Exposure to Critical Facilities from Dam Hazard (High Risk)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	6	109	8	0	1	19	0	0	2	0	0	6	57	208
	Exposure (x$1000)	30,000	156,788	760	0	104,500	28,500	0	0	10,000	0	0	3,000	35,600	369,148
Maricopa County Total Number		16	909	61	4	13	206	0	18	35	2	10	464	469	2,207
Maricopa County Total Exposure (X$1000)		80,000	1,979,914	5,795	4,144	1,358,500	309,000	0	18,000	175,000	190	20,710	232,000	533,400	4,716,653

Table 7-30: Potential Exposure to Critical Facilities from Dam Hazard (Unsafe Risk)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	0	10	0	0	0	8	0	0	1	0	0	0	11	30
	Exposure (x$1000)	0	6,139	0	0	0	12,000	0	0	5,000	0	0	0	1,100	24,239
Maricopa County Total Number		1	20	0	0	1	20	0	2	1	0	1	6	48	100
Maricopa County Total Exposure (X$1000)		5,000	23,747	0	0	104,500	30,000	0	2,000	5,000	0	2,071	3,000	5,700	181,018

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Table 7-31: Potential Exposure to Critical Facilities from Dam Hazard (High, Unsafe, and Both High & Unsafe Risks Combined)

Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	7	124	9	0	1	28	0	0	3	0	0	7	82	261
	Exposure (x$1000)	35,000	168,666	855	0	104,500	42,000	0	0	15,000	0	0	3,500	68,000	437,521
Maricopa County Total Number		20	975	62	4	15	233	0	22	37	2	11	484	572	2,437
Maricopa County Total Exposure (X$1000)		100,000	2,081,898	5,890	4,144	1,567,500	349,500	0	22,000	185,000	190	22,781	242,000	667,800	5,248,703

Table 7-32: Potential Exposure to Critical Facilities from Dam Hazard (Inundation Risk)

Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	3	74	0	0	0	16	0	0	0	0	0	4	30	127
	Exposure (x$1000)	15,000	102,410	0	0	0	24,000	0	0	0	0	0	2,000	3,000	146,410
Maricopa County Total Number		14	309	3	1	7	87	0	5	8	0	3	143	238	818
Maricopa County Total Exposure (X$1000)		70,000	697,358	285	1,036	731,500	130,500	0	5,000	40,000	0	6,213	71,500	475,000	2,228,392

Table 7-33: Potential Exposure to Critical Facilities from Earthquake Hazard (100 Year)

Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	28	514	9	0	1	45	1	1	2	1	0	21	90	713
	Loss (x$1000)	140	568	1	0	105	68	1	1	10	0	0	11	69	972
Maricopa County Total Number		47	1,415	64	4	17	264	1	27	36	6	10	543	577	3,011
Maricopa County Total Exposure (X$1000)		235	2,873	6	4	1,777	396	1	27	180	1	21	272	636	6,427

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Table 7-34: Potential Exposure to Critical Facilities from Earthquake Hazard (500 Year)														
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	28	514	9	0	1	45	1	1	2	1	0	21	90	713
	Loss (x$1000)	1,400	5,681	9	0	1,045	675	10	10	100	1	0	105	688	9,724
Maricopa County Total Number		47	1,415	64	4	17	264	1	27	36	6	10	543	577	3,011
Maricopa County Total Exposure (X$1000)		2,350	28,730	61	41	17,765	3,960	10	270	1,800	6	207	2,715	6,357	64,273

Table 7-35: Potential Loss to Critical Facilities from Flood Hazard (100 Year)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	Loss (x$1000)	0	0	0	0	0	0	0	0	0	0	0	0	189,810	189,810
Maricopa County Total Number		0	0	2	0	2	0	0	0	0	0	1	0	5	10
Maricopa County Total Exposure (X$1000)		0	0	190	0	209,000	0	0	0	0	0	2,071	0	284,715	495,976

Table 7-36: Potential Exposure to Critical Facilities from HazMat Hazard (2-Mile Radius)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	2	48	2	0	1	23	0	1	2	1	0	7	40	127
	Exposure (x$1000)	10,000	54,293	190	0	104,500	34,500	0	1,000	10,000	95	0	3,500	4,000	222,078
Maricopa County Total Number		14	759	19	4	16	194	0	20	32	6	9	435	407	1,915
Maricopa County Total Exposure (X$1000)		70,000	1,780,382	1,805	4,144	1,672,000	291,000	0	20,000	160,000	570	18,639	217,500	375,000	4,611,040

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Table 7-37: Potential Exposure to Critical Facilities from Subsidence Hazard (Historical)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	3	26	0	0	0	12	0	0	1	1	0	3	12	58
	Exposure (x$1000)	15,000	18,156	0	0	0	18,000	0	0	5,000	95	0	1,500	1,200	58,951
Maricopa County Total Number		6	181	0	0	3	52	0	7	4	2	0	77	114	446
Maricopa County Total Exposure (X$1000)		30,000	210,424	0	0	313,500	78,000	0	7,000	20,000	190	0	38,500	193,500	891,114

Table 7-38: Potential Exposure to Critical Facilities from Subsidence Hazard (Water Level Decline)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	3	52	3	0	1	15	0	1	1	0	0	5	33	114
	Exposure (x$1000)	15,000	62,544	285	0	104,500	22,500	0	1,000	5,000	0	0	2,500	63,100	276,429
Maricopa County Total Number		11	491	13	4	12	142	0	14	28	4	9	356	312	1,396
Maricopa County Total Exposure (x$1000)		55,000	1,305,733	1,235	4,144	1,254,000	213,000	0	14,000	140,000	380	18,639	178,000	246,800	3,430,931

Table 7-39: Potential Exposure to Critical Facilities from Wildfire Hazard (Extreme Risk)															
Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	1	225	0	0	0	0	0	0	0	0	0	0	0	226
	Exposure (x$1000)	5,000	242,492	0	0	0	0	0	0	0	0	0	0	0	247,492
Maricopa County Total Number		1	226	0	0	0	0	0	0	0	0	0	0	0	227
Maricopa County Total Exposure (x$1000)		5,000	242,740	0	0	0	0	0	0	0	0	0	0	0	247,740

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Table 7-40: Potential Exposure to Critical Facilities from Wildfire Hazard (Medium Risk)

Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	14	139	3	0	0	4	0	0	1	0	0	0	23	184
	Exposure (x$1000)	70,000	130,116	285	0	0	6,000	0	0	5,000	0	0	0	62,100	273,501
Maricopa County Total Number		17	253	8	0	2	35	0	1	2	0	1	43	119	481
Maricopa County Total Exposure (x$1000)		85,000	318,753	760	0	209,000	52,500	0	1,000	10,000	0	2,071	21,500	194,000	894,584

Table 7-41: Potential Exposure to Critical Facilities from Wildfire Hazard (Extreme and Medium Risks Combined)

Jurisdiction	Data	AIR	BRG	BRT	BUS	ELEC	EMER	GAS	GOVT	HOSP	OIL	RAIL	SCH	WTR	Total
Unincorporated Maricopa County	Number	15	364	3	0	0	4	0	0	1	0	0	0	23	410
	Exposure (x$1000)	75,000	372,608	285	0	0	6,000	0	0	5,000	0	0	0	62,100	520,993
Maricopa County Total Number		18	479	8	0	2	35	0	1	2	0	1	43	119	708
Maricopa County Total Exposure (x$1000)		90,000	561,493	760	0	209,000	52,500	0	1,000	10,000	0	2,071	21,500	194,000	1,142,324

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7.5 Vulnerability Assessment

The fourth step of the risk assessment and its primary intent is the vulnerability assessment. This provides an approximation of vulnerability and potential losses from hazards, typically based on a commonly accepted methodology and event type. Wherever possible, a quantitative and comparable assessment of vulnerability to hazards was made.

Note that the loss estimates provided herein use the best data currently available and the methodologies applied result in an approximation of risk. These estimates may be used to understand relative risk from hazards and potential losses. However, uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning hazards, their effects on the built environment, as well as approximations and simplifications that are necessary for a comprehensive analysis.

It is also important to note that the quantitative vulnerability assessment results are limited to the exposure of people, buildings, and critical facilities and infrastructure to hazards and, where possible, annualized loss estimates in dollar value for the buildings and critical facilities. It was beyond the scope of this first Maricopa County Unincorporated Area Hazard Mitigation Plan to analyze other types of hazard impacts (e.g., people injured or killed, shelter requirements, loss of facility/system function, and economic losses). Such impacts will be addressed as possible with future updates of the plan.

In addition, several of the hazards that are profiled in the preceding sections may not include corresponding exposure and loss data and are, therefore, not included in the vulnerability assessment which follows. Disease, for example, is a wide-ranging and unpredictable hazard to humans, animals, and plants. This variability in historic occurrence of these phenomena prevents meaningful predictability for disease. The vulnerability of people, buildings, and critical facilities/infrastructure associated with other hazards, including landslides and lightning, are nearly impossible to evaluate given the uncertainty associated with where these hazards will occur as well as the relatively limited focus and extent of damage. Due to these factors the following hazards, though creating vulnerability for the residents and structures in Unincorporated Maricopa County, do not include a quantitative analysis in the vulnerability assessment.

- Disease
- Extreme Heat
- Landslides
- Lightning
- Tropical Cyclone
- Winter Storm

Several of these phenomena have been included in the following discussion because a quantitative review of vulnerability does provide some insight to the nature of loss associated with the hazard. Through subsequent updates of this plan the data used to evaluate these unpredictable hazards may become refined such that a comprehensive vulnerability statement and thorough loss estimates can be made for hazards currently left out of the following review.

7.5.1 Methodology

To conduct the vulnerability assessment, wherever possible, a quantitative approach was used. Where this was not possible, a more qualitative approach was adopted.

Where adequate quantitative information and standardized software was available, a quantitative risk assessment was made. In this case, the preferred methodology was the use of FEMA's Hazards U.S. Multi-Hazard (HAZUS-MH) loss estimation software (see below for further information). Where HAZUS-MH could not be applied but quantitative information was available, another statistical risk assessment methodology was used. These quantitative methods provide estimates for the potential impact by using, where possible, a common, systematic framework for evaluation.

Where quantitative information or standardized software was lacking, a more qualitative evaluation has been made on the basis of each hazard's characteristics. These approaches are discussed in more detail below, followed by the

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individual hazard vulnerability assessments. General descriptions of the methodologies used for assessing the risks associated with the different hazards are included in the individual hazard profile/risk assessments as well as their results.

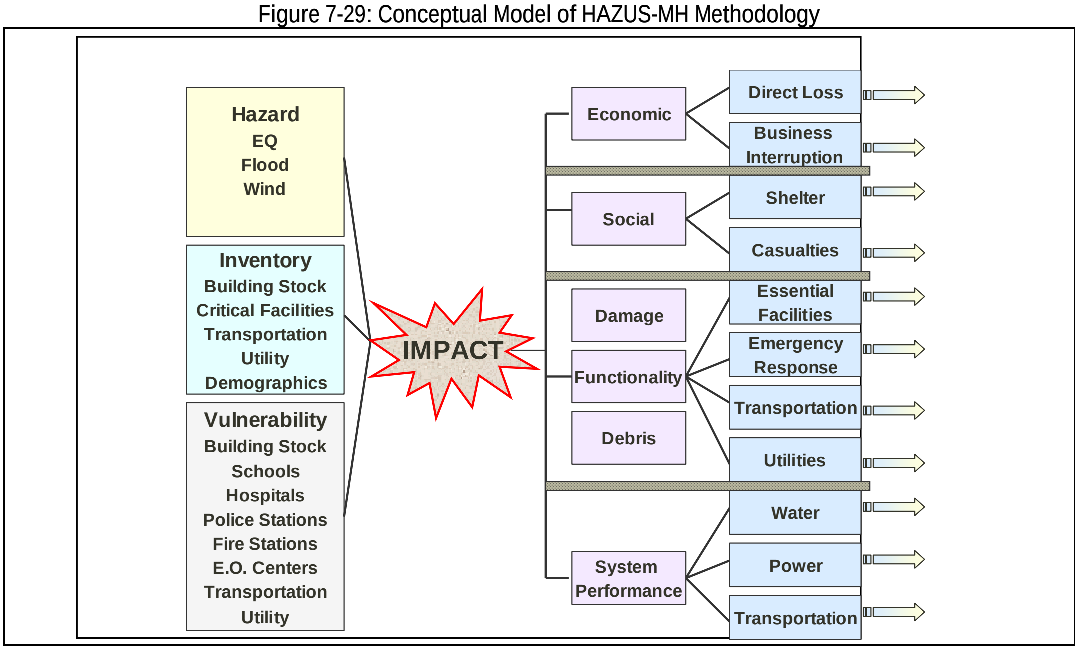
7.5.1.1 Quantitative Methodology – HAZUS-MH

Following the introduction of HAZUS-99 by FEMA for the analysis of earthquake risks, FEMA has expanded the program to allow the analysis of multiple hazards, with the new program known as Hazards U.S. Multi-Hazard (HAZUS-MH). In addition to earthquakes, HAZUS-MH can be used to evaluate risks for floods and wind events. HAZUS-MH also facilitates quantitative comparisons between hazards and may assist in the prioritization of hazard mitigation activities.

HAZUS-MH uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. The HAZUS-MH risk assessment methodology is parametric, in that distinct hazard and inventory parameters (e.g., wind speed and building types) are used to determine the impact (e.g., damages and losses) on the built environment. HAZUS-MH is built on an integrated Geographic Information System (GIS) platform, as shown in Figure 7-29.

At the time this analysis was completed, HAZUS-MH was available only in beta format and portions of the program were undergoing refinement. As such, where the modules were considered to still be in development, another standardized statistical assessment method/software was used (see below).

Figure 7-29: Conceptual Model of HAZUS-MH Methodology



Source: PBS&J, July 2003.

The economic loss results are presented as Annualized Losses (AL) whenever possible. AL addresses the two key components of risk: the probability of the hazard occurring in the study area and the consequences of the hazard, largely a function of building construction type and quality, and of the intensity of the hazard event. By annualizing estimated losses, the AL factors in historic patterns of frequent smaller events with infrequent but larger events to provide a balanced presentation of the risk.

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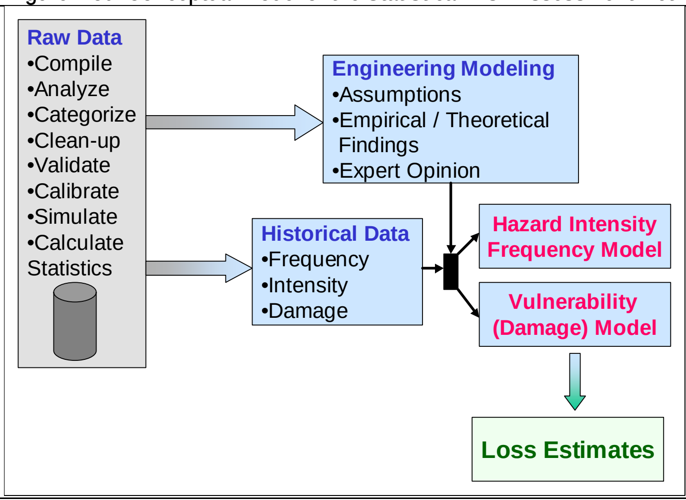
7.5.1.2 Quantitative Methodology – Statistical Vulnerability Assessment

For hazards outside the scope of HAZUS-MH, a specific statistical vulnerability assessment was developed and used. This approach is based on the same principals as HAZUS-MH, but does not rely on readily available automated software. Historical data for each hazard are used and statistical evaluations are performed using manual calculations.

A conceptual model of the statistical risk assessment methodology as applied is shown in Figure 7-30. The general steps used in the statistical risk assessment methodology are summarized below:

- Compile data from national and local sources
- Conduct statistical analysis of data to relate historical patterns within data to existing hazard models (minimum, maximum, average, and standard deviation)
- Categorize hazard parameters for each hazard to be modeled (e.g., tornado)
- Develop model parameters based on analysis of data, existing hazard models, and risk engineering judgment

Figure 7-30: Conceptual Model of the Statistical Risk Assessment Methodology



Source: PBS&J, July 2003.

- Apply hazard model including:
  - Analysis of frequency of hazard occurrence
  - Analysis of intensity and damage parameters of hazard occurrence
  - Development of intensity and frequency tables and curves based on observed data
  - Development of simple damage function to relate hazard intensity to a level of damage *(for example, one flood = $ in estimated damages)*
  - Development of exceedance and frequency curves relating a level of damage for each hazard to an annual probability of occurrence
  - Development of annualized loss estimates

Risk (Vulnerability) Assessment is presented in terms of annualized losses, whenever possible. In general, presenting results in the annualized form are very useful on three fronts:

- Contribution of potential losses from all future disasters is accounted for with this approach.

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- Results in this form from different hazards are readily comparable and hence easier to rank.
- When evaluating mitigation alternatives, use of annualized losses is the most objective approach for this purpose.

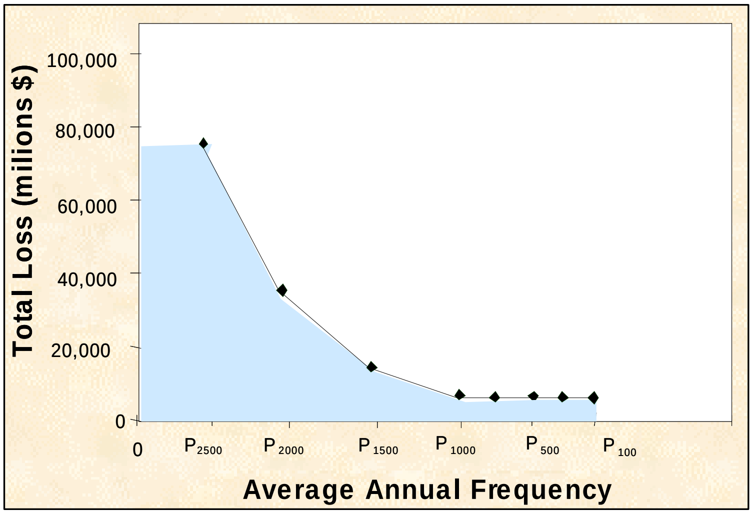
Annualized losses for the hazards where the parametric approach is utilized are computed in a three-step process:

1. Compute / estimate losses for a number of scenario events with different return periods [e.g., 10-year, 100-year, 200-year, 500-year, etc…]
2. Approximate the Probability versus Loss Curve through curve fitting
3. Calculate the area under the fitted curve to obtain annualized losses

This approach is illustrated graphically in the figure below.

For other hazards where the statistical approach was used, the computations are based primarily on the observed historical losses.

Figure 7-31: Graphical Representation of the Annualized Loss Methodology



Risks associated with other natural hazards were analyzed using a statistical assessment methodology developed and used specifically for this effort. Historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in the statistical risk assessment methodology are summarized below:

Compile data from the following sources;

- Local
- National
- Literature
- Clean up data
- Remove duplicates
- Update losses (For inflation)
- Modify losses (For population growth and distribution)

Identify patterns in;

- Frequency
- Intensity

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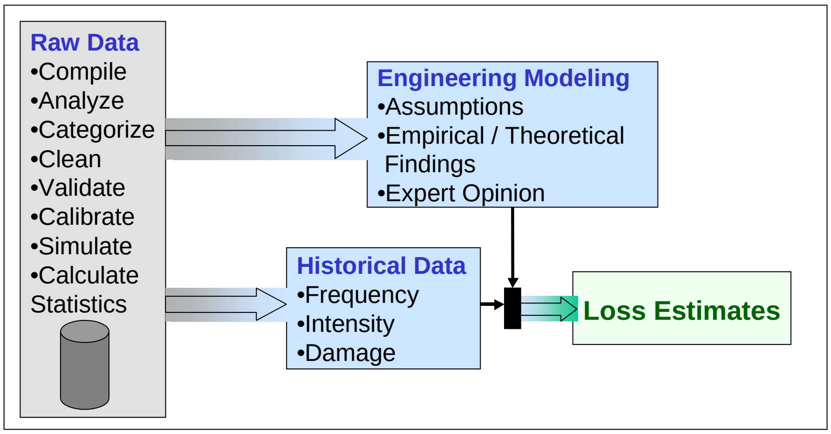
- Vulnerability
- Loss
- Statistically and probabilistically extrapolate the patterns
- Produce meaningful results
- Development of exceedance and frequency curves relating a level of damage for each hazard to an annual probability of occurrence
- Development of annualized loss estimates

The figure below illustrates a conceptual model of the statistical risk assessment methodology as applied to the Arizona projects.

Figure 7-32: Conceptual Model of the Statistical Risk Assessment Methodology



7.5.1.3 Qualitative Vulnerability Assessment Methodology

Where quantitative information or standardized software was lacking, a more qualitative evaluation has been made on the basis of each hazard's characteristics. This methodology is less rigorous than that available via the quantitative methodologies (i.e., HAZUS-MH, statistical vulnerability), but provides an indication as to potential consequences due to hazard events. This also provides a starting point for more detailed analysis in the future.

7.5.1.4 Dam Failure

To quantitatively assess the vulnerability of Unincorporated Maricopa County to individual dam failures, data was used from the United States Army Corps of Engineers (USACE) National Inventory of Dams (NID) from 2002 and the Arizona Department of Water Resources (ADWR). NID data includes the location, capacity, and distance to the community, normal capacity, and a hazard rating for each dam. ADWR data includes safety-rating data for each ADWR jurisdiction dam. In the absence of inundation maps, the vulnerability assessment is based on the following:

- Selection of dams with an NID hazard rating of "high", an ADWR safety rating of "unsafe non-emergency", or both.
- Determination of the 10-mile downstream radius from the selected dams.
- Estimated total population and exposure falling inside the 10-mile downstream radius areas.
- Results totaled by county and/or jurisdiction.

Data from USACE, National Inventory of Dams (NID, year 2002)

Data includes the location, capacity, and distance to specified location, normal capacity, and a level of severity for each dam. In absence of inundation maps:

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- Based on the maximum capacity of dams and digital elevation data, best approximation of potentially inundated area downstream is estimated.
- Total population and exposure falling inside inundation areas are estimated.
- Results are then arranged and ranked.

Starting with Table 7-42: Potential Exposure from Dam Hazard (High Risk), and continuing through Table 7-48: Potential Exposure from Dam Hazard (New Waddell Dam), the seven tables presented below reflect the potential exposure to hazards that are created by the dams in Unincorporated Maricopa County. Based upon these findings the greatest risk to Unincorporated Maricopa County residents is created through the NID-classified "High Risk" Dams. These facilities present a cumulative exposure to over 148,094 residents of Unincorporated Maricopa County, with 74,228 residential buildings and 332 commercial buildings at risk. Table 7-43, Table 7-44, and Table 7-45 illustrate the exposure data for dams classified as "Unsafe Risk", "Both High & Unsafe Risk", and "Combined Unsafe, High, & Both Risks", respectively. Table 7-46, presents exposure data that assumes a 10-mile downstream inundation region. Finally, Table 7-47 and Table 7-48 present special findings for exposure created by the Roosevelt and New Waddell Dams.

Table 7-42: Potential Exposure from Dam Hazard (High Risk)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	148,094	74,228	9,886,343	332	717,241
Maricopa County Total	2,772,765	879,624	151,614,260	9,825	19,346,092

Table 7-43: Potential Exposure from Dam Hazard (Unsafe Risk)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	53,064	30,817	4,575,752	124	229,742
Maricopa County Total	130,615	62,654	9,418,383	178	414,748

Table 7-44: Potential Exposure from Dam Hazard (Both High & Unsafe Risk)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	14,516	4,149	566,978	7	24,618
Maricopa County Total	68,584	25,390	3,820,693	76	229,741

Table 7-45: Potential Exposure from Dam Hazard (Combined Unsafe, High, & Both Risks)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	215,674	109,194	15,029,073	463	971,601
Maricopa County Total	2,971,964	967,668	164,853,336	10,079	19,990,581

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Table 7-46: Potential Exposure from Dam Hazard (Inundation Risk)					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	74,334	33,497	4,075,596	189	473,324
Maricopa County Total	815,324	253,802	41,887,681	2,669	5,622,423

Table 7-47: Potential Exposure from Dam Hazard (Roosevelt Dam)					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	8,059	2,370	280,889	17	33,069
Maricopa County Total	422,817	103,092	19,011,669	3,003	5,482,409

Table 7-48: Potential Exposure from Dam Hazard (New Waddell Dam)					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	62,746	32,754	4,905,726	190	260,352
Maricopa County Total	216,380	83,728	12,866,956	413	832,237

7.5.1.5 Disease

The wide variation in disease characteristics makes evaluation of the vulnerability of people, animals and plants difficult to analyze. Preventable diseases and injuries are studied and vulnerability assessments have been made. However, a highly contagious and severe disease, such as smallpox or a new strain of influenza, could swiftly kill large numbers of people and incapacitate major systems (e.g. hospitals). Although the vulnerability to people, animals and plants is valuable and desirable information, for emergency planning purposes, a vulnerability assessment of the healthcare infrastructure would be invaluable in assessing the ability of hospitals, public health departments, clinics, urgent care centers and the like to ensure continued health care in all of Maricopa County should any one healthcare support system become inoperable or overwhelmed. Systems that should be included in a future vulnerability assessment study would include but would not be limited to: local and outside pharmaceutical suppliers, their alternate sources, means of delivery and timeframe, local laboratories, their alternate sources, means of delivery and timeframe, general and specialized medical suppliers, their alternate sources, means of delivery and timeframe, local military medical and hazardous materials support and possible alternate resources from the private sector to include means of delivery and timeframe.

Likewise, an animal equivalent, such as foot-and-mouth disease could result in the destruction of numerous animals and cause tremendous economic impacts. The Arizona Department of Agriculture has identified numerous systemic, administrative, or organizational vulnerabilities that currently affect disease prevention in Arizona. Some of the more compelling factors that influence these vulnerabilities in Unincorporated Maricopa County include the following:

- Inspection services at all ports. No port has an animal inspector; most ports are manned by the Motor Vehicle Division and plant health inspection personnel who assist the Animal Services Division by visualizing animal health papers, without examining the animals.

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- Safeguarding the food supply by inspecting commercial trucks destined for areas both inside and outside Arizona's borders.
- Continued observation of border crossings for animals arriving from Mexico after their USDA inspection.
- Create and enforce animal identification plan for cattle and horses in the United States.
- Prevent the illegal smuggling of fighting birds, pet birds, and other poultry; as well as meat products.
- The importation of shell eggs to the United States without USDA approval.
- Biosecurity at Arizona dairies, feedlots, and poultry producers.
- The animal inspection service of the Arizona Department of Agriculture employed over 100 people just a few years ago. Currently 18 full time positions exist to expedite this function.

7.5.1.6 Drought

No standardized methodology exists for estimating vulnerability to drought. As opposed to posing a direct threat to life, drought is primarily measured by its potential and actual economic effect. Therefore, it makes sense to note economic sectors at greater risks to the hazards of drought than to delineate hazardous areas of the State. Drought sensitive sectors within the County economy and natural resources include the following:

- Agriculture and livestock,
- Forestry from the increased risk of wildland fire,
- Wildlife and wildlife habitat, and municipal and industrial water supply.

Rural and agricultural areas of Maricopa County are particularly sensitive to the ravages of drought. Rural areas rely heavily on dwindling ground water supplies, generally have small surface water drainage to recharge supply lakes, and generally lack alternative sources of water (Jacobs and Morehouse, June 11-13, 2003).

Table 7-49 identifies the potential for both exposure and losses due to the influence of drought in Unincorporated Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of drought, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the affects of drought in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings in Unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with drought in Maricopa County may be expected in connection with agricultural assets. In Unincorporated Maricopa County, a potential exposure of $22.5 million in agricultural resources is coupled with a potential annual loss of $1.2 million, creating a loss-to-exposure ratio of 0.0528. Maricopa County's total agricultural exposure is just under $182 million, with a potential annualized loss estimate of only $9.6 million. These figures create a countywide loss-to-exposure ratio of 0.0528.

Table 7-49: Potential Exposure and Losses from Drought Hazard

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk		Agriculture at Risk		
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	13,169,438	364	808,085	1,186	22,474	0.0528
Maricopa County Total	3,072,149	984,192	168,089,817	10,191	20,290,586	9,600	181,975	0.0528

* Loss Ratio < 0.0001

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7.5.1.7 Earthquake

The HAZUS-MH software model employs a probabilistic hazard approach. This approach accounts for the contribution of earthquakes of different magnitudes and occurring at different locations. The base data used in the earthquake hazard assessment were: 100, 250, 500, 750, 1000, 1500, 2000, and 2500 year return periods USGS probabilistic hazard. Default soft soil conditions were assumed uniformly throughout the State. The use of soft soils allowed for a greater degree of amplification of ground shaking throughout the study region. The earthquake risk assessment did not explore the potential for collateral hazards such as liquefaction or landslide. However, losses associated with these ground failures would have been negligible given the level of shaking expected for AZ (i.e., not enough strong shaking to trigger significant ground failure). Table 7-50 illustrates the relationship between intensity and magnitude for earthquakes, and provides an indication to the potential damage that may be experienced through this relationship.

Table 7-50: Relationship Between MMI, PGA, and Expected Damage

Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	None	None	None	Very Light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
Peak Acceleration (% g)	< 0.17	.17 to 1.4	1.4 to 3.9	3.9 to 9.2	9.2 to 18	18 to 34	34 to 65	65 to 124	>124
Peak Velocity (cm's)	< 0.1	0.1 to 1.1	1.1 to 3.4	3.4 to 8.1	8.1 to 16	16 to 31	31 to 60	60 to 116	>116
Instrumental Intensity	I	II to III	IV	V	VI	VII	VIII	IX	X+

Table 7-51 identifies the potential for both exposure and losses due to the influence of earthquakes in Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of earthquakes, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the affects of earthquakes in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings in Unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with earthquakes in Unincorporated Maricopa County may be expected to cause $445,000 in damage to residential buildings and $32,000 in damage to commercial buildings. These anticipated losses are expected to create loss-to-exposure rations that are less than 0.0001. Similarly, Maricopa County totals are not expected to create significant losses associated with residential or commercial assets.

Table 7-51: Potential Exposure and Loss from Earthquake Hazard

		Residential Buildings at Risk				Commercial Buildings at Risk			
Jurisdiction	Exposed Population	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	445	13,169,438	*	364	32	808,085	*
Maricopa County Total	3,072,149	984,192	5,628	168,089,817	*	10,191	810	20,290,586	*

* Loss Ratio < 0.0001

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7.5.1.8 Extreme Heat

While no standardized methodology exists for estimating vulnerability to extreme heat, as shown in Figure 7-8 most of Maricopa County has a high probability of reaching summer temperatures that may be classified as dangerous or even extremely dangerous. While Unincorporated Maricopa County is relatively well prepared for excessive summer heat (e.g., most buildings have evaporative coolers or air conditioning), as noted above, an estimated 35-50 people die annually due to the heat (Arizona Department of Health Services, June 18, 2001).

Dependence on air conditioning in most of Arizona to moderate the effects of high summer temperatures could result in a hazardous situation should the electricity supply be interrupted for an extended period of time. In addition, Unincorporated Maricopa County has a relatively high proportion of elderly and low-income people, with both groups historically vulnerable to extreme summer heat.

As noted previously, temperatures in the Western U.S. rose 2-5°F during the 20th century. The two major climate change models, the Canadian Model and the Hadley Model, both forecast continued temperature increases in the West of 5-11°F during the 21st century, including Arizona (National Assessment Synthesis Team, May 2001). If these increases occur during the summer months, Arizona could be subject to even more sever summer heat.

7.5.1.9 Flood

The effects of flooding include loss of life, property damage and destruction, damage and disruption of communications, transportation, electric service, and community services; crop and livestock damage and loss and interruption of business. Hazards of fire, health and transportation accidents; and contamination of water supplies are likely secondary effects of flooding.

The vulnerability assessment for Unincorporated Maricopa County to riverine flood is based on the following methodology:

1. Considered were areas with digital flood maps (Q3) available and affected Census Block polygons with non-zero exposure by occupancy.
2. A base flood elevation model was derived for each county to estimate flood depth:
   - Only flood polygons affecting occupied Census Blocks were included.
   - Transect lines across the flood polygon (perpendicular to the flow direction) were created using an approximation method for Zone A flood polygons.
   - A point file was extracted from the line (Begin node, End node and center point). The Zonal operation in Spatial Analyst (with the point file and a Digital Elevation Model (DEM) was used to estimate the ground elevation in the intersection of the line with the flood polygon borders. The average value of the End and Begin point of the line was calculated. This value was assumed as the Base Flood Elevation (BFE) for each transect.
3. A Triangular Irregular Network (TIN) file was derived from both, the original transect with the derived BFE value and the flood polygon. This TIN file approximate a continuous and variable flood elevation along the flood polygon. A grid file was derived from the TIN file with the same extent and pixel resolution of the DEM.
4. The difference of the Flood Elevation grid file and the DEM was calculated to produce an approximate flood depth for the area.
5. A HAZUS-MH based damage function raster map was created for each one of the seven types of occupation from the resulting Flood Depth Raster map. A Visual Basic for Applications (VBA) script was written to assign the ratio of damage expected for each type of occupancy as a function of the flood depth.
6. Seven exposure value ($) raster maps were created converting a Census Block polygons shape file using Spatial Analyst. Several Census Block polygons are not contained completely in the flood area. In order of

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avoiding overestimation of the total value of damage for each occupancy type, the value ($) of exposure for each block was divided by the count of pixel belonging to the block.

7. A simple "map algebra" operation (multiplication) was applied with the seven damage function raster maps with seven exposure value ($) raster maps using raster calculator of Spatial Analyst.
8. Annualized losses were then approximated based on 100 and 500-year losses.

Table 7-52 identifies the potential for both exposure and losses due to the influence of floods in both Unincorporated Maricopa County and Maricopa County in total. Unincorporated Maricopa County presents a resident population of 13,569 people who are exposed to the affects of floods, while more than 318,000 Maricopa County residents are exposed to this hazard. Almost 6,000 residential and 44 commercial buildings are at risk to damage created through the affects of floods in the unincorporated areas of Maricopa County, while the County as a whole presents a total of 104,760 residential and 1,430 commercial buildings at risk. These building counts translate to a potential exposure value of $887 million for residential structures and $193.5 million for commercial buildings in unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $18.8 billion, and $3.15 billion for commercial structures. Losses associated with floods in unincorporated Maricopa County may be expected to cause $381,000 in damage to residential buildings and $63,000 to commercial buildings. These anticipated losses are expected to create loss-to-exposure ratios that are less than 0.0004 for residential and 0.0003 for commercial structures. Maricopa County includes cumulative potential losses due to floods of $2.5 million to residential structures and $470,000 to commercial buildings. These potential losses yield loss-to-exposure ratios of 0.0013 and 0.0015, respectively.

Table 7-52: Potential Exposure and Loss from Flood Hazard

Jurisdiction	Exposed Population	Residential Buildings at Risk				Commercial Buildings at Risk			
		Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	13,569	5,923	381	886,796	0.0004	44	63	193,499	0.0003
Maricopa County Total	318,218	104,760	2,495	18,800,664	0.00013	1,430	470	3,149,887	0.00015

* Loss Ratio < 0.0001

7.5.1.10 Hail

Hailstorm frequency and damage data for Unincorporated Maricopa County was derived from a National Oceanographic and Atmospheric Administration (NOAA) funded study that analyzed hailstorm impacts for recorded events between 1948 and 2000. Historical data was compiled by the size of the hailstone. The vulnerability assessment for hail in Unincorporated Maricopa County is based on the following methodology:

1. Hail stone size and frequency of recurrence were utilized as the main parameters for the hazard model. The duration of storms and number of hail per square feet are implicitly included in the model due to the high correlation to hail frequency.
2. Hazard severity parameters were measured for hail size and were calculated for both residential property and crops. Based on the intensity/frequency relationship, damage data were applied to understand the probability of occurrence and its relation to a particular level of damage.
3. Vulnerability-Exposure was modeled by developing a Hail versus Loss relation (hail-size versus property loss value).
4. Losses are simulated for the subset of data for which historical losses are not provided (would-be loss values).

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- Probabilistic loss model is then developed.
- EP curves (Exceeding Annual Probability of Observed Losses).
- AEL values (Annualized Expected Loss) are computed.

Table 7-53 identifies the potential for both exposure and losses due to the influence of hail in Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of hail, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the effects of hail in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings in Unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with hail in Unincorporated Maricopa County may be expected in association with agricultural assets. Here, a potential exposure of $22.5 million in agricultural resources is coupled with a potential annual loss of only $7,000, creating a loss-to-exposure ratio of 0.0003. Maricopa County's total agricultural exposure is just under $182 million, with a potential annualized loss estimate of only $91,000. These figures create a countywide loss-to-exposure ratio of 0.0005.

Table 7-53: Potential Exposure and Losses from Hail Hazard

		Residential Buildings at Risk		Commercial Buildings at Risk		Agriculture at Risk		
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	13,169,438	364	808,085	7	22,474	0.0003
Maricopa County Total	3,072,149	984,192	168,089,817	10,191	20,290,586	91	181,975	0.0005

* Loss Ratio < 0.0001

7.5.1.11 Hazardous Materials

The Areal Locations of Hazardous Atmospheres (ALOHA) model is an atmospheric dispersion model used to evaluate the release of hazardous chemical vapors. It has been used together with the location of facilities with Extremely Hazardous Substances (EHS) in Arizona via the following procedure:

- The 845 Extremely Hazardous Substance (EHS) facilities in Arizona were mapped. The most hazardous and most populated locations were subjectively selected on the basis of the worst combination of toxicity and population.
- ALOHA is run to estimate the affected area (1-mile, 3-mile, and 5-mile radius).
- Population and exposure falling inside the plume shapes are estimated.

Table 7-54 and Table 7-55 identify the potential for both exposure and losses due to the influence of hazardous materials in Maricopa County. Unincorporated Maricopa County presents a resident population of 226,347 residents that live within one mile of a hazardous materials facility. These resident populations are coupled with residential and commercial structure counts of 98,268 and 881, respectively, within a one-mile radius. The potential exposure associated with these counts is $15.3 billion for residential structures and $1.8 billion for commercial structures. Unincorporated Maricopa County also presents a resident population of 322,625 residents that live within two miles of a hazardous materials facility. These resident populations include residential and commercial structure counts of

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138,275 and 1,047, respectively, within a two-mile radius. The potential exposure associated with these counts is $20.8 billion for residential structures and $2.1 billion for commercial structures.

Table 7-54: Potential Exposure from HazMat Hazard (1-Mile Radius) by Jurisdiction

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	226,347	98,268	15,305,608	881	1,751,967
Maricopa County Total	2,638,910	829,778	145,038,860	10,515	20,811,869

Table 7-55: Potential Exposure from HazMat Hazard (2-Mile Radius) by Jurisdiction

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	322,625	138,275	20,806,636	1,047	2,118,158
Maricopa County Total	3,292,980	973,669	182,788,066	11,560	23,001,513

7.5.1.12 Severe Wind

It was determined that the American Society of Civil Engineers (ASCE) 7-98 Design Wind Speed provided the best available data from which to conduct the wind hazard loss estimates. The ASCE design wind speed maps take into account historical events such as hurricanes, tropical storms, as well as in-land windstorms. Damage parameters to general building stock were extracted from HAZUS-MH and anchored to the ASCE Design Wind Speed map. Damage estimates were then calculated for the average wind speeds for 100 and 500-year return period.

Table 7-56 identifies the potential for both exposure and losses due to the influence of severe wind in Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of severe wind, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the affects of severe wind in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings in Unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with severe wind in Unincorporated Maricopa County may be expected to cause $155,000 in damage to residential buildings and $10,000 in damage to commercial buildings. These anticipated losses are expected to create loss-to-exposure ratios that are less than 0.0001. Unincorporated Maricopa County includes cumulative potential losses due to floods of $1.8 million to residential structures and $255,000 to commercial buildings. These potential losses also yield loss-to-exposure ratios that are less than 0.0001.

Table 7-56: Potential Exposure and Loss from Severe Wind Hazard by Jurisdiction

Jurisdiction	Exposed Population	Residential Buildings at Risk				Commercial Buildings at Risk			
		Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	155	13,169,438	*	364	10	808,085	*
Maricopa County Total	3,072,149	984,192	1,849	168,089,817	*	10,191	255	20,290,586	*

* Loss Ratio < 0.0001

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7.5.1.13 Subsidence

For this hazard vulnerability assessment values were obtained by applying a GIS overlay of exposure and population at risk with the various URS subsidence hazard maps.

The following tables present two variations of findings that illustrate the potential for exposure due to the influence of subsidence in Maricopa County. Table 7-57 demonstrates the historical exposure Unincorporated Maricopa County and Maricopa County have experienced from subsidence. Finally, Table 7-58represents exposure that is created by water level decline of greater than 100 feet. Each of the two measures presents widely variable findings, with the "water level decline" model identifying the greatest potential exposure to subsidence in Unincorporated Maricopa County. Here, nearly 101,416 residents are exposed to the influence of subsidence, and 53,515 residential and 218 commercial structures are exposed, respectively. By contrast, the historical record of exposure from subsidence in Unincorporated Maricopa County indicates a more conservative estimate of 53,378 residents exposed to this hazard. Additionally, this method identifies 25,176 residential and 125 commercial buildings at risk, with potential exposures of $3.6 billion and $346.2 million, respectively.

Table 7-57: Exposure from Subsidence Hazard (Historical)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	53,378	25,176	3,616,269	125	346,156
Maricopa County Total	408,110	169,444	25,489,750	946	1,964,839

Table 7-58: Exposure from Subsidence Hazard (Water Level Decline)

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk	
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	101,416	53,515	6,760,446	218	392,648
Maricopa County Total	2,027,889	585,669	103,369,147	7,415	14,518,323

7.5.1.14 Thunderstorm

Exposed populations and structures, as well as the associated risk created by thunderstorms were established through the following process:

National weather databases and data was collected, reviewed, and analyzed. Historical data for thunderstorm events between 1980 and 2000 were utilized to develop frequency and damage parameters for the thunderstorm hazard. These parameters were developed for the severe thunderstorm hazard from a limited number of recorded events.

The hazard model was developed based on patterns found in a limited dataset. Historical patterns were assumed to be the dominant feature to determine future events. Intensity/frequency tables were developed that outlined the recurrence for each type of severe thunderstorm events. Based on the intensity/frequency relationship, damage data were applied to understand the probability of occurrence and its relation to a particular level of damage.

- NOAA statistical thunderstorm data is cleaned and duplicate data is removed.

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- Historical observed losses are plotted against time. Non-linear regression modeling is assumed in modeling the trend underlying the historical losses.
- To estimate the expected loss that might occur in a given future year, the above regressed relationship is extrapolated.
- To account for historical changes to exposure, historical losses are modified/normalized by the ratio of the above-expected loss and average historical.
- Exceedance Probability (EP) curve is extracted from the modified set of historical data.
- Annualized loss is then computed as the area under the EP curve.

Table 7-59 identifies the potential for both exposure and losses due to the influence of thunderstorms in Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of thunderstorms, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the affects of thunderstorms in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with thunderstorms in Unincorporated Maricopa County may be expected in association with agricultural assets. A potential exposure of $22.5 million in agricultural resources is coupled with a potential annual loss of $88,000, creating a loss-to-exposure ratio of 0.00 39. Maricopa County's total agricultural exposure is just under $182 million, with a potential annualized loss estimate of only $1.2 million. These figures create a countywide loss-to-exposure ratio that is 0.0068.

Table 7-59: Potential Exposure and Losses from Thunderstorm Hazard by Jurisdiction

Jurisdiction	Exposed Population	Residential Buildings at Risk		Commercial Buildings at Risk		Agriculture at Risk		
		Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	13,169,438	364	808,085	88	22,474	0.0039
Maricopa County Total	3,072,149	984,192	168,089,817	10,191	20,290,586	1,231	181,975	0

* Loss Ratio < 0.0001

7.5.1.15 Tornado

Exposed populations and structures, as well as the associated risk created by tornadoes were established through the following process:

(1) Hazard frequency and weather data from the NOAA national tornado database for 1950 to 2002 were collected, reviewed, and analyzed.

(2) Tornado Intensity-Frequency relation was then developed (Probability of experiencing or exceeding a certain Fujita Intensity).

(3) Vulnerability-Exposure was modeled by developing a Tornado-Loss relation (Fujita Intensity versus property loss value).

(4) Losses are simulated for the subset of data for which historical losses are not provided (would-be loss values).

- o Probabilistic loss model is then developed

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- EP curves (Exceeding Annual Probability of observing Losses).
- AEL values (Annualized Expected Loss) are computed

Table 7-60 identifies the potential for both exposure and losses due to the influence of tornadoes in Maricopa County. Unincorporated Maricopa County presents a resident population of 203,675 people who are exposed to the affects of tornadoes, while more than three million Maricopa County residents are exposed to this hazard. More than 96,814 residential and 364 commercial buildings are at risk to damage created through the affects of tornadoes in Unincorporated Maricopa County, while the County presents a total of 984,192 residential and 10,191 commercial buildings at risk. These building counts translate to a potential exposure value of $13.2 billion for residential structures and $808.1 million for commercial buildings in Unincorporated Maricopa County. By contrast, Maricopa County as a whole presents potential exposure values for residential buildings of $168 billion, and $20.3 billion for commercial structures. Losses associated with tornadoes may be expected to cause $43,000 in damage to residential buildings and $5,000 in damage to commercial buildings. These anticipated losses are expected to create loss-to-exposure ratios that are less than 0.0001. Maricopa County includes cumulative potential losses due to floods of $592,000 to residential structures and $66,000 to commercial buildings. These potential losses also yield loss-to-exposure ratios that are less than 0.0001.

Table 7-60: Potential Exposure and Loss from Tornado Hazard by Jurisdiction

		Residential Buildings at Risk				Commercial Buildings at Risk			
Jurisdiction	Exposed Population	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio	Building Count	Potential Loss (x$1000)	Potential Exposure (x$1000)	Loss Ratio
Unincorporated Maricopa County	203,675	96,814	43	13,169,438	*	364	5	808,085	*
Maricopa County Total	3,072,149	984,192	592	168,089,817	*	10,191	66	20,290,586	*
* Loss Ratio < 0.0001									

7.5.1.16 Wildfire

For this hazard vulnerability assessment values were obtained by applying a GIS overlay of exposure and population at risk with the various URS wildfire hazard maps.

Beginning with Table 7-61: Potential Exposure from Wildfire Hazard (Extreme Risk) by Jurisdiction and continuing through Table 7-64: Potential Exposure from Wildfire Hazard (Combined Extreme, High and Medium Risks) by Jurisdiction, the four tables presented below reflect the potential exposure to hazards that are created by wildfires in and Unincorporated Maricopa County. Based upon these findings the greatest risk to Unincorporated Maricopa County residents is created through the “Medium Risk” category. This type of wildfire event presents a cumulative exposure to 19,945 residents, with 9,464 residential buildings and 21 commercial buildings at risk. These structure counts translates to a total annual risk of $1.3 billion for residential structures and $53 million for commercial structures. Table 7-61 and Table 7-62 illustrate the exposure data for wildfires that are classified as “Extreme Risk” and “High Risk”. Table 7-63 presents exposure data that summarizes the cumulative exposure of all three classifications of wildfire risk in Unincorporated Maricopa County. Because Unincorporated Maricopa County includes no exposure or risk attributes for Extreme or High Risk wildfires, the summary table information is identical to that reported in the Medium Risk table.

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Table 7-61: Potential Exposure from Wildfire Hazard (Extreme Risk) by Jurisdiction					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	538	270	46,185	0	943
Maricopa County Total	1,024	884	160,818	0	2,362

Table 7-62: Potential Exposure from Wildfire Hazard (High Risk) by Jurisdiction					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	0	0	0	0	0
Maricopa County Total	356	382	71,398	0	2,172

Table 7-63: Potential Exposure from Wildfire Hazard (Medium Risk) by Jurisdiction					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	19,945	9,464	1,292,765	21	52,624
Maricopa County Total	124,966	52,745	9,137,721	406	817,876

Table 7-64: Potential Exposure from Wildfire Hazard (Combined Extreme, High and Medium Risks) by Jurisdiction					
		Residential Buildings at Risk		Commercial Buildings at Risk	
Jurisdiction	Exposed Population	Building Count	Potential Exposure (x$1000)	Building Count	Potential Exposure (x$1000)
Unincorporated Maricopa County	20,483	9,734	1,338,950	21	53,567
Maricopa County Total	126,346	54,011	9,369,937	406	822,410

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7.5.1.17 Summary of Special Needs Populations

Table 7-65 below provides a summary of the exposure the various hazards profiled in this document create to the special populations of Maricopa County. For many non-specific hazards in Maricopa County 359,119 elderly persons and 200,697 low-income households are potentially vulnerable to hazards. Specifically, the total elderly population in the County is defined as those older than the age of 65. Households earning less than $20,000 also have been included in this review. These data indicate that several non location-specific hazards, including Drought, Earthquakes, Hail, and Severe Wind, all include a potentially vulnerable elderly population of 359,119 and identify 200,697 households that are susceptible to these hazards. Among the remaining hazards, those elderly and low-income populations residing within the 2-mile boundaries that surround Extremely Hazardous Substance facilities contain the highest numbers. Here, 385,371 aged residents are potentially vulnerable and 213,028 low-income households are at risk.

Table 7-65: Summary of Special Needs Population Exposure to All Hazards in Maricopa County

Hazard	Total Elderly Population (>65 years of age	Households Earning Less Than $20,000
Dam-Both	9,134	2,713
Dam-High Hazard	332,496	189,005
Dam-Inundation	110,781	61,604
Dam-Unsafe	56,839	8,964
Dam-Roosevelt	29,025	37,118
Dam-New Waddell	62,639	16,068
Drought	359,119	200,697
Earthquake	359,119	200,697
Flood	34,363	21,856
Hail	359,119	200,697
Hazmat-1 mile radius	313,097	180,774
Hazmat-2 mile radius	385,371	213,028
Severe Wind	359,119	200,697
Subsidence-Historic	82,064	20,582
Subsidence-Water level decline	210,096	140,877
T-Storm	359,119	200,697
Tornado	359,119	200,697
Wildfire-Extreme	247	70
Wildfire-High	52	7
Wildfire-Medium	18,883	6,490

Within these overall Maricopa County populations, Table 7-66 illustrates the exposure these hazards create for special needs populations that reside in Unincorporated Maricopa County. Overall, 359,119 elderly persons and 200,697 low-income households exist in Maricopa County with the elderly representing 11.7% of the overall population and low-income households representing 6.5%. Of these overall figures, 80,411 elderly persons and 17,681 low-income households are at risk to all hazards within the unincorporated area of Maricopa County. Proportionally, there are 40% elderly and 9% low-income households at risk.

These data indicate that most non location-specific hazards, including Drought, Earthquakes, Hail, and Severe Wind, all include a potentially vulnerable elderly population of 80,411 and identify 17,684 households that are susceptible to these hazards. Among the remaining hazards, those elderly and low-income populations residing within the 2-mile boundaries that surround Extremely Hazardous Substance facilities contain the highest numbers. Here, 91,905 aged residents are potentially vulnerable and 23,346 low-income households are at risk.

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Table 7-66: Summary of Special Needs Population Exposure to All Hazards in Unincorporated Maricopa County		
Hazard Type	Data	Unincorporated Maricopa County
Dam- Both	Sum of # Elderly People (>65 y.o.)	841
	Sum of # <20K Households	552
Dam- High	Sum of # Elderly People (>65 y.o.)	69216
	Sum of # <20K Households	14812
Dam- Inundation	Sum of # Elderly People (>65 y.o.)	27611
	Sum of # <20K Households	8042
Dam- Roosevelt	Sum of # Elderly People (>65 y.o.)	631
	Sum of # <20K Households	522
Dam- Unsafe	Sum of # Elderly People (>65 y.o.)	39781
	Sum of # <20K Households	5333
Dam-New Waddell	Sum of # Elderly People (>65 y.o.)	41073
	Sum of # <20K Households	7917
Drought	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Earthquake	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Flood	Sum of # Elderly People (>65 y.o.)	3,513
	Sum of # <20K Households	755
Hail	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Hazmat- 1 mile radius	Sum of # Elderly People (>65 y.o.)	74,204
	Sum of # <20K Households	17,843
Hazmat- 2 mile radius	Sum of # Elderly People (>65 y.o.)	91,905
	Sum of # <20K Households	23,346
Severe Wind	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Subsidence- Historical	Sum of # Elderly People (>65 y.o.)	26690
	Sum of # <20K Households	4234
Subsidence- Water level decline	Sum of # Elderly People (>65 y.o.)	49349
	Sum of # <20K Households	11133
Thunderstorm	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Tornado	Sum of # Elderly People (>65 y.o.)	80411
	Sum of # <20K Households	17681
Wildfire- Extreme	Sum of # Elderly People (>65 y.o.)	146
	Sum of # <20K Households	51

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7.5.2 Development Trend Analysis

The greater metropolitan region is geographically situated in the south-central interior region of the State of Arizona, and encompasses an area of 9,223 square miles. Together this urbanized area contains 25 incorporated cities and towns, four Native American Communities and a large area of unincorporated land. The region is located in the Sonoran Desert with elevations generally ranging from 500 to 2,500 feet above sea level. In 2002, Maricopa County contained approximately 60 percent of the population in Arizona, as well as eight of the nine cities in Arizona with populations greater than 100,000 people.

According to data compiled by the Maricopa Association of Governments (MAG) in 2000, approximately 29 percent of all county lands were under private ownership; 28 percent of lands were under the direct ownership of the Bureau of Land Management; 14 percent of lands were under the jurisdiction of the U.S. Military; 11 percent of lands were held within State trust; 11 percent of lands were under the direct ownership of the U.S Forest Service; 5 percent of land was comprised of Indian Communities; and the remaining 2 percent of lands in the county were classified as "other" public lands.

In the rapidly growing urban environment of Maricopa County it is critical that local jurisdictions maintain an accurate database of the expanding number of commercial and residential structures that exist within these communities. Accompanying this increase in the number of structures will be a commensurate increase in the quantity of critical facilities that serve these communities. To adequately account for this rapidly expanding number of structures and facilities, any subsequent update to this document must identify efficient methods to identify and incorporate updated data. At the local level, the most accurate data for structures may be accessed from the jurisdictional government. Most communities, for instance, operate a Building Safety Division that catalogues annual building permit statistics that may be used to provide a current structure count for both residential and commercial buildings. These new figures (and accompanying spatial data) may be added to the existing dataset to create an updated total for these structures. Critical facility figures, by contrast, may prove to be more difficult to accurately update. This is because the vulnerability assessment application of these sites created an assumption for the frequency of these facilities, rather than using local-level data. Therefore, to update these figures at any point in the future would require that either 1) a community gathers new and complete data for each category of critical facility, or 2) an assumption method similar to that employed for this document is used to apply new population figures. Given the rapid growth in most Maricopa County jurisdictions, this calculation would most likely yield a higher value than presented in this document.

Population Projections

For the past several decades, this region has been one of the fastest-growing metropolitan areas in the United States, among those with populations of more than one million people. In April of 2000, Maricopa County had a resident population of 3,072,149. This was a population growth of approximately 44 percent, or 950,000 people in the decade from 1990 to 2000. MAG Interim Socioeconomic Projections indicate that this high growth rate is expected to continue. By 2030, Maricopa County is projected to double in population over the 2000 base population, with an anticipated total of 6.24 million people. This means that the region will experience a growth of approximately one million people during each decade.

Table 7-25 shows the total resident population for Municipal Planning Areas (MPAs) from July 1, 2000, to July 1, 2030. Total resident population includes the resident population in households, and the resident population in group quarters (dorms, nursing homes, prisons and military establishments). Over the 30-year period (2000- 2030), nine of the regions' communities are projected to grow by more than 100,000 persons. These areas include Phoenix, Buckeye, Surprise, Goodyear, Mesa, Gilbert, Peoria, Avondale and Chandler. Another three such communities are projected to experience population growth greater than 50,000 persons: Scottsdale, Glendale, and the Maricopa County portion of Queen Creek. Currently, there are four cities within the MAG Region with populations of more than 200,000 persons: Phoenix, Mesa, Glendale and Scottsdale. By 2010, Chandler and Gilbert are expected to surpass 200,000 in population, and will be followed by Peoria prior to the beginning of 2020. By 2025, the largest Municipal Planning Area –Phoenix, will contain 2.1 million persons, followed by Mesa at 630,000 and Surprise at 312,000.

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Employment Growth

By 2025, Maricopa County is projected to nearly double its reported 2000 employment total. This means that employment within the region will grow by approximately 575,000 jobs each decade. Compared to 2000, it is projected that there will be a more even distribution of jobs by place of work among MPAs throughout the MAG Region. Although the Phoenix MPA is expected to contain the most jobs in the region, its share declines from 47 percent of all jobs in 2000, to approximately 37 percent in 2030. In 2000, the top four MPAs of Phoenix, Mesa, Tempe and Scottsdale contained 78 percent of all jobs by place of work. By 2030, their collective share is projected to decline to 60 percent. Between 2000 and 2025, total job growth in Maricopa County is projected to be 1.4 million jobs, which includes the following stages of growth: 547,000 jobs between 2000 and 2010; 593,000 jobs between 2010 and 2020; and 297,000 jobs between 2020 and 2025 (MAG, 2003).

As reflected through these figures, the urbanized areas of Maricopa County are growing at a rate that presents considerable challenges to hazard mitigation planning in two respects. First, this region is adding thousands of new residents and structures to the greater metropolitan area every year. While these new residents are locating throughout the region, they become at risk populations through the susceptibility of the area to various weather-related and other natural phenomena. For example, thousands of new residents now call the east portion of the greater metropolitan area home. This area, along with much of Maricopa County, is prone to late summer "monsoon" thunderstorms. These new residents have now inherited this storm event susceptibility. Second, much of this new development is being planned for and growing into specific areas that may present new hazard-based challenges to the population. Much of the new growth in the northeast portion of Maricopa County, for example, may be confronted with wildfire events that consume the higher volume of flora known to populate the region.

Growth Areas

Rapid residential and employment growth is expected to occur in both the east and west portions of the urbanized regions of Maricopa County. Some of the more prominent areas of specific increase include the communities of Surprise, Goodyear, Glendale, Peoria, and Buckeye in the west portion of the greater metropolitan area. To the east the Cities of Gilbert and Chandler are projected to experience similar growth trends in the immediate future. Table 7-25 documents the estimated growth all Maricopa County communities are projected to experience through the year 2030. Hazards mapped in these regions include wildfire, flood, drought, and dam failure. The most prevalent vulnerability caused by this growth appears to be the strain massive development will place on the physical and programmatic infrastructure that currently exists within the respective jurisdictions in Maricopa County. Because of this pervasive and rapid population growth both natural hazards, including wildfires and drought, as well as other hazards that include manmade resources, such as dam failure and hazardous materials releases, are expected to place an increasing number of residents and structures in danger of being affected by these hazards. It should also be noted that high-rise residential and commercial development is expected to increase within the downtown and uptown Phoenix areas; these developments present a potential new type of structural fire hazard risk.

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8. MITIGATION STRATEGY

Maricopa County's Hazard Mitigation Strategy describes the County's blueprint for the unincorporated Maricopa County area only to reduce potential losses due to natural and human-caused hazards. This Strategy is based on the ability of County authorities, policies, programs, and resources to expand on and improve existing tools that will mitigate the effects of natural and human-caused hazards in the County's physical and human environment. The County's hazard mitigation goals, along with their corresponding objectives, have guided the development and implementation of the specified mitigation actions.

8.1 Capability Assessment

While not required by the *Disaster Mitigation Act of 2000*, an important component of the Mitigation Strategy is a review of the County's resources in order to identify, evaluate, and enhance the capacity of local resources to mitigate the effects of hazards. The first part of the Capability Assessment is a review of the County's legal and regulatory capability, including ordinances, codes, and plans to address hazard mitigation activities. This Assessment also describes the administrative and technical ability of the County's staff and personnel resources. The third part of the Assessment, which crosses all technical and regulatory boundaries, is the fiscal capability of the County to provide the financial resources to implement the mitigation strategy. The final part of the Capability Assessment is a summary review of the activities of each administrative division within Unincorporated Maricopa County that supports hazard mitigation activities, and details any previous mitigation activities undertaken by these entities.

The legal and regulatory hazard mitigation capability of the Unincorporated Maricopa County, as shown in Table 8-1, including a review of existing ordinances and codes that affect the physical or built environment in Unincorporated Maricopa County. In particular, the County's applicable Building Codes, Zoning Ordinance, Subdivision Regulations, Capital Improvement Plan, and other regulatory development guides provide specified support to hazard mitigation activities. Other less prescriptive documents that describe Unincorporated Maricopa County's hazard mitigation capability include the County's various General Plan elements, Economic Development Strategy, Emergency Response Plan, and Post-Disaster Recovery Plans, among others. This section lists these various tools, recognizes the local authority of the specific activity, and identifies the interaction of the specific tools with State and higher-level authorities.

The administrative and regulatory capability of Unincorporated Maricopa County, as shown in Table 8-2, provides an identification of the staff, personnel, and department resources available to expedite the actions identified in the Mitigation Strategy. Specific resources reviewed include those involving technical personnel that apply planning and engineering, floodplain management, Geographic Information Systems (GIS), environmental scientists, management authority, and various other services needed to facilitate hazard mitigation in Unincorporated Maricopa County.

The fiscal capability of Unincorporated Maricopa County to achieve the goals and objectives of the Mitigation Strategy is shown in Table 8-3. Specific financial and budgetary tools available to the County include federal entitlements, County general fund money, secondary sales and property taxes, user fees for infrastructure, impact fees applied to new development, and various unique debt service techniques including bonding indebtedness.

The local mitigation capability assessment describes the potential hazard mitigation activities that occur in the County's many departments and divisions. Most importantly, this matrix details plans, policies, regulations, funding, and practices within these divisions that promote or facilitate hazard mitigation in Unincorporated Maricopa County, and provides contact information for each division in the County. In addition, where available, specific examples of previous hazard mitigation activities are also described. Prior mitigation actions in Unincorporated Maricopa County include the following:

1. *Bridge Scour Protection Projects – MCDOT has designed and either constructed or is about to construct scour protection on the following bridges through the Transportation Improvement Plan:*

- W.O. 68937 Indian School Road at the Agua Fria River – Scour protection completed in August 2002

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- W.O. 68938 Tuthill Road at the Gila River – Scour protection completed in 2000 and a flood warning system installed in November 2003.
- W.O. 68933 MC85 at the Agua Fria River - Pier reconstruction - October 2003 -Scour protection – January – March 2004
- W.O. 68934 Old U.S. 80 Highway at the Hassayampa River- Scour protection – April – May 2004 -Design complete
- W.O. 68931 Alma School Road at the Salt River- Scour protection – January – March 2005- Design complete

2. Flooded Crossing Gates – MCDOT installed automatic sensors and gates at the following locations:

- Old Stage Coach Road at New River
- Patton Road at the Hassayampa River
- Rocky Point Road at the Gila River

3. Erosion Hazard Ordinance

Under ARS § 48-3605 the Arizona Department of Water Resources has established criteria and standards for determining flood and erosion hazard areas. The District is including delineation of erosion hazard areas in recently completed Area Drainage Master Plans (ADMP's), and will continue to analyze these areas in future studies. In conjunction with identifying and mapping the erosion hazard areas, the District will be looking at its current regulations and need for additional policy or action items. Completed studies that include erosion hazard areas are the following: Skunk Creek Water Course Master Plan and the North Peoria ADMP.

4. Floodprone Properties Acquisition or Floodproofing

To reduce the occurrence of repetitive loss properties and to protect the public by working with property owners to remove them from harm's way, the District developed the *Alternative Flood Control Works Program* (Resolution FCD 95-01). This Program provides another mechanism through which the District could achieve its mission of protecting the public from hazards due to flooding. There was clearly a need for a consistent, proactive program for addressing properties in these flood and erosion prone areas. Through implementation of this Program, the District will allow limited funding for the use of voluntary, non-structural flood mitigation measures, such as property acquisition or floodproofing. This funding will provide assistance to residents of flood or erosion prone properties where large-scale structural or non-structural CIP projects are determined to be unfeasible.

The voluntary floodproofing or acquisition and relocation program with uniform guidelines and annual funding is being implemented to address properties in high-hazard flood or erosion prone areas. Acquired properties may serve a dual purpose as community open space in addition to providing a conveyance for floodwaters. Two areas where this Program has been implemented are the following:

- Six homes in the floodway that had been flooded in a winter of 2000 storm were purchased and removed in the community of Aguila in the western portion of the county.
- Ten homes were purchased along the Skunk Creek in the northern portion of the County to remove them from high hazard areas.

The goals of the *Alternative Flood Control Works Program* are the following:

- To reduce the risk of injury, death, and property damage due to flooding by providing flood or erosion hazard remediation in the form of acquisition or floodproofing.
- To establish a program and funding source to acquire or floodproof properties in flood or erosion prone areas including delineated floodways, erosion hazard zones, and local areas of repetitive flooding.
- To maximize the use of federally sponsored programs for flood or erosion remediation while avoiding conflicts with existing floodplain regulations.
- To identify all properties in flood or erosion prone areas in Unincorporated Maricopa County that poses a threat to personal and public safety, and to identify similar properties in all future District studies.

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- To encourage local jurisdictions to consider alternative flood control programs, and to provide a mechanism through which they might remove or floodproof properties in flood or erosion prone areas.

This policy is intended as a voluntary program, with limited exceptions, that would increase the District's and its client communities' economic, technical and administrative flexibility while improving beneficial floodplain characteristics. The Program is not intended to facilitate urban renewal or Community Development Block Grant projects or to allow non-structural, stand-alone CIP projects to bypass the requirements of the *Procedure for Identifying and Prioritizing Potential 5-Year CIP Projects.*

5. The Phoenix Rio Salado Project in the Lower ACDC Watershed involves the environmental restoration of approximately five miles of the Salt River within the City of Phoenix from the I-10 Bridge to 19th Avenue. The project will provide riparian habitat restoration and include channel stabilization, riverbank protection, water quality improvements, aesthetic improvements and recreational opportunities. The low flow channel will stabilize the river gradient, safely convey frequent flood flows and reduce the frequency of inundation of channel vegetation from flood events.

6. The Tres Rios Basins Project is planned for the southwestern portion of the South Mountain Watershed. The Tres Rios Project calls for four detention basins, two adjacent to the Salt River and two adjacent to the Gila River. The basins would be located between 107th Avenue and Dysart Road. This project will remove 21 structures from the floodplain, which is approximately 62 percent of the structures in a repetitive loss area. A levee is being constructed as part of a USACE/City of Phoenix project.

7. Salt River Project's (*SRP)'s continuing involvement and leading role with the Multi-Agency Taskforce on Flood Warning, which was created after the 1993 floods:*

During the floods of January 1993, local response efforts statewide were hindered by poor coordination among agencies and by a lack of information on flood threat. As a result, state, federal, and local agencies formed a Multi-Agency Task Force to address these issues. In 1997, the U.S. Army Corps of Engineers and ADWR sponsored the design and construction of the Arizona Statewide Flood Warning System to: 1) improve collection of real-time precipitation and stage data; 2) strengthen or establish communication links among agencies for better data-sharing; and 3) expand data coverage through additional rain and stage gages.

The Arizona Flood Warning System collects rainfall and stage data from existing and new sites statewide and offers many products to help assess flood threat. Data are transferred to and from a three-hub computer network located at the Phoenix, Tucson, and Flagstaff NWS offices. The primary communications portion of the project is complete and the system is being used by participating agencies; additional connections and new gages will be installed in the next year.

The task force has bi-monthly meetings at SRP facilities. (web site: www.afws.org). SRP operates and maintains the AFWS under an agreement with ADWR.

8. *Drought Education Program*

Joint sponsorship and promotion with the Valley cities of the "Water: Use It Wisely" campaign. This program is designed to provide end water users practical advice on how to conserve water.

SRP Speakers Bureau program provides information on the drought situation, water supply situation, educates users on where the Valley water comes from, and provides conservation tips. The program stresses the need for water stewardship on all our behalf.

Media involvement including several radio and TV spots, and op ed newspaper articles describing the water situation and extent of the drought.

The Governor's Drought Task Force will touch upon a variety of programs and actions designed for the rural communities to better prepare and respond to drought.

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Cities, water resource organizations, and the business community have partnered on several Valley events (e.g. Home Depot's "100 Ways in 30 Days to Save Water") to educate water users and provide information on water stewardship and conservation.

Multiple education programs are designed for children. These include city programs (visit city water conservation websites for more detail on specifics), Project WET (water education for teachers), and videos (e.g. SRP's "Making a Splash in the Desert").

Each Valley city has developed drought plans that provide information on the city response to drought, depending upon the severity. Typically the drought response plan is in four stages, with the fourth stage having the most severe mandatory restrictions. Several cities have announced a Stage 1 drought. Visit each city website for more information on each cities specific drought response plan program.

9. *Utility Poles*

Wood Pole Asset Management Program

A regular and repeating program to inspect the structural integrity of wood poles in the SRP electric system. Once every 10-11 years, every wood pole in the system is evaluated for decay and termite attack, re-treated with preservative chemicals and if necessary, structurally reinforced or replaced. This program was started in 1996 and is ongoing. The second cycle of the program will start in approximately 2006-07.

Specifications for Treated Wood Poles

The specification for the quality of and preservative treatment of wooden utility poles has been upgraded three times in the last ten years. Improvements include stricter requirements for the quality of the wood and enhanced provisions for treatment of the wood.

NESC Grade B Construction in the 69kV System for New Construction

The National Electrical Safety Code establishes two benchmark levels for structural reliability. The minimum performance requirement for the majority of 69kV structures is "Grade C Construction". In 1998, SRP established a higher level of structural performance by upgrading to "Grade B Construction" for all new construction in the 69kV system. This upgrade increases the structural performance of poles in extreme wind events (microburst) though the use of larger and stronger wood poles and light duty steel poles.

69kV Structural Upgrade Initiative

The 69kV SUI was developed to replace those wood poles in the 69kV system most susceptible to failure in extreme wind events (microbursts). There are four main emphases in this 10-year program:

- Install heavy duty pole structures at freeways crossings and substations
- Structurally reinforce susceptible wood poles
- Install cascade limiting structures at regular intervals (every 8 poles)
- Replace segments of wood pole lines and replace with larger and stronger pole structures.

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Table 8-1: Legal and Regulatory Capability				
Regulatory Tools (ordinances, codes, plans)	Local Authority (Y/N)	Does State Prohibit? (Y/N)	Higher Level Jurisdiction Authority (Y/N)	Comments
A. Building code	Yes	No	No	
▪ Zoning ordinance	Yes	No	No	
▪ Subdivision ordinance or regulations	Yes	No	No	
▪ Special purpose ordinances (floodplain management, stormwater management, hillside or steep slope ordinances, wildfire ordinances, hazard setback requirements)	Yes	No	No	
B. Growth management ordinances (also called "smart growth" or anti-sprawl programs)	Yes	No	No	
C. Site plan review requirements	Yes	No	No	
D. General or comprehensive plan	Yes	No	No	
E. A capital improvements plan	Yes	No	No	Certain departments: MCDOT, Parks, FC
F. An economic development plan	Yes	No	No	
G. An emergency response plan	Yes	No	No	
H. A post-disaster recovery plan	Yes	No	No	
I. A post-disaster recovery ordinance	Yes	No	No	
J. Real estate disclosure requirements	Yes	No	No	Have authority but not regulatory requirement, conduct notifications

Table 8-2: Administrative and Technical Capacity		
Staff/Personnel Resources	Y/N	Department/Agency and Position
A. Planner(s) or engineer(s) with knowledge of land development and land management practices	Yes	Planning & Development, Environmental Services, FCD, MCDOT – Engineers
B. Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	Yes	Planning & Development, Environmental Services, FCD – Engineers
C. Planners or Engineer(s) with an understanding of natural and/or human-caused hazards	Yes	Planning & Development, Environmental Services, FCD – Engineers
D. Floodplain manager	Yes	FCD
E. Surveyors	Yes	MCDOT for roadways
F. Staff with education or expertise to assess the community's vulnerability to hazards	Yes	Planning & Development, MCDEM, FCD, MCDOT - Planners
G. Personnel skilled in GIS and/or HAZUS	Yes	MCDOT, FCD, MCDEM, Planning & Development, Assessors Office, Environmental Services, Public Health, Elections, Sheriff's Office
H. Scientists familiar with the hazards of the community	No	Contract out
I. Emergency manager	Yes	MCDEM – Director
J. Grant writers	Yes	Parks, Community Development, Human Services - Staff

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Table 8-3: Fiscal Capability	
Financial Resources	Accessible or Eligible to Use (Yes/No/Don't Know)
A. Community Development Block Grants (CDBG)	Yes, don't know for mitigation
B. Capital improvements project funding	Yes
C. Authority to levy taxes for specific purposes	Yes
D. Fees for water, sewer, gas, or electric service	No
E. Impact fees for homebuyers or developers for new developments/homes	Yes, limited use
F. Incur debt through general obligation bonds	Yes
G. Incur debt through special tax and revenue bonds	Yes
H. Incur debt through private activity bonds	Yes
I. Withhold spending in hazard-prone areas	Yes

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Table 8-4: Local Mitigation Capability Assessment

Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Adult Probation Mission: Legal Authority:				No Effect	Chief Probation Officer Barbara Broderick, 111 S. 3rd Avenue Phoenix, AZ T: 602-506-3262 F: 602-506-5952	
Animal Care & Control Services				No Effect	Director Edward A. Boks 5231 N. 35th Avenue Phoenix, AZ T: 602-506-2772 F: 602-249-6480	
Assessor Mission: The Mission of the Maricopa County Assessor's Office is to efficiently administer state property tax laws and to provide quality information to the taxpayers and various taxing jurisdictions to assure that all county property is valued fairly and equitably. Legal Authority:	1. Property Assessment 2. Mapping / GIS 3. Ownership 4. Property Characteristics 5. Information Technology Program	1. The purpose of the Property Assessment program is to provide ownership, mapping, property characteristics and valuation information to the public, government agencies and internal customers so that they can be assured that our valuations are fair and equitable. 2. The purpose of the Mapping / GIS activity is to provide GIS information and customer service to the public, government agencies and internal customers so that they can utilize current, quality mapping information of Maricopa County. 3. The purpose of the Ownership activity is to provide updated ownership information to the public, government agencies and internal customers so that they can identify the ownership and related information of all property in Maricopa County. 4. The purpose of the property characteristics activity is to provide updated and new property component data to the public, government agencies and internal customers so that they can utilize our component data and establish fair and equitable valuations. 5. The purpose of the Information Technology Program is to provide IT leadership and services to the client departments so that management can obtain maximum benefit from the IT resource.	no	Support	Assessor Kevin Ross 301 W. Jefferson, 3rd Fl Phoenix, AZ T: 602-506-3877 F: 602-506-4643	Has provided GIS parcel layers for use by contractor URS for development of the countywide hazard mitigation plan.
Attorney Mission: The mission of the Maricopa County Attorney's Office is to provide quality prosecution, victim services, crime prevention and legal counsel for county government on behalf of the people of Maricopa County so that they can live in a safe and well-governed community. Legal Authority:	1. Administrative Services Program	1. The purpose of the Administrative Services Program is to provide standardized performance data on a variety of internal administrative and support services for County departments and the Board of Supervisors so they can conduct benchmarking analyses and track program performance and costs.		Support	County Attorney Richrd M. Romley 301 W. Jefferson, 8th Fl Phoenix, AZ T: 602-506-3411 F: 602-506-8102	The county attorney's office has supported emergency management from the beginning of this project by way of reviewing FEMA agreements and providing legal direction on issues such as how to properly integrate terms such as "For Official Use Only" into the final plan.
Board of Supervisors Mission: Legal Authority:		See County Administration		Support	Chairman Fulton Brock 301 W. Jefferson, 10th Fl Phoenix, AZ	

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Table 8-4: Local Mitigation Capability Assessment						
Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Budget Mission: Legal Authority:				No Effect	Deputy County Administrator Sandra Wilson 301 W. Jefferson, Phoenix, AZ T: 602-506-7280 F: 602-506-3063	
Chief Information Officer Mission: Legal Authority:				No Effect	Acting Chief Information Officer Paul Allsing 301 W. Jefferson, Ste 420 Phoenix, AZ T: 602-506-3932 F: 602-506-5864	
Clerk of the Board of Supervisors Mission: Legal Authority:				No Effect	Clerk of the Board of Supervisors Fran McCarroll 301 W. Jefferson, 10th Fl Phoenix, AZ T: 602-506-3767	
Clerk of the Superior Court Mission: Legal Authority:				No Effect	Clerk of the Superior Court Michael K. Jeanes 201 W. Jefferson, 2nd Fl Phoenix, AZ T: 602-506-3676 F: 602-506-7684	
Community Development Mission: Legal Authority:				No Effect	Director Isabel McDougall 3003 N. Central, Ste 1040 Phoenix, AZ T: 602-240-2210 x210 F: 602-240-6960	
Correctional Health Services Mission: Legal Authority:				No Effect	Deputy Director Joe Tansill 111 W. Monroe, Ste 900 Phoenix, AZ T: 602-506-4581 F: 602-506-2577	

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Table 8-4: Local Mitigation Capability Assessment						
Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
County Administration Mission: The mission of the County Administrative Office is to provide leadership and direction for county departments and agencies so that they can deliver services countywide to residents of Maricopa County. Legal Authority:	1. Administrative Services Program	1. The purpose of the County Administrative Office program is to provide administrative leadership, budget and policy recommendations, and countywide management coordination for the Board of Supervisors so that they can achieve the county's strategic goals and fulfill the county's legal mandates and local policy initiatives in the most fiscally responsible manner.		Support	County Administrative Officer David Smith 301 W. Jefferson Ste 1050 Phoenix, AZ	County Administration, to include the Board of Supervisors, has approved the departments request for and to accept the grants to fund this project. The BOS will also need to approve the final plan before it is forwarded to ADEM for approval.
Court Appointed Counsel Mission: Legal Authority:				No Effect	Contract Administrator Mark Kennedy 411 N. Central, Ste 400 Phoenix, AZ	
Criminal Justice Facilities Development Mission: Legal Authority:				No Effect	Director Robert B. Williams 411 N. Central, Ste 400 Phoenix, AZ	

Emergency Management
Mission: The mission of the Maricopa County Department of Emergency Management is to provide community-wide education, planning, coordination, and continuity of government for the people of Maricopa County in order to protect lives, property and the environment in the event of a major emergency.
Legal Authority:
	1. Mitigation	1. The purpose of the mitigation program is to provide mitigation plans and programs to Maricopa County and political subdivisions therein so that they can reduce or eliminate the effects of future disasters.		Support	Director
					Robert Spencer
					2035 N. 52nd Street
					Phoenix, AZ
					T: 602-273-1411
					F: 602-275-1638
						▪ One planner has been designated as the project manager and devotes the majority of work time to the completion of this project
						▪ Currently all six planners, the supervisor, GIS planner, the Director and one administrative support person for the department attend the Hazard Mitigation Planning meetings regularly
						▪ Three planners support this project additionally in the following areas:
						  ▪ LEPC
						  ▪ Unincorporated
						  ▪ Project Manager back-up
						▪ Finance, GIS and Admin have and will continue to support this project until its completion

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Table 8-4: Local Mitigation Capability Assessment						
Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Environmental Services Mission: The mission of the Environmental Services Department is to provide effective environmental management to the people of Maricopa County so they can be confident that they live in a safe and healthful environment. Legal Authority:	1. Air Quality Program 2. Air Quality Monitoring and Compliance 3. Air Quality Planning and Permitting 4. Water / Wastewater Plan Review 5. Water and Wastewater Inspections 6. Environmental Health Services	1. The purpose of the Air Quality Program is to provide air pollution information and regulatory services to industry, other governmental agencies, and the general public 2. The purpose of Air Quality Monitoring and Compliance is to provide oversight of all stationary and activity based air pollution sources 3. The purpose of the Air Quality Planning and Permitting Activity is to provide rule writing and reviewing applications for stationary and activity based air pollution to permitted stationary air pollution sources so that they operate in compliance with all applicable regulations. 4. The purpose of water / wastewater plan review activity is to provide engineering plan review of on-site wastewater disposal systems and public or commercial water and wastewater systems and public bathing places to stakeholders in Maricopa County so that they can be safe from hazards caused by non-compliance with the applicable design and construction rules governing environmental and public health for these facilities. 5. The purpose of water and wastewater inspections activity is to provide construction and operation and maintenance inspections of On-Site wastewater disposal systems, and public or commercial water and wastewater systems to the stakeholders in Maricopa County so that they can be safe from hazards caused by non compliance with applicable water supply rules governing environmental and public health protection for these facilities. 6. The purpose of the Environmental Health Division is to provide Environmental Health Inspections and educational services for the general public and regulated facilities so that compliance is maintained with applicable regulations of the Maricopa County Environmental Health Code.	Yes	Support	Director Al Brown 1001 N. Central Phoenix, AZ T: 602-506-6617	
Equipment Services Mission: Legal Authority:				No Effect	Director Fentress Truxon T: 602-506-2938 F: 602-506-8730	
Facilities Management				No Effect		
Finance				No Effect		
Flood Control Mission: The mission of the Flood Control District of Maricopa County is to provide flood hazard identification, regulation, remediation, and education to the people in Maricopa County so that they can reduce their risks of injury, death, and property damage due to flooding while enjoying the natural and beneficial values served by floodplains. Legal Authority:	1. Flood Hazard Identification Program 2. Floodplain Delineation Activity 3. Hydrometeorology Activity 4. Planning Activity 5. Flood Hazard Regulation Program	1. The purpose of the Flood Hazard Identification program is to provide the identification of, and alternative solutions to flood hazards, and flood warning data to public and private organizations so that they can incorporate knowledge of flood hazards in their plans within presently developed and future urban growth areas. 2. The purpose of the Floodplain Delineation activity is to provide a map of the physical boundaries of the area adjoining a watercourse that may be covered by floodwater during a flood so that the public is aware of the dangers inherent in that property. 3. The purpose of the Hydrometeorology activity is to provide weather, water level, and stream flow information to agencies that need to respond to flooding so that they can make their decisions in a timely and effective manner. 4. The purpose of the Planning activity is to provide studies which identify and document, flood and erosion hazards, and alternative mitigation solutions to public and private organizations so that they can incorporate knowledge of flood hazards in their plans and their flood hazard remediation requests to the District. 5. The purpose of the Flood Hazard Regulation program is to provide guidance, direction, and enforcement for the public so that they can avoid causing adverse impacts to floodplains, and use their property safely and in compliance with applicable state and federal laws.		Support	Chief Engineer & General Manager Michael S. Ellegood 2801 W. Durango Street Phoenix, AZ 85009 T: 602-506-1501 F: 602-506-4601	
Health Care Mandates				No Effect		
Housing				No Effect		

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Table 8-4: Local Mitigation Capability Assessment						
Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Human Resources				No Effect		
Infrastructure Technology Center				No Effect		
Internal Audit				No Effect		
Integrated Criminal Justice Information System Agency				No Effect		
Justice Court Services				No Effect		
Justices of the Peace				No Effect		
Juvenile Probation				No Effect		
Legal Advocate				No Effect		
Legal Defender				No Effect		
Library District				No Effect		
Managed Care Systems				No Effect		
Maricopa Integrated Health System				No Effect		
Materials Management				No Effect		
Medical Eligibility				No Effect		
Medical Center				No Effect		
Medical Examiner				No Effect		
Organizational Planning & Training				No Effect		
Parks & Recreation				No Effect		
Planning & Development Mission: The mission of the Planning and Development Department is to provide planning and development services to constituents of unincorporated Maricopa County so they can responsibly develop and enjoy real property. Legal Authority:	1. Code Enforcement 2. Comprehensive Planning 3. Plan Review 4. Planning and Zoning	1. The purpose of the Code Enforcement Activity is to provide inspection, enforcement, licensing and permitting services, under the operational guidelines of the Planning and Development Department, to constituents, so they can enjoy their properties and/or operate their businesses in compliance with County codes and ordinances. 2. The purpose of the Comprehensive Planning Activity is to develop and maintain planning elements and provide information to various private and public entities of Maricopa County so they make informed decisions concerning growth, development and investment. 3. The purpose of the Plan Review Activity is to provide plan review comments or approvals to the Distribution Center so they can notify permit applicants of required changes to their plans or to pick up their approved permits. 4. The purpose of the Planning and Zoning Activity is to provide information, support and a recommendation to the Planning Commission so they are enabled to make planning and land use recommendations to the Board of Supervisors.		Supports	Director Joy Rich 411 N. Central, 3rd Floor Phoenix, AZ 85004 T: 602-506-6150 F: 602-506-8510	• One staff member has been assigned to participate in the Hazard Mitigation Plan committee, and to provide input, recommendations, and information on an as-requested basis. • Department assigned to assist the consultant in obtaining and reviewing necessary GIS information for Maricopa County. • In processing entitlements and building permits, department coordinates with Flood Control District, Environmental Services, and other agencies to ensure potential hazards are mitigated. • Through its building inspection division, the Planning & Development Department helps ensure that mitigation measures are fully implemented.
Public Defender				No Effect		
Public Fiduciary				No Effect		

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Table 8-4: Local Mitigation Capability Assessment						
Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Public Health Mission: The mission of the Department of Public Health is to provide leadership, resources, and services to people and diverse communities in Maricopa County so that health is promoted, preserved, and protected. Legal Authority	1. Bio-Defense Preparedness and Response 2. Bio-Defense Intelligence Gathering 3. Planning and Training	1. The purpose of the Bio-Defense Preparedness and Response Program is to provide a comprehensive plan for detecting and responding to a public health disaster as well as provide leadership and coordination of the Department's response so that the Department can mount a coordinated, rapid and appropriate response. 2. The purpose of Bio-Defense Intelligence Gathering is to conduct disease surveillance so that the Maricopa County Department of Public Health (MCDPH) can mount a coordinated, rapid and appropriate response to any natural or intentional biological event, disease outbreak, or other public health disaster threatening the health and safety of Maricopa County residents. 3. The purpose of Planning and Training is to provide readiness assessment, preparedness and response planning and training to the Maricopa County Department of Public Health (MCDPH) and to the Health and Human Services (H&HS) Constellation partners and other identified partners so that they can be fully prepared and responsive to a public health disaster or emergency.		Support	Director Jonathan Weisbuch 1825-1845 E. Roosevelt Phoenix, AZ 85006 T: 602-506-6609 F: 602-506-0272	
Public Information Mission: The mission of the Maricopa County Office of Communications is to provide consistent, effective, and accurate communication, media relations, and community relations to the residents and employees of the County so they are informed of Maricopa County's activities, services, and achievements. Legal Authority:	1. Communication 2. Media Relations Activity	1. The purpose of the Communications Program is to provide consistent and effective communication, media relations, and community relations to the residents and employees of the County so they are informed of Maricopa County's activities, services, and achievements. 2. The purpose of the Media Relations Activity is to provide accurate information about Maricopa County to the media so they can have accurate information to disseminate to the public.		Support	Director Al Macias 301 W. Jefferson, Ste. 1086 Phoenix, AZ 85003 T: 602-506-3271 F: 602-506-3328	
Risk Management Mission Legal Authority				No Effect	Assistant Risk Manager Bill Warren 222 N. Central, Ste. 1110 Phoenix, AZ 85004 T: 602-506-5526 F: 602-506-6290	
Schools Mission: Legal Authority				No Effect	Superintendent Sandra E. Dowling 301 W. Jefferson, Ste. 660 Phoenix, AZ 85003 T: 602-506-3661 F: 602-506-3753	

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Table 8-4: Local Mitigation Capability Assessment

Agency / Organization (Mission / Function)	Potential Hazard Mitigation Activities (Divisions, Programs)	Plans, Policies, Regulations, Funding, Practices, Comments	Hazards Addressed	Effect on Hazard Loss Reduction? (Supports, No Effect, Hinders)	Contact (Name, Address, Phone, Email)	Specific Examples of Mitigation Activities/Participation (e.g., participation on committees, inter-agency meetings, provision/use of grants, preparation of mitigation/related plans, pre/post-disaster activities)
Sheriff Mission: The mission of the Maricopa County Sheriff's Office is to provide law enforcement, detention and crime prevention services to the public so they can be safe and secure in our community. Legal Authority	1. Enforcement Support 2. Intelligence 3. Patrol	1. The purpose of the Enforcement Support Activity is to provide specialized, volunteer, and preventive support services to MCSO Divisions and the community so that law enforcement and crime prevention can be enhanced. a. Aviation missions b. Community outreach programs c. High risk responses d. Volunteer organization coordination 2. The purpose of the Intelligence Activity is to provide for the lawful collection, synthesis and assessment of criminal information for the Sheriff's Office and the criminal justice system so that crime can be deterred. The purpose of the Patrol Activity is to provide preventive enforcement and law enforcement response to the general public so that criminal activity can be deterred and offenders can be apprehended.		Support	Sheriff Joseph Arpaio 102 W. Madison Phoenix, AZ 85003 T: 602-256-1801 F: 602-251-3709	
Solid Waste Management Mission: The Mission of Solid Waste Management Department is to provide collection sites and tire recycling programs for residents and businesses so they may dispose of waste and tires conveniently in a safe manner that preserves and protects the environment and public health. Legal Authority	1. Environmental Waste Management	1. The purpose of the Environmental Waste Management Program is to provide management services for household hazardous waste and illegal dumping clean-up as well as waste tire storage, disposal and recycling services so that it can provide its citizens with convenient, safe and economical and environmental sound waste disposal.		Support	Director Ash Madhok 2801 W. Durango Phoenix, AZ 85009 T: 602-506-7336 F: 602-506-8396	Illegal dumping
Transportation – MCDOT Mission: The Mission of the Department of Transportation is to provide a quality transportation system to the travelers in Maricopa County so they can experience a safe, efficient and cost-effective journey. Legal Authority	1. Build Roads and Bridges 2. Design 3. Environmental Clearance 4. Roadway Maintenance 5. Manage Traffic	1. The purpose of the Build Roads and Bridges program is to provide design and construction of roads and bridges to the traveling public so that they can get to their destination in a safe and efficient manner. 2. The purpose of the Design activity is to provide fundable construction plans to contractors so they can build and implement cost effective projects in a timely manner with minimal changes. 3. The purpose of the Environmental Clearance activity is to provide environmental compliance documentation to the appropriate government agency so they can allocate funds, issue permits, grant right-of-way and ensure environmental mitigation for construction projects. 4. The purpose of the Roadway (roads and bridges) Maintenance activity is to provide upkeep of roadways in primarily unincorporated areas of the County for the traveling public so they can have safe trips on smooth, cost effective roads. 5. The purpose of the Manage Traffic program is to provide traffic safety solutions to contractors, and provide coordinated traffic information, and emergency and event traffic control services to the traveling public so that their trip is safe and travel delays are minimized.		Support	Director & County Engineer Mike Ellegood, P.E. 2901 W. Durango St Phoenix, AZ 85009 T: 602-506-4622 F: 602-506-4858	

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8.2 Goals, Objectives and Actions

The following vision and mission statement were developed by the Maricopa County Hazard Mitigation Plan Team during the hazard mitigation plan preparation process and provided guidance to those involved in the preparation of the *Maricopa County Multi-Jurisdictional All-Hazard Mitigation Plan*:

Vision: Maricopa County's communities shall be disaster resistant, enabling our residents to enjoy an environment where the effects of disasters are greatly reduced or eliminated.

Mission: The mission of the Maricopa County Multi-Jurisdictional All Hazard Mitigation Plan is to encourage emergency managers to set goals according to public risk and identified need for protection of life, property and the environment and to outline a strategy for implementation of mitigation projects.

In order to accomplish the above vision and mission, specific goals and objectives have been established. Below is a review of mitigation strategy terms, followed by the County's mitigation strategy.

8.2.1 Definitions

For the purpose of this Plan, the following definitions of Goals, Objectives, Actions and Implementation Strategy have been adopted from *Disaster Mitigation Act of 2000* guiding documents, and have been accepted as functional by all levels of government involved in hazard mitigation.

Goals: General guidelines that explain what you want to achieve. Goals are usually broad statements with long-term perspective.

Example: G1: Protect subdivisions from flooding.

Objectives: Defined strategies or implementation steps intended to attain the identified goals. Unlike goals, objectives are specific, measurable, and have a defined time horizon.

Examples: G1/OA: Reduce the number of structures in the 100-year floodplain.

G1/OB: Minimize future damage due to flooding of current structures in the 100-year floodplain.

Actions: Specific actions that help achieve goals and objectives. Multiple mitigation actions may be defined to feed into an evaluation of the alternative actions.

Examples: G1/OA/A1: Adopt zoning ordinances prohibiting new residential development in the 100-year floodplain.

G1/OA/A2: Relocate 5 residential structures on XYZ Street.

G1/OB/A1: Elevate 2 commercial structures on ABC Street.

G1/OB/A2: Retrofit 10 residential structures on XYZ Street with storm shutters, elevated utilities, and water back flow valves.

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Implementation Strategy: A comprehensive strategy that describes how the mitigation actions will be implemented.

Questions: How will the mitigation actions be prioritized?

Who will implement them?

When will they be implemented?

How will they be implemented?

8.2.2 Goals, Objectives and Potential Actions

In accordance with the *Disaster Mitigation Act of 2000*, Maricopa County developed goals to reduce the County's vulnerability to natural and human-caused hazards, as shown in Table 8-5.

Table 8-5: DMA 2000 Requirements – Mitigation Strategy and Identification and Analysis of Mitigation Measures

Section	Title	Requirement	Language
Mitigation Strategy	Local Hazard Mitigation Goals	§201.6(c)(3) (i):	[The hazard mitigation strategy shall include: a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.
Mitigation Strategy	Identification and Analysis of Mitigation Measures	§201.6(c)(3) (ii):	[The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Source: FEMA, July 11, 2002.

Listed below are the County's specific hazard mitigation goals and objectives as well as related potential actions. For each goal, one or more objectives have been identified that provide strategies to attain the goal. Where appropriate, the County has identified a range of specific actions to achieve the objective and goal.

The goals and objectives were originally derived from the preliminary draft *State of Arizona Enhanced Hazard Mitigation Plan* that was developed in parallel to the *Unincorporated Maricopa County Hazard Mitigation Plan* as well as those of other Maricopa County jurisdictions. The Maricopa County Hazard Mitigation Plan Team modified the goals and objectives in order to account for historic or potential hazards that could threaten the health, safety and welfare of the County's residents, as well as the social, economic and physical fabric of the community. As shown through Table 8-6, the Maricopa County Team met several times to consider potential goals, objectives, and actions. At these meetings, specific consideration was given to the County's hazard identification/profiles and the vulnerability assessment results.

Members of the Maricopa County Hazard Mitigation Plan Team included representatives of numerous County departments involved in hazard mitigation planning, including the Flood Control District, Planning & Development, Environmental Services and Salt River Project (utility). In addition, the draft *Maricopa County Hazard Mitigation Plan,* including draft goals, objectives and actions, was available for review and comment by the public at an open house meeting and at two public hearings. The Maricopa County Board of Supervisors also adopted the plan.

Table 8-6: Local Planning Team Meetings

Date	Topic	Who Attended
October 30, 2002	Introduction to HMP	Entire Planning Group to include local team
March 11, 2003	Finalize contract with URS, MC Materials Mgmt and MCDEM	M. Ayala, B. Thornton, B. Lagomarsino
March 19, 2003	Attend Board of Supervisors meeting to accept grant funds and approve URS contract	M. Ayala, B. Spencer, M. Will, BOS, public meeting

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Table 8-6: Local Planning Team Meetings		
Date	Topic	Who Attended
March 21, 2003	First meeting with URS to prepare for first HMP Group meeting the next week	M. Ayala, URS
March 25, 2003	First Group Meeting after contractor, URS, hired 3-19-03	Entire Planning Group to include local team
April 4, 2003	Went to URS	M. Ayala, URS
April 14, 2003	SRP, public utility	M. Ayala, Ed Copp
April 17, 2003	Went to URS	M. Ayala, URS
April 18, 2003	Went to ADEM, HazMit Dept	M. Ayala, D. Trammell
April 23, 2003	See minutes & sign in sheet	Entire Planning Group to include local team
April 24, 2003	Went to City of Glendale re: follow up, they missed meeting previous day.	M. Ayala, K. Mure
April 30/31, 2003	Regional HazMit mtg FEMA RIX	RIX HazMit Reps
May 1, 2003	Regional HazMit mtg FEMA RIX	RIX HazMit Reps
May 6, 2003	GIS sharing data	MAG, MCDEM, URS
May 22, 2003	State HMP	State Team
May 28, 2003	See minutes & sign in sheet	Entire Planning Group to include local team
June 3, 2003	Went to URS to get maps	M. Ayala, URS
June 6, 2003	Went to URS to get maps	M. Ayala, URS
June 25, 2003	Went to URS re: status of Hazard Identification	M. Ayala, URS
July 3, 2003	HMP Briefing to new Group and Team members	M. Ayala, D. McBlane, Jon O'Hare, Ann McCraken
July 15, 2003	Went to Town Mgr of Gila Bend to bring him up to date of HMP project and to take maps with hazards	M. Ayala, David Evertsen
July 22, 2003	Went to URS to prepare for Group meeting the next week.	M. Ayala, URS
July 24, 2003	Went to Environmental Services MC, to brief new members to local team	M. Ayala, T. Waldbillig, Kirk Dymbrowski, Cheryl Piscitella, Jenny Young
July 25, 2003	Went to Carefree Town Marshall to update on HMP project and do homework to date	M. Ayala, Elmer Withers, Janeen Dutcher
July 25, 2003	Met with URS at FCD to prepare for large group meeting	M. Ayala, URS
July 30, 2003	83 people from 23 of the 27 jurisdictions attended day-long HMP meeting, gave homework and current hazard maps. See minutes from meeting.	See sign up sheet
August 11, 2003	Went to Litchfield Park to go over 7-30-03 meeting	M. Ayala, H. Skeete
August 11, 2003	Went to Peoria to clarify HMP homework	M. Ayala, M. Fusco
August 18, 2003	URS at MCDEM with MCDEM staff to discuss format of plan	URS, M. Ayala, W. Leek, G. Floe, R. Aud, T. Newbill, D. Cvancara, Greg Manning
August 20, 2003	GOA's, development	Local team
August 26, 2003	Met with El Mirage, GOA's	M. Ayala, R. Levenda
August 26, 2003	Met with Goodyear, GOA's	M. Ayala, R. Lilley
August 27, 2003	Went to Chandler, GOA's	M. Ayala, D. McBlane, Deborah Simpkins
August 27, 2003	Went to Gilbert, GOA's	M. Ayala, E. Encinas
August 28, 2003	Went to Glendale, GOA's	M. Ayala, T. Williams

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Table 8-6: Local Planning Team Meetings		
Date	Topic	Who Attended
August 28, 2003	Went to Wickenburg, GOA's	M. Ayala, S. Bowman, Jerry Strickland
Sept 3, 2003	GOA's, development	Local team
Sept 4, 2003	GOA's, development/rewording	Local team
Sept 5, 2003	GOA's, ranking, weighted vote	Local team
Sept 15,2003	Met with Peoria, GOA's	M. Ayala, M. Fusco
Sept 15, 2003	Went to Youngtown, GOA's	M. Ayala, D. Connelly
Sept 19, 2003	Went to Glendale, GOA's	M. Ayala, T. Williams
Sept 23, 2003	Went to Gila Bend, GOA's	M. Ayala, B. Turner, Public Works Director
Sept 24, 2003	Went to Queen Creek, GOA's	M. Ayala, J. LaFortune
Sept 24, 2003	Went to FCDMC, Flood Control Advisory Board, to answer question and explain HMP	M. Ayala, K.Sertich, plus 5-member FCAB and audience
Sept 25, 2003	Went to Fountain Hills, GOA's	M. Ayala, T. Ward
Sept 29, 2003	Met with Surprise, GOA's	M. Ayala, K. Pool
October 1, 2003	Went to Fountain Hills, GOA's	M. Ayala, T. Ward
October 3, 2003	At URS, vulnerability assess	M. Ayala, URS
October 6, 2003	Went to Litchfield Park, GOA's	M. Ayala, H.Skeete
October 7, 2003	Went to Carefree, GOA's	M. Ayala, E. Withers, Janeen Dutcher, Gary Neiss
October 8, 2003	Went to Guadalupe, GOA's	M. Ayala, A. Figueroa-Iturralde
October 9, 2003	Met with Tolleson, GOA's	M. Ayala, Steve Godinez
October 29, 2003	Went to Ft. McDowell, GOA's	M. Ayala, R. Jarvis
Nov 5, 2003	Went to URS, project update	M. Ayala, URS
Nov 19, 2003	Went to MAG gave update to Building Code sub-committee	M. Ayala, M. Holm, MAG sub-committee
Dec 11, 2003	Met with GIS ad hoc committee	See minutes
Dec 16, 2003	GIS @ State Land dept	M. Ayala, M. Philp, G. Trobia
Dec 18, 2003	GIS @ State Land dept	M. Ayala, M. Philp, G. Trobia, R. Heisinger, FCDMC (2), State Homeland Security committee on GIS
Jan 12, 2004	Went to URS, project status	M. Ayala, B. Sands, B. Patton
Salt River Project Team Meetings:		
Various work session meetings, telephone meetings and email sessions were conducted specifically for contributing to the Arizona and Maricopa County Hazard Mitigation Planning processes. Additionally, on the power side of the business, there are regular meetings between Electric System Engineering, System Design and Construction and Maintenance Engineering to plan and establish priority to activities within the programs listed in the next section. A partial listing of additional meetings and activities on the water side of the business includes:		
March 18, 2002	AZTech Mass Evacuation Planning Workshop at ASU facilities downtown Phoenix	Tim Skarupa, Yvonne Reinink, Ed Copp
July 30, 2003	Hazard Mitigation Planning Group Meeting at FCDMC	Tim Skarupa, Yvonne Reinink, Ed Copp
Ongoing	Arizona Drought Taskforce	Charlie Ester, Tom Sands
August 2003	E-mail meeting regarding Drought and Flood Mitigation Activities	Bruce Hallin, Yvonne Reinink, Ed Copp
January 7, 2004	Meeting to review SRP actions listed in the HMP	Yvonne Reinink, Bruce Hallin, Dallas Reigle, Ed Copp
January 8, 2004	Meeting to review SRP actions listed in the HMP	Wayne Wisdom, Mike Voda, Ed Copp

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Goal 1. Promote disaster-resistant future development.

Objective 1.A Encourage and facilitate the development and updating of comprehensive plans and zoning ordinances to limit development in hazard areas.

Action 1.A.1 Review the existing Maricopa county comprehensive plan and zoning ordinance to determine how these documents help limit development in hazard areas. Modify with additional guidelines, regulations, and land use techniques as necessary within the limits of state statutes, while also respecting private property rights.

Action 1.A.2 Establish periodic monitoring and review of Maricopa County's comprehensive plan and zoning ordinance to determine effectiveness at preventing and mitigating hazards. Based on the results, amend as necessary.

Objective 1.B Encourage and facilitate the adoption of building codes that protect existing assets and development in hazard areas.

Action 1.B.1 Review existing building codes to determine if they adequately protect new development in hazard areas. Where feasible and necessary, modify codes to help mitigate hazards imposed on such development within the limits of state statutes, while also respecting private property rights.

Objective 1.C. Promote consistent enforcement of comprehensive plans, zoning ordinances, and building codes.

Action 1.C.1 Distribute all development master plan, zone change, and subdivision applications as applicable to the Maricopa County Department of Emergency Management for review to ensure consistency with the adopted hazard mitigation plan.

Action 1.C.2 Maricopa County Department of Emergency Management will provide training to applicable Maricopa County Planning and Development department staff of the adopted hazard mitigation plan and its requirements.

Action 1.C.3 Maricopa County Department of Emergency Management will provide training to the Maricopa County Planning and Zoning Commission, Zoning Ordinance Review Committee, and Building Code Advisory Board about the hazard mitigation plan and its requirements.

Action 1.C.4 Continued coordination between Maricopa County departments to identify and mitigate hazards associated with new development.

Objective 1.D Address identified data limitations regarding the lack of information about new development and build-out potential in hazard areas.

Action 1.D.1 Continued coordination between Maricopa County departments, municipalities, Maricopa Association of Governments, and other agencies in the development and maintenance of accurate geographic information system information for those hazard areas identified in the adopted hazard mitigation plan.

Action 1.D.2 Through the Maricopa County Leadership Program, establish Maricopa County as a central location for geographic information system data regarding the hazards identified in the adopted hazard mitigation plan.

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Goal 2. Promote public understanding, support and demand for hazard mitigation.

Objective 2.A Promote partnerships between the state, counties, local, tribal governments, public sector, private industry, civic and non-profit groups to identify, prioritize, and implement mitigation actions.

Action 2.A.1 Pro-actively promote availability of Pre Disaster Mitigation and Hazard Mitigation Grant Program funds.

Action 2.A.2 Educate jurisdictions how to explore variety of funding sources.

Action 2.A.3 Promote outreach of County Mitigation Plan through Maricopa County Regional Leadership Program.

Action 2.A.4 Continue and maintain relationship with the Arizona Emergency Services Association and the Arizona Contingency Planners.

Objective 2.B Educate the public to increase awareness of hazards and opportunities for mitigation actions.

Action 2.B.1 Create or supplement Maricopa County public information sheets to include suggested mitigation actions.

Action 2.B.2 Add mitigation actions to Maricopa County Department of Emergency Management website as well as those websites affiliated with MCDEM.

Action 2.B.3 Announce approval of plan with suggested mitigation actions through a variety of media outlets.

Action 2.B.4 Develop mitigation brochure.

Goal 3. Build and support local capacity to warn the public about emergency situations and assist in their response.

Objective 3.A Improve upon existing capabilities to warn the public of emergency situations.

Action 3.A.1 Initiate a system to test the ability of local emergency managers to activate the Emergency Alert System (EAS).

Action 3.A.2 Provide technical support for the development of a reverse 9-1-1 system.

Objective 3.B Develop a program to enhance the safety of the residents of Maricopa County during an emergency.

Action 3.B.1 Develop a Mass Evacuation strategy for Maricopa County.

Action 3.B.2 Develop a Shelter-in-Place educational program.

Action 3.B.3 Develop and install Intelligent Transportation System (ITS)

Goal 4. Improve hazard mitigation coordination and communication within the County.

Objective 4.A Address identified data limitations regarding the lack of information about County infrastructure.

Action 4.A.1 Adopt a common Geographical Information System (GIS) data system throughout Maricopa County government.

Goal 5. Reduce the possibility of damage and losses due to floods.

Objective 5.A Develop a comprehensive approach to reducing the possibility of damage and losses due to floods.

Action 5.A.1 The Flood Control District of Maricopa County (FCDMC) will study, each year for the next five years, two major areas of Maricopa County that are not yet under

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development, but are expected to be according to the Maricopa Association of Governments' projections.

Action 5.A.2 Each year for the next five years, the FCDMC will evaluate five existing flood control facilities' safety monitoring procedures, evaluate District-owned flood control facilities, and begin plans to mitigate, upgrade, or redesign these facilities to reduce the increased risk and liability associated with them, meet all regulatory requirements, and maintain or improve their flood control functions.

Action 5.A.3 The FCDMC will continue working with County Planning and Development on a cooperative effort to notify developers of Area Drainage Master Plans (ADMP's) and floodplain regulations early on in the development process.

Action 5.A.4 FCDMC will continue development of the series of levees, channels, storm drain diversions, retention basins, and FRS's similar to those built over the years in the County for flood protection. (There are currently 35 structural projects identified in the FY 2001-2002 to 2005-2006 CIP).

Action 5.A.5 Encourage bridge or culvert construction where roads are in locations susceptible to flooding.

Action 5.A.6 Maricopa County Department of Transportation (MCDOT) will inspect and monitor all structures (bridges and box culverts) under their control on a semi-annual basis.

Objective 5.B Protect existing assets with the highest relative vulnerability to the effects of floods within the 100-year floodplain.

Action 5.B.1 FCDMC staff will conduct two floodplain delineation studies per year for the next five years to identify flood prone areas, limit growth in those areas, and establish plans for the required drainage infrastructure.

Action 5.B.2 FCDMC staff will complete the updates of the "Drainage Design Manual for Maricopa County" and the "Uniform Drainage Policies and Standards for Maricopa County", with the goal of promoting adoption of the Drainage Design Manual by all communities within Maricopa County. This will promote consistency in technical methodology and reduce future losses related to flooding.

Action 5.B.3 FCDMC staff will continue delineation of erosion hazard zones in its current studies. [54+ erosion hazard zones were recently delineated in the following studies: Skunk Creek Watercourse Master Plan (2001), Agua Fria Watercourse Master Plan (2002), North Peoria ADMP (2002)], Revision of the Volume III - Erosion Control Manual will address Phase II stormwater issues.

Objective 5.C Coordinate with and support existing efforts to mitigate floods (e.g., US Army Corps of Engineers, US Bureau of Reclamation, Arizona Department of Water Resources, Arizona Flood Warning System).

Action 5.C.1 The County through FCDMC will continue to participate in the Community Rating System (CRS) program and get credit for the various activities that assist property owners in receiving reduced insurance premiums.

Action 5.C.2 FCDMC staff will continue to account for and incorporate wetlands protection and mitigation sites into the planning process when preparing new studies for watercourses.

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Action 5.C.3 FCDMC will continue to operate its ALERT (Automated Local Evaluation in Real Time) flood hazard information/mitigation system and other flood warning and response programs as a means of providing real-time weather information to county departments and other agencies.

Action 5.C.4 FCDMC staff will evaluate providing templates and a list of resources for communities to create Flood Response Plans (FRP) as part of a County Flood Warning System with a tool on the ALERT system for communities to test/exercise the FRP.

Objective 5.D Minimize repetitive losses caused by flooding.

Action 5.D.1 FCDMC staff will implement the recently adopted Floodprone Properties Acquisition Policy that defines existing programs for acquisition and relocation especially in situations where a few structures need to be removed from the floodway and floodplain. Floodproofing is included in this policy.

Action 5.D.2 FCDMC staff will continue to require property owners to provide the federal elevation certification forms for building elevations for new construction to protect the public from flood damage.

Action 5.D.3 Evaluate the increased hazard posed by the encroachment of non-native plant species into floodways.

Action 5.D.4 MCDOT will continue to monitor accident rates and traffic counts on un-bridged crossings of major waterways to determine whether bridging is necessary.

Objective 5.E Provide assistance to local and, upon request, tribal governments, to enable them to participate in and maintain compliance with the National Flood Insurance Program (NFIP) requirements.

Action 5.E.1 FCDMC staff will continue to offer technical assistance to 13 of the 24 municipalities in Maricopa County as their Floodplain Management Agency, to residents seeking information, and to municipalities that do their own floodplain management at their request.

Action 5.E.2 FCDMC will assist other cities and Indian Communities in improving their Community Rating System (CRS) classification.

Objective 5.F Address identified data limitations regarding the lack of information about relative vulnerability of assets from floods.

Action 5.F.1 Map information will continue to be made available in paper form, but increased emphasis will be to utilize Geographic Information Systems (GIS) to expand access to flood delineation/boundary maps to the public.

Action 5.F.2 FCDMC staff will complete the Digital-Flood Insurance Rate Map (D-FIRM) project, which places the FIRM maps in a digital database per FEMA's standards which makes for easier updating and multi-hazard GIS use.

Action 5.F.3 FCDMC staff will continue to maintain and update the library at the District's main facility that contains all past studies and reports. Much of this information can be accessed on-line from the District's web page (www.fcd.maricopa.gov).

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Objective 5.G Educate the public to increase awareness of hazards and opportunities for mitigation actions through outreach projects.

Action 5.G.1 FCDMC staff will increase its Public School Safety Presentation Program. (21,000+ elementary school children have participated in the Public School Safety Presentation in the last 3 years 2000-2002).

Action 5.G.2 Real estate disclosures – FCDMC will adopt Resolutions, as needed to alert property owners to areas that are being studied for flood and erosion hazard.

Action 5.G.3 General education will be provided year-round through increased visibility utilizing FCDMC's web site, print media, electronic media, pamphlets available on basic flood preparedness for distribution, and staffed display booths at trade shows.

Goal 6. Reduce the possibility of damage and loss to businesses, homes and county-owned facilities due to wildfires.

Objective 6.A Establish agreements with state and federal agencies that will reduce damage and losses due to wildfires.

Action 6.A.1 Continue the existing intergovernmental agreement between the county and the Fire Management Division of the State Land Department for assistance in the provision of emergency services within each other's jurisdictions.

Action 6.A.2 Ensure that the county has heavy equipment operators certified to operate in a support role in the vicinity of a wildfire.

Action 6.A.3 Encourage cities, towns, and fire districts in the county to enter into intergovernmental agreements for wildfire prevention/control with state and federal land management agencies that are adjoining or within their jurisdictions.

Objective 6.B Protect existing county assets from the effects of wildfires.

Action 6.B.1 Establish a standard safety zone of 30 feet around county-owned structures that are vulnerable to the effects of wildfire.

Action 6.B.2. Establish standards for the clearing of brush on county-owned lands that are subject to wildfires.

Objective 6.C Develop building codes for unincorporated Maricopa County that will minimize damage to homes and other structures from wildfires.

Action 6.C.1 Ensure that subdivision regulations for new subdivisions ensure adequate access for fire trucks.

Action 6.C.2. Ensure that building codes for all new homes prohibit the use of untreated wood shake roofs and mandate the use a spark arresting system on the chimneys of homes with wood burning fireplaces.

Objective 6.D Educate the public about wildfire dangers and the steps that can be taken to prevent or minimize their effects.

Action 6.D.1 Ensure that the Department of Emergency Management's web page provides sufficient guidance on wildfire mitigation to the public.

Action 6.D.2 Distribute wildfire mitigation information to persons applying for building permits in unincorporated areas of the county.

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Goal 7. Reduce the possibility of damage and losses due to severe weather.

Objective 7.A Develop a comprehensive approach to reducing the possibility of damage and losses due to severe weather.

Action 7.A.1 Pursue partnerships with the National Weather Service and State Universities to research the prediction of microburst.

Action 7.A.2 Educate the public on the dangers of severe weather through various media and outreach programs.

Action 7.A.3 Ensure building codes for construction are strengthened to prevent roof damage from high winds.

Action 7.A.4 Ensure enough compliance inspectors are available to ensure construction compliance.

Objective 7.B Protect infrastructure from the effects of severe weather.

Action 7.B.1 Perform periodic assessments to identify infrastructure vulnerabilities to severe weather.

Action 7.B.2 Promote higher levels of structural reliability in new and replacement utility poles for transmission lines for improved resistance to extreme wind events. ELIGIBLE APPLICANT: PUBLIC UTILITY, SALT RIVER PROJECT

Objective 7.C Improve early warning communication to the public the threat of severe weather.

Action 7.C.1 Encourage the use of weather radios, especially in schools, hospitals and other locations where people congregate to inform them of the approach of severe weather.

Action 7.C.2 Make Flood Control District of Maricopa County forecast products available to the public with a direct link from the main County web page.

Goal 8. Reduce the possibility of damage and losses due to drought.

Objective 8.A Support the State's comprehensive approach to reducing the possibility of damage and losses due to drought.

Action 8.A.1 Mandate, where appropriate, the use of xeriscaping or desert landscaping at County facilities and projects.

Action 8.A.2 Lend technical support to those agencies tasked with conservation actions.

Objective 8.B Protect existing assets with the highest relative vulnerability to the effects of drought.

Action 8.B.1 Investigate the feasibility of using reclaimed (gray) water for appropriate applications.

Action 8.B.2 Investigate the possibility of increased recharging of aquifers.

Objective 8.C Support State and local water conservation messages and programs through a variety of media.

Action 8.C.1 Participate in water summits and resource workshops identifying various water conserving mechanisms (retrofitting, landscaping, repairing, etc.). ELIGIBLE APPLICANT: PUBLIC UTILITY, SALT RIVER PROJECT

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Goal 9. Reduce the possibility of damage and losses due to infestations and diseases.

Objective 9.A Develop a comprehensive approach to reducing the possibility of damage and losses due to infestations and diseases.

Action 9.A.1 Conduct public outreach, information and immunizations.

Action 9.A.2 Enforce Health Code requirements through on-going inspections of permitted establishments and environmental surveillance. (I.e. routine inspection of public water systems and treatment plants, air quality monitoring, food service inspections, vector control enforcement and abatement activities).

Action 9.A.3 Conduct vulnerability assessments and develop incident response plans at high risk public water system facilities and food service establishments, and other areas and programs related to vector control activities and air quality monitoring activities.

Action 9.A.4 Increased surveillance and development of more stringent requirements at high-risk facilities, i.e. day-care centers, hospitals, nursing homes and schools.

Action 9.A.5 Facilitate abatement, prevention and investigation of public health nuisance conditions, illegal dumping activities and the storage and handling of potentially infectious material and locations.

Objective 9.B Protect existing assets with the highest relative vulnerability to the effects of infestations and diseases.

Action 9.B.1 Conduct and enhance environmental and epidemiological surveillance activities in those areas identified as being of high public health importance and related to environmental factors such as; air quality, drinking water/public water systems and water/wastewater treatment plant operations, food safety and protection and vector control activities. Surveillance activities must include the identification of vulnerabilities and environmental factors that may contribute to the transmission of the communicable diseases associated with the operation and presence of these facilities in Maricopa County, as well as the implementation of preventative action which may be applied to reduce or eliminate the potential for transmission of communicable illnesses. Develop and improve the system of coordination and communication of these findings, trends and observations with other federal, state and local agencies that have similar or related interest.

Action 9.B.2 Development and implementation of multi-agency exercises and drills related to outbreaks of communicable illnesses and vector control.

Action 9.B.3 Enforcement of federal & state mandates in routine compliance inspections.

Action 9.B.4 Performing joint ventures and activities related to communicable disease outbreaks and vector infestations, such as the response activities to *Nigleria fowleri, Norwalk* virus, and roof rat infestation (R*attus rattus*).

Action 9.B.5 Standardization practice and training of regulatory inspection staff.

Objective 9.C Coordinate with and support existing efforts to mitigate infestations and diseases (e.g., Arizona Pine Bark Beetle Task Force, Arizona Department of Agriculture, US Department of Agriculture).

Action 9.C.1 Provide designated staff access to and use of database information to browse/analyze histories of permitted facilities, and nuisance abatements to observe trends and identify needs in public health protection.

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Action 9.C.2 Acquire GIS equipment and interactive software to identify patterns of transmission of disease and at-risk facility locations.

Action 9.C.3 Development of common database for Environmental Services, Public Health and other agencies to facilitate effective communication of information on infectious illnesses, citizen complaints and potential environmental disease sentinel observations.

Goal 10. Reduce the possibility of damage and losses due to geological hazards.

Objective 10A Develop a comprehensive approach to reducing the possibility of damage and losses due to geological hazards.

Action 10.A.1 Work with Arizona Department of Water Resources (ADWR) on expanding the geo-physical identification of geological hazards.

Objective 10B Protect existing assets with the highest relative vulnerability to the effects of geological hazards.

Action 10.B.1 Each year, for the next five years, investigate a minimum of five county-owned Flood Retarding Structures (FRS) for subsidence, fissures and earthquake vulnerability.

Action 10.B.2 Investigate the feasibility of utilizing recharge to mitigate subsidence.

Action 10.B.3 Assess existing county-owned bridges for their susceptibility to geo-hazards.

Objective 10C Coordinate with and support efforts to mitigate geological hazards (e.g., Arizona Geological Survey, US Geological Survey).

Action 10.C.1 Work with Arizona Geological Survey and US Geological Survey on projects that mitigate geo-hazards.

Goal 11. Prevent or minimize damage and losses due to hazardous materials (HAZMAT) incidents.

Objective 11A Develop a comprehensive approach to reducing the possibility of damage and losses due to hazardous materials.

Action 11.A.1 Continue to ensure the involvement of industry, fire, law enforcement and other key players in the Maricopa County Local Emergency Planning committee (LEPC).

Action 11.A.2 Under the auspices of the Maricopa County LEPC, provide guidance to HAZMAT incident first responders in the Maricopa County Emergency Operations Plan.

Objective 11.B Protect existing assets with the highest relative vulnerability to the effects of hazardous materials.

Action 11.B.1 Develop and maintain a database of schools, hospitals, and other key facilities within a one-mile radius of HAZMAT facilities and make that database available to responders to incidents at those facilities.

Action 11.B.2 Assist operators of facilities that store hazardous materials in developing emergency response plans for those facilities.

Objective 11.C Reduce the number of, and volume of, hazardous materials.

Action 11.C.1 Through the LEPC, encourage the use of less hazardous alternatives to the chemicals currently used when possible.

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Objective 11.D Reduce the risk of injury or loss of life to first responders to hazardous materials incidents.

Action 11.D.1 Provide emergency response guidebooks to all fire and law enforcement vehicles.

Action 11.D.2 Sponsor, under LEPC guidance, an annual exercise simulating response to a large-scale HAZMAT incident.

Objective 11.E Increase government and public knowledge of safe handling of extremely hazardous substance (EHS).

Action 11.E.1 Offer, through the safety office, basic HAZMAT awareness ("Right-to-Know") courses to Maricopa County employees.

Action 11.E.2 Provide information regarding safe handling of household chemicals on the Department of Emergency Management's website.

Goal 12. Reduce the possibility of damage and losses to existing assets due to other human-caused hazards.

Objective 12.A Develop a comprehensive approach to reducing the possibility of damage and losses due to other human-caused hazards.

Action 12.A.1 Offer, through the department of Emergency Management, basic weapons of mass destruction (WMD) courses to Maricopa County employees and the public.

Action 12.A.2 Support on going efforts of the Urban Area Security Initiative Law Enforcement Standards Committee to develop uniform procedures and equipment.

Action 12.A.3 Promote child drowning prevention programs throughout the County.

Action 12.A.4 Provide program direction in support and development of Community Emergency Response Teams (CERT).

Action 12.A.5 Promote and expand existing County programs aimed at school violence and family preparedness.

Objective 12.B Protect existing assets with the highest relative vulnerability to the effects of other human-caused hazards.

Action 12.B.1 Reassess vulnerability of potential terrorist targets and share information among law enforcement agencies.

Action 12.B.2 Provide leadership role to support Maricopa County Hospital Preparedness Council efforts to standardize hospitals' capability to decontaminate patients in the event of a chemical, biological or radiological terrorist event.

Objective 12.C Coordinate with and support efforts to mitigate other human-caused hazards.

Action 12.C.1 Provide County leadership role in support of efforts to limit development in the departure and approach corridors for Luke Air Force Base.

Action 12.C.2 Allocate and administer Department of Homeland Security (DHS) funding to appropriate agencies throughout the County.

Action 12.C.3 Develop a Disaster Medical Assistance Team (DMAT) to support disaster operations.

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8.2.2.1 Potential Actions and Evaluation Process

As listed above, the Maricopa County Hazard Mitigation Plan Team identified 106 potential hazard mitigation actions that will assist the County in mitigating the impact of natural and human-caused hazards. The *Disaster Mitigation Act of 2000* requires the evaluation of the potential mitigation actions, as noted previously in Table 8-5.

In order to evaluate these potential actions, the City of Phoenix Hazard Mitigation Plan Team used the STAPLEE criteria, which provides a systematic approach weighing the pros and cons of potential mitigation actions. STAPLEE stands for Social, Technical, Administrative, Political, Legal, Economic, and Environmental. For each of these characteristics, a series of questions was posed that assisted in evaluating the appropriateness of each potential action to the community, as described below:

Social. The public must support the overall implementation strategy and specific mitigation actions. Therefore, the projects will have to be evaluated in terms of community acceptance by asking questions such as:

- Will the proposed action adversely affect one segment of the population?
- Will the action disrupt established neighborhoods, break up voting districts, or cause the
- Relocation of lower income people?
- Is the action compatible with present and future community values?
- If the community is a tribal entity, will the actions adversely affect cultural values or resources?

Technical. It is important to determine if the proposed action is technically feasible, will help to reduce losses in the long term, and has minimal secondary impacts. Here, you will determine whether the alternative action is a whole or partial solution, or not a solution at all, by considering the following types of issues:

- How effective is the action in avoiding or reducing future losses? If the proposed action involves upgrading culverts and storm drains to handle a 10-year storm event, and the objective is to reduce the potential impacts of a catastrophic flood, the proposed mitigation cannot be considered effective. Conversely, if the objective were to reduce the adverse impacts of frequent flooding events, the same action would certainly meet the technical feasibility criterion.
- Will it create more problems than it solves?
- Does it solve the problem or only a symptom?

Administrative. Under this part of the evaluation criteria, you will examine the anticipated staffing, funding, and maintenance requirements for the mitigation action to determine if the jurisdiction has the personnel and administrative capabilities necessary to implement the action or whether outside help will be necessary.

- Does the jurisdiction have the capability (staff, technical experts, and/or funding) to implement the action, or can it be readily obtained?
- Can the community provide the necessary maintenance?
- Can it be accomplished in a timely manner?

Political. Understanding how your current community and state political leadership feels about issues related to the environment, economic development, safety, and emergency management will provide valuable insight into the level of political support you will have for mitigation activities and programs. Proposed mitigation objectives sometimes fail because of a lack of political acceptability. This can be avoided by determining:

- Is there political support to implement and maintain this action?
- Have political leaders participated in the planning process so far?
- Is there a local/departmental champion willing to help see the action to completion?
- Who are the stakeholders in this proposed action?
- Is there enough public support to ensure the success of the action?
- Have all of the stakeholders been offered an opportunity to participate in the planning process?
- How can the mitigation objectives be accomplished at the lowest "cost" to the public?

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Legal. Without the appropriate legal authority, the action cannot lawfully be undertaken. When considering this criterion, you will determine whether your jurisdiction has the legal authority at the state, tribal, or local level to implement the action, or whether the jurisdiction must pass new laws or regulations. Each level of government operates under a specific source of delegated authority. As a general rule, most local governments operate under enabling legislation that gives them the power to engage in different activities. Legal authority is likely to have a significant role later in the process when your state, tribe, or community will have to determine how mitigation activities can best be carried out, and to what extent mitigation policies and programs can be enforced.

- Does the state, tribe, or community have the authority to implement the proposed action?
- Is there a technical, scientific, or legal basis for the mitigation action (i.e., does the mitigation action "fit" the hazard setting)?
- Are the proper laws, ordinances, and resolutions in place to implement the action?
- Are there any potential legal consequences?
- Will the community be liable for the actions or support of actions, or lack of action?
- Is the action likely to be challenged by stakeholders who may be negatively affected?

Economic. Every local, state, and tribal government experiences budget constraints at one time or another. Cost-effective mitigation actions that can be funded in current or upcoming budget cycles are much more likely to be implemented than mitigation actions requiring general obligation bonds or other instruments that would incur long-term debt to a community. States and local communities with tight budgets or budget shortfalls may be more willing to undertake a mitigation initiative if it can be funded, at least in part, by outside sources. "Big ticket" mitigation actions, such as large-scale acquisition and relocation, are often considered for implementation in a post-disaster scenario when additional federal and state funding for mitigation is available.

Economic considerations must include the present economic base and projected growth and should be based on answers to questions such as:

- Are there currently sources of funds that can be used to implement the action?
- What benefits will the action provide?
- Does the cost seem reasonable for the size of the problem and likely benefits?
- What burden will be placed on the tax base or local economy to implement this action?
- Does the action contribute to other community economic goals, such as capital improvements or economic development?
- What proposed actions should be considered but be "tabled" for implementation until outside sources of funding are available?

Environmental. Impact on the environment is an important consideration because of public desire for sustainable and environmentally healthy communities and the many statutory considerations, such as the National Environmental Policy Act (NEPA), to keep in mind when using federal funds. You will need to evaluate whether, when implementing mitigation actions, there would be negative consequences to environmental assets such as threatened and endangered species, wetlands, and other protected natural resources.

- How will this action affect the environment (land, water, endangered species)?
- Will this action comply with local, state, and federal environmental laws or regulations?
- Is the action consistent with community environmental goals?

Numerous mitigation actions may well have beneficial impacts on the environment. For instance, acquisition and relocation of structures out of the floodplain, sediment and erosion control actions, and stream corridor and wetland restoration projects all help restore the natural function of the floodplain. Also, vegetation management in areas susceptible to wildfires can greatly reduce the potential for large wildfires that would be damaging to the community and the environment. Such mitigation actions benefit the environment while creating sustainable communities that are more resilient to disasters.

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Members of the City's Hazard Mitigation Plan Team used the STAPLEE characteristics and respective questions to evaluate the potential mitigation actions, including the probable costs and benefits of the actions. This formed the basis of the subsequent hazard mitigation Action Plan.

8.2.2.2 Action Plan

The *Disaster Mitigation Action of 2000* requires the development of an action plan that includes prioritized actions and information on how the prioritized actions will be implemented, as shown in Table 8-7. Members of the County 's Hazard Mitigation Plan Team worked together and with appropriate County departments and organizations to prepare an implementation strategy for the top 13 prioritized mitigation actions.

Table 8-7: DMA 2000 Requirements – Implementation of Mitigation Measures

Section	Title	Requirement	Language
Mitigation Strategy	Implementation of Mitigation Measures	Requirement: §201.6(c)(3) (iii):	[The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

Source: FEMA, July 11, 2002.

In order to focus on the County's hazard mitigation priorities and to comply with the *Disaster Mitigation Act of 2000*, the Team members identified the County's top 13 priorities for hazard mitigation for the next five years (after which local jurisdiction hazard mitigation plans must be updated), as shown in Table 8-8. Note that additional actions may be considered if the 13 prioritized actions are accomplished or events warrant consideration of additional actions. Information is provided for each of the 13 actions listed in the Mitigation Action Plan on associated goals/objectives, category of benefit, implementation responsibility, and resources required.

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Table 8-8: Mitigation Action Plan				
Prioritized Actions	Associated Goal(s) and Objective(s) (Actions may address multiple objectives)	Category of Benefit (Prevention, Property Protection, Public Education and Awareness, Natural Resources Protection, Emergency Services, Structural Projects)	Implementation Responsibility (Primarily responsible entity, Support entities)	Resources Required
1) 5.D.1. FCDMC staff will implement the recently adopted Floodprone Properties Acquisition Policy that defines existing programs for acquisition and relocation especially in situations where a few structures need to be removed from the floodway and floodplain. Floodproofing is included in this policy.	5.D	▪ Prevention ▪ Property Protection	▪ Flood Control District ▪ Chief Engineer and General Manager ▪ Flood Control Advisory Board	▪ FCD staff
2) 5.A.3. The FCDMC will continue working with County Planning and Development on a cooperative effort to notify developers of Area Drainage Master Plans (ADMP's) and floodplain regulations early on in the development process.	5A	▪ Prevention ▪ Property Protection ▪ Public Education and Awareness	▪ Flood Control District ▪ Chief Engineer and General ▪ Manager ▪ Planning & Development Director	▪ FCD staff ▪ Planning & Development staff
3) 3.A.1. Develop and install Intelligent Transportation System (ITS)	3A	▪ Prevention ▪ Emergency Services	▪ Department of Emergency Management ▪ KTAR ▪ NWS	▪ MCDEM staff ▪ KTAR staff ▪ NWS staff
4) 11.B.1. Develop and maintain a database of schools, hospitals and other key facilities within a one-mile radius of HAZMAT facilities and make that database available to responders to incidents at those facilities.	11B	▪ Save Lives ▪ Prevention ▪ Emergency Services ▪ Property Protection	▪ MCLEPC ▪ MCDEM ▪ Representative from local jurisdiction	▪ MCDEM staff ▪ Local jurisdiction staff
5) 12.A.4. Promote child drowning prevention programs throughout the County.	12, 12A	Save Lives ▪ Prevention ▪ Public Education & Awareness	▪ MCDEM ▪ County Attorney's Office ▪ Drowning Prevention Coalition of Central Arizona ▪ Local jurisdictions	▪ MCDEM staff ▪ County Attorney staff ▪ Drowning Prevention Coalition volunteers ▪ Local jurisdiction staff

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Table 8-8: Mitigation Action Plan				
Prioritized Actions	Associated Goal(s) and Objective(s) (Actions may address multiple objectives)	Category of Benefit (Prevention, Property Protection, Public Education and Awareness, Natural Resources Protection, Emergency Services, Structural Projects)	Implementation Responsibility (Primarily responsible entity, Support entities)	Resources Required
6) 1.B.1. . Review existing building codes to determine if the adequately protect new development in hazard areas. Where feasible and necessary, modify codes to help mitigate hazards imposed on such development within the limits of state statutes, while also respecting private property rights.	1B	Property Protection Prevention	Planning & Development Director	Planning & Development staff
7) 5.A.6 Maricopa County Department of Transportation will inspect and monitor all structures (bridges and box culverts) under their control on a semi-annual basis.	5A	Prevention Property Protection	MCDOT Director & County Engineer	MCDOT staff
8) 7.A.1. Pursue partnerships with the National Weather Service and State Universities to research the prediction of microburst.	7, 7A	Save Lives Property Protection Emergency Services	MCDEM FCD NWS ASU NAU U of A	Staff for: MCDEM, FCD, NWS, ASU, NAU, U of A

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Table 8-8: Mitigation Action Plan				
Prioritized Actions	Associated Goal(s) and Objective(s) (Actions may address multiple objectives)	Category of Benefit (Prevention, Property Protection, Public Education and Awareness, Natural Resources Protection, Emergency Services, Structural Projects)	Implementation Responsibility (Primarily responsible entity, Support entities)	Resources Required
9) 9.B.1. Conduct and enhance environmental and epidemiological surveillance activities in those areas identified as being of high public health importance and related to environmental factors such as; air quality, drinking water/public water systems and water/wastewater treatment plant operations, food safety and protection and vector control activities. Surveillance activities must include the identification of vulnerabilities and environmental factors that may contribute to the transmission of the communicable diseases associated with the operation and presence of these facilities in Maricopa County, as well as the implementation of preventative action which may be applied to reduce or eliminate the potential for transmission of communicable illnesses. Develop and improve the system of coordination and communication of these findings, trends and observations with other federal, state and local agencies that have similar or related interest.	9, 9B	Save Lives Prevention Emergency Services Public Education & Awareness	MC Public Health MC Environmental Services Local jurisdictions Local business	Staff for: MCPH, MC Environmental Svcs., local jurisdiction, local business
10) 12.C.1. Provide County leadership role in support of efforts to limit development in the departure and approach corridors for Luke Air Force Base.	12C	Save Lives Prevention Property Protection Public Education & Awareness	MCDEM MC Board of Supervisors Luke AFB Local jurisdictions: Peoria, Glendale, Surprise, Gila Bend as well as west valley communities	MCDEM staff MC BoS MC Clerk of the Board Luke AFB staff Local jurisdiction staff

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Table 8-8: Mitigation Action Plan				
Prioritized Actions	Associated Goal(s) and Objective(s) (Actions may address multiple objectives)	Category of Benefit (Prevention, Property Protection, Public Education and Awareness, Natural Resources Protection, Emergency Services, Structural Projects)	Implementation Responsibility (Primarily responsible entity, Support entities)	Resources Required
11) 1.E.2. Through the Maricopa County Regional Leadership program, establish Maricopa County as a central source for regional geographic information system data and information.	1E	Emergency Services Prevention	MC Assessors Office Director MCDOT FCD MCDEM Local jurisdictions MAG	Staff for: Assessor's office, MCDOT, FCD, MCDEM, MAG, Local jurisdictions
12) 5.A.5 Encourage bridge or culvert construction where roads are in locations susceptible to flooding.	5, 5A	Save Lives Prevention Property Protection Emergency Services	MCDOT MCSO Local jurisdictions	Staff for: MCDOT, MCSO, Local jurisdictions
13) 12.A.5. Provide program direction in support and development of Community Emergency Response Teams (CERT) teams.	12, 12A	Public Education & Awareness Emergency Services Prevention	MCDEM Local jurisdictions	MCDEM CERT Coordinator Local jurisdiction staff

Source: Maricopa County, October 2003.

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9. PLAN MAINTENANCE PROCEDURES

The *Disaster Mitigation Act of 2000* requires a formal plan maintenance process to take place to ensure that the *Maricopa County Unincorporated Area Hazard Mitigation Plan* remains an active and applicable document. The plan maintenance process adopted by the County for the Maricopa County unincorporated area only should include a schedule for monitoring and evaluating the plan at least every five years, implementation of the plan through existing programs, and continued public participation throughout the plan maintenance process is required.

This section also includes an explanation of how the Maricopa County Unincorporated Area and the Maricopa County Department of Emergency Management (MCDEM) intend to organize their efforts to ensure that improvements and revisions to the County's Plan occur in a well-managed, efficient, and coordinated manner.

This section includes the following three subsections, which are addressed in turn below:

- Monitoring, Evaluating, and Updating the Plan
- Implementation Through Existing Programs
- Continued Public Involvement

9.1 Monitoring, Evaluating, and Updating the Plan

The task of monitoring, evaluating, and updating the Plan also falls largely on the shoulders of the County because local resources to accomplish this task are most affectively applied by those who are most influenced by the Plan's implementation. In compliance with the *Disaster Mitigation Act of 2000* (see Table 9-1), the County details below a method to ensure that the Plan is reviewed and updated regularly.

Table 9-1: DMA 2000 Requirements – Monitoring, Evaluating, and Updating the Plan

Section	Title	Requirement	Language
Plan Maintenance Procedures	Monitoring, Evaluating, and Updating the Plan	§201.6(c)(4)(i):	[The plan maintenance process shall include a section describing the] method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Source: FEMA, July 11, 2002.

The *Maricopa County Unincorporated Area Hazard Mitigation Plan* was originally prepared as a collaborative effort between the Maricopa County Department of Emergency Management (MCDEM) and the Maricopa County Unincorporated Area. Along with 27 jurisdictions in Maricopa County, the Maricopa County Unincorporated Area had a representative who attended a series of meetings and workshops organized by MCDEM aimed at assisting the jurisdictions to prepare hazard mitigation plans in compliance with the *Disaster Mitigation Act of 2000*. The Maricopa County Unincorporated Area representative led the Maricopa County Unincorporated Area's Hazard Mitigation Plan Team, which prepared, revised, and supported the adoption of the *Maricopa County Unincorporated Area Hazard Mitigation Plan*.

In order to maintain momentum and build upon previous hazard mitigation planning efforts and success, the Maricopa County Unincorporated Area will utilize the County Hazard Mitigation Plan Team to monitor, evaluate, and update the Plan. In addition to the original members of the County Hazard Mitigation Plan Team, members of the Team may come from the Board of Supervisors, Maricopa County Planning Commission, the County Administrators Office, and any other department representative responsible for implementing the County's Action Plan. This group will include a team leader, who will serve as the primary point of contact for County, State, and Federal Officials, and who will coordinate all local efforts to monitor, evaluate, and revise the Plan.

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The County's Hazard Mitigation Plan Team will conduct an annual review of progress implementing the *Maricopa County Unincorporated Area Hazard Mitigation Plan*, particularly the Action Plan. The review will include an evaluation of the following:

- Notable changes in the County's risk to natural or human-caused hazards.
- Impacts of land development activities and related programs on hazard mitigation.
- Correspondence between the County's hazards and the Plan's goals, objectives, and actions.
- Progress on implementation of the Plan. If necessary, this will include identification of problems and suggested improvements.
- Actual progress implementing the Plan versus expectations.
- The adequacy of resources for implementation of the Plan.
- Participation of County agencies and others in the Plan's implementation versus expectations.

The findings from this review will be presented annually by the Maricopa County Unincorporated Area Hazard Mitigation Plan Team to the County Board of Supervisors and also submitted in memorandum format to the Maricopa County Department of Emergency Management (MCDEM) and the Arizona Division of Emergency Management (ADEM). The annual review will provide the basis for possible changes in the Plan's implementation through refocusing on new or more threatening hazards, changes to or increases in resources allocations, and engaging additional support for the Plan's implementation.

The *Disaster Mitigation Act of 2000* requires the updating of hazard mitigation plan's every five years at the local level. To ensure that this occurs, in the fourth year following adoption of the Plan, the Maricopa County Unincorporated Area Hazard Mitigation Team will undertake the following activities:

- Work with MCDEM to thoroughly analyze and update the County's risk to natural and man-made hazards (as was done to prepare the original Plan).
- Provide a new annual review (as noted above), plus a review of the three previous annual reports.
- Provide an additional detailed review and revision of the Mitigation Strategy, including each goal, objective, and potential action.
- Prepare a new Action Plan with prioritized actions, responsible parties, and resources.
- Prepare a new draft *Maricopa County Unincorporated Area Hazard Mitigation Plan* and submit to the County Board of Supervisors for adoption.
- Submit an updated Plan to the Arizona Division of Emergency Management for approval.

9.2 Implementation Through Existing Programs

The many processes that allow the County to function as a community are also those that will ensure a viable outcome due to a hazard event or natural disaster. Therefore, local-level experts are those expected to ensure that the Plan's goals, objectives, and actions are implemented. In compliance with the *Disaster Mitigation Act of 2000* (see Table 9-2), described below are procedures to implement the hazard mitigation plan through existing programs.

Table 9-2: DMA 2000 Requirements – Implementation Through Existing Programs

Section	Title	Requirement	Language
Plan Maintenance Procedures	Implementation Through Existing Programs	§201.6(c)(4) (ii):	[The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate…

Source: FEMA, July 11, 2002.

Within two years of the formal adoption of the Plan, the County will strive to incorporate into the process of existing planning mechanisms any local policies recommended for revision by the County's Hazard Mitigation Plan Team. The Maricopa County Unincorporated Area utilizes comprehensive land use planning, development standards, capital improvements planning, building codes, and various other regulatory mechanisms to guide and control

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development in the community. Since the County has autonomy over these various tools – it is provided an excellent opportunity to augment them as necessary to address applicable hazard mitigation requirements. However, as a community that exists in a very active regional context, many of these processes may also affect neighboring communities and development. To ensure that altering these standards do not negatively affect adjacent communities, the County will seek consistency and collaboration with its counterpart regulatory documents from surrounding jurisdictions.

After adoption of the *Maricopa County Unincorporated Area Hazard Mitigation Plan*, the County should encourage its divisions and departments to be aware of the hazards that are affected by the planning and development decisions they may make and implement. The Maricopa County Unincorporated Area Hazard Mitigation Team, supported by Maricopa County Department of Emergency Management, will conduct periodic reviews of the County's planning documents, development guidelines, and land use policies. This Team will also analyze any plan amendments, and provide technical assistance to any division or department in implementing these requirements.

9.3 Continued Public Involvement

The Maricopa County Unincorporated Area is dedicated to involving the public directly in the continual reshaping and updating of the *Hazard Mitigation Plan*. The County's Hazard Mitigation Plan Team members are responsible for the review and update of the Plan. Although they represent the public to some extent, the public is entitled to directly comment on and provide feedback regarding updates and revisions to the Plan. In compliance with the *Disaster Mitigation Act of 2000* (see Table 9-3), public access to the Plan and to the various revision processes will be made through mechanisms described below.

Table 9-3: DMA 2000 Requirements – Continued Public Involvement

Section	Title	Requirement	Language
Plan Maintenance Procedures	Continued Public Involvement	§201.6(c)(4) (iii):	[The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

Source: FEMA, July 11, 2002.

Copies of the Plan will be provided to participating municipal Division Directors and kept on hand at the County Administrator's Office and the Emergency Management Director's Office. Upon approval, the existence and location of these documents will be made public through postings to be placed in visible locations in municipal facilities, and will be posted on the County's website. Contained in the hard copies of the Plan are the address and phone number of the Maricopa County Unincorporated Area Hazard Mitigation Plan Evaluation Team leader, who is responsible for monitoring public comments and accepting suggestions regarding Plan revisions.

In addition, a downloadable copy of the plan and any proposed changes will be posted on the County's website, with specific direction made to hazard mitigation materials. This site will also contain an email address and phone number to which people can direct their comments or concerns. A link to this site will also be provided on the Maricopa County Department of Emergency Management website.

The Maricopa County Unincorporated Area Hazard Mitigation Team will also identify opportunities to raise awareness in the community about the Plan and the County's hazards. This could include attendance and provision of materials at major County sponsored events, such as festivals, chamber of commerce events, and neighborhood meetings.

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10. ACRONYMS

ACERP	Arizona Comparative Environmental Risk Project
AAWE	American Association for Wind Engineering
ADA	Arizona Department of Agriculture
ADEMA	Arizona Department of Emergency and Military Affairs
ADEM	Arizona Division of Emergency Management (a division of ADEMA)
ADEQ	Arizona Department of Environmental Quality
AGFD	Arizona Game and Fish Department
AL	Annualized Loss
ANSI	American National Standards Institute
APA	American Planning Association
ARS	Arizona Revised Statutes
ASCE	American Society of Civil Engineers
ASLD	Arizona State Land Department
ASU	Arizona State University
BLM	Bureau of Land Management
CAP	Central Arizona Project
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DFIRM	Digital Flood Insurance Rate
DMA 2000	Disaster Mitigation Act of 2000
EHS	Extremely Hazardous Substance
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
FEMA	Federal Emergency Management Agency
HAZMAT	Hazardous Material
HAZUS-99	Hazards United States1999
HAZUS-MH	Hazards United States Multi-Hazard
HUD	Department of Housing and Urban Development
IOM	Institute of Medicine
LEPC	Local Emergency Planning Committee
MCDEM	Maricopa County Department of Emergency Management
MCFlood	Maricopa County Flood Control District
MMI	Modified Mercalli Intensity
NCDC	National Climate Data Center
NESDIS	National Environmental Satellite, Data and Information Service
NFIP	National Flood Insurance Program
NHC	National Hurricane Center
NIBS	National Institute of Building Services
NID	National Inventory of Dams
NIST	National Institute of Standards and Technology
NFIP	National Flood Insurance Program

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NSF	National Science Foundation
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center
NWS	National Weather Service
OIE	Office International des Epizooties
PSDI	Palmer Drought Severity Index
RL	Repetitive Loss
SARA	Superfund Amendments and Reauthorization Act
SERC	State Emergency Response Commission
SRP	Salt River Project
UBC	Uniform Building Code
URS	URS Corporation
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
WMD	Weapon(s) of Mass Destruction

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11. DEFINITIONS

Actions: Specific actions that help achieve goals and objectives. Multiple mitigation actions may be defined to feed into an evaluation of the alternative actions.

Arson: The act of willfully and maliciously burning of property, especially with criminal or fraudulent intent.

Asset: Any natural or human-made feature that has value, including, but not limited to people; buildings; infrastructure like bridges, roads, and sewer and water systems; lifelines like electricity and communication resources; or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.

Avalanche: Avalanches are massive downward and outward movements of slope-forming materials. These masses may range from car-size to entire mountainsides and includes movement of snow, ice, and debris moving rapidly enough to threaten life. Snow avalanches are caused by the added weight of fresh snow or by gradual weakening of older snow and are often triggered by recreational activity or the impact of small masses of snow or ice falling from above. Three main factors determine whether avalanches are likely to occur - the weather, snow pack, and terrain. There are two principal types of avalanches: a loose snow avalanche gathers more and more snow as it descends a mountainside; a slab avalanche consists of more compact, cohesive snow and ice that breaks away from the slope in a discrete mass. The latter type is responsible for the great majority of accidents.

Biological Hazards: A hazard caused by the presence of any micro-organism, virus, infectious substance, or biological product that may be engineered as a result of biotechnology or any naturally occurring micro-organism, virus, infectious substance, or biological product, capable of causing death, disease, or other biological malfunction.

Building: A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Building / Structure Collapse: The failure and downfall of a structure. The collapse may result from a variety of natural causes such as hurricanes, earthquakes, tornadoes, floods, or from manmade circumstances such as construction deficiencies, neglect, aging infrastructure, or acts of terrorism.

Civil Disobedience: The refusal to obey civil laws or decrees, usually taking the form of passive resistance. People practicing civil disobedience break a law because they consider the law unjust, want to call attention to its justice, and hope to bring about its repeal or amendment. They are also willing to accept a penalty for breaking the law.

Civil Disturbance: When individuals or segments of the population create a situation, often a result of civil unrest, requiring a response from the emergency response community to protect lives and property. The disturbance may be small and isolated to a small area or be of a larger scale and exceeding the response capabilities of a jurisdiction. Activities are normally active (demonstrations, looting, riots) rather than passive (public speeches, sit-downs, marches).

Civil Unrest: When a segment of the civil population indicates its discontent or dissatisfaction with existing political, social, or religious issues. The unrest may materialize as a civil disturbance or civil disobedience. Activities may be passive (public speeches, sit-downs, marches) or active (demonstrations, looting, riots).

Consequences: The damages (full or partial), injuries, and losses of life, property, environment, and business that can be quantified by some unit of measure, often in economic or financial terms.

Critical Facilities and Infrastructure: Systems or facilities whose incapacity or destruction would have a debilitating impact on the defense or economic security of the nation. The Critical Infrastructure Assurance Office (CIAO) defines eight categories of critical infrastructure, as follows:

- Telecommunications infrastructure: Telephone, data services, and Internet communications, which have become essential to continuity of business, industry, government, and military operations.

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- Electrical power systems: Generation stations and transmission and distribution networks that create and supply electricity to end-users.
- Gas and oil facilities: Production and holding facilities for natural gas, crude and refined petroleum, and petroleum-derived fuels, as well as the refining and processing facilities for these fuels.
- Banking and finance institutions: Banks, financial service companies, payment systems, investment companies, and securities/commodities exchanges.
- Transportation networks: Highways, railroads, ports and inland waterways, pipelines, and airports and airways that facilitate the efficient movement of goods and people.
- Water supply systems: Sources of water; reservoirs and holding facilities; aqueducts and other transport systems; filtration, cleaning, and treatment systems; pipelines; cooling systems; and other delivery mechanisms that provide for domestic and industrial applications, including systems for dealing with water runoff, wastewater, and firefighting.
- Government services: Capabilities at the federal, state, and local levels of government required to meet the needs for essential services to the public.
- Emergency services: Medical, police, fire, and rescue systems.

Dam / Levee Failure: Dam/levee failure can be caused by natural occurrences such as floods, rock slides, earthquakes, or the deterioration of the foundation or the materials used in construction. Usually the changes are slow and not readily discovered by visual examination. Such a failure presents a significant potential for a disaster in that significant loss of life and property would be expected in addition to the possible loss of power and water resources.

Department of Homeland Security (DHS): Following the September 11, 2001 terrorist attacks, President George W. Bush created a new federal government department in order to bring 22 previously separate domestic agencies together. The new department's first priority is protecting the nation against further terrorist attacks. Component agencies analyze threats and intelligence, guard borders and airports, protect critical infrastructure, and coordinate the response for future emergencies. The new department is organized into five major directorates: Border and Transportation Security (BTS); Emergency Preparedness and Response (EPR); Science and Technology (S&T); and Information Analysis and Infrastructure Protection (IAIP); Management. In addition, several other critical agencies have been folded into the new department or are newly created. The Federal Emergency Management Agency (FEMA) is the foundation of the Emergency Preparedness and Response (EPR) Directorate.

Disaster Mitigation Act of 2000 (DMA2K): A law signed by the President on October 30, 2000 that encourages and rewards local and state pre-disaster planning, promotes sustainability as a strategy for disaster resistance, and is intended to integrate state and local planning with the aim of strengthening statewide mitigation planning.

Drought: A drought occurs when water supplies cannot meet established demands. "Severe" to "extreme" drought conditions endanger livestock and crops, significantly reduce surface and ground water supplies, increase the potential risk for wildland fires, increase the potential for dust storms, and cause significant economic loss. Humid areas are more vulnerable than arid areas. Drought may not be constant or predictable and does not begin or end on any schedule. Short-term droughts are less common due to the reliance on irrigation water in arid environments.

Dust / Sand Storms: A dust or sand storm is a severe windstorm that sweeps clouds of dust across an arid region. They can be hazardous to transportation and navigation and to human health. Severe or prolonged dust and sand storms can result in disasters causing extensive economic damage over a wide area and personal injury and death. In Arizona, dust or sand storms are generally associated with the advance of a thunderstorm.

Earthquake: An earthquake is a naturally induced shaking of the ground, caused by the fracture and sliding of rock within the Earth's crust. The magnitude is determined by the dimensions of the rupturing fracture (fault) and the amount of displacement that takes place. The larger the fault surface and displacement, the greater the energy. In addition to deforming the rock near the fault, this energy produces the shaking and a variety of seismic waves that

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radiate throughout the Earth. Earthquake magnitude is measured using the Richter Scale and earthquake intensity is measured using the Modified Mercalli Intensity Scale.

Emergency Preparedness and Response (EPR) Directorate: One of five major Department of Homeland Security Directorates that builds upon the formerly independent Federal Emergency Management Agency (FEMA). EPR is responsible for preparing for natural and man-made disasters through a comprehensive, risk-based emergency management program of preparedness, prevention, response, and recovery. This work incorporates the concept of disaster-resistant communities, including providing federal support for local governments that promote structures and communities that reduce the chances of being hit by disasters.

Emergency Response Plan: A document that contains information on the actions that may be taken by a governmental jurisdiction to protect people and property before, during, and after a disaster.

Enemy Attack: The use of aggressive action against an opponent in pursuit of an objective. An "enemy attack" is considered an attack of one sovereign government against another as either a declared or undeclared act of war.

Explosion / Fire: An explosion is the sudden loud release of energy and a rapidly expanding volume of gas that occurs when a gas explodes or a bomb detonates. Explosions result from the ignition of volatile products such as petroleum products, natural and other flammable gases, hazardous materials/chemicals, dust, and bombs. While an explosion surely may cause death, injury and property damage, a fire routinely follows which may cause further damage and inhibit emergency response.

Exposure: The number, types, qualities, or monetary values of various types of property or infrastructure and life that may be subject to an undesirable or injurious hazard event.

Extreme Air Pollution: Pollution is the contamination of the earth's environment with materials that interfere with human health, the quality of life, or the natural functioning of ecosystems. Air pollution is the addition of harmful substances to the atmosphere. It makes people sick, causing breathing problems and sometimes cancer, and it harms plants, animals, and the ecosystems in which they live. Some pollutants return to earth in the form of acid rain and snow that corrodes structures, damages vegetation, and makes streams and lakes unsuitable for life. "Extreme air pollution" exceeds established thresholds resulting in the need to take corrective actions and cause the public to take precautions.

Extreme Cold: Extreme cold is associated with either polar regions or extreme winter storms. Communities in polar regions are less threatened as they are normally prepared to cope with extreme cold. The extreme cold associated with winter storms is a deceptive killer as it indirectly causes injury and death resulting from exhaustion and overexertion, hypothermia and frostbite from wind chill, and asphyxiation.

Extreme Heat: Extreme heat is defined as temperatures that hover ten degrees or more above the average high temperature for the region and last for several weeks. Humid conditions may also add to the discomfort of high temperatures. Excessively dry and hot conditions can provoke dust storms and low visibility.

Federal Emergency Management Agency (FEMA): Formerly independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery. As of March 2003, FEMA is a part of the Department of Homeland Security's Emergency Preparedness and Response (EPR) Directorate.

Flood Insurance Rate Map(FIRM): of a community, prepared by FEMA, that shows the special flood hazard areas and the risk premium zones applicable to the community.

Fuel / Resource Shortage: A fuel/resource shortage is defined as an actual or potential shortage of natural gas, crude and refined petroleum, petroleum-derived fuels, or other critical commodities that significantly impacts the ability to: render essential government and emergency services (medical, fire, safety); and threatens the health and safety of the public.

Frequency: A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a

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hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered. Probability is a related term.

Fujita Scale of Tornado Intensity: Rates tornadoes with numeric values from F0 to F5 based on tornado winds peed and damage sustained. An F0 indicates minimal damage such as broken tree limbs or signs, while an F5 indicates severe damage sustained.

Geographic Information Systems (GIS): A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.

Goals: General guidelines that explain what you want to achieve. Goals are usually broad statements with long-term perspective.

Hazard: A source of potential danger or adverse condition. Hazards include both natural and man-made events. A natural event is a hazard when it has the potential to harm people or property and may include events such as floods, earthquakes, tornadoes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. Man-made hazard events originate from human activity and may include technological hazards and terrorism. Technological hazards arise from human activities and are assumed to be accidental and/or have unintended consequences (e.g., manufacture, storage and use of hazardous materials). While no single definition of terrorism exists, the Code of Federal Regulations defines terrorism as "…unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives."

Hazard Event: A specific occurrence of a particular type of hazard.

Hazard Identification: The process of identifying hazards that threaten an area.

Hazard Mitigation: Cost effective measures taken to reduce or eliminate long-term risk associated with hazards and their effects.

Hazard Profile: A description of the physical characteristics of hazards and a determination of various descriptors including magnitude, duration, frequency, probability, and extent.

Hazardous Materials Incidents: A spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment of a hazardous material, but excludes: (1) any release which results in exposure to poisons solely within the workplace, with respect to claims which such persons may assert against the employer of such persons; (2) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; (3) release of source, byproduct, or special nuclear material from a nuclear incident; and (4) the normal application of fertilizer.

HAZUS: A GIS-based nationally standardized earthquake loss estimation tool developed by FEMA.

Hostage Situation: A situation in which people are held hostage and negotiations take place for their release. The situation may range from a simple domestic or isolated criminal act to an attempt to impose will on a national or international scale to intimidate or coerce a government to further a political, social, or religious objective.

Hysteria (Mass): Also known as "mass psychogenic illness" and "hysterical contagion," mass hysteria is a situation in which a symptom or set of symptoms for which there is no physical explanation spreads quickly among a group. It may occur as a reaction to an incident of domestic terrorism.

Implementation Strategy: A comprehensive strategy that describes how the mitigation actions will be implemented.

Infestations: An infestation consists of an invasion or spreading of a living organism (plant, animal, etc.) that has an adverse (unwanted) effect on the population or the environment. The effect may range from a simple nuisance to an infectious disease or destructive parasite or insect. Infestations may result from non-indigenous plants, rodents, weeds, parasites, insects, and fungi, and may adversely affect people, animals, agriculture, economy (e.g., tourism), and property.

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Liquefaction: The phenomenon that occurs when ground shaking (earthquake) causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength.

Landslides / Mudslides: Landslides, like avalanches are massive downward and outward movements of slope-forming materials. The term landslide is restricted to movement of rock and soil and includes a broad range of velocities. Slow movements, although rarely a threat to life, can destroy buildings or break buried utility lines. A landslide occurs when a portion of a hill slope becomes too weak to support its own weight. The weakness is generally initiated when rainfall or some other source of water increases the water content of the slope, reducing the shear strength of the materials. A mudslide is a type of landslide referred to as a flow. Flows are landslides that behave like fluids: mud flows involve wet mud and debris.

Mitigate: To cause to become less harsh or hostile; to make less severe or painful. Mitigation activities are actions taken to eliminate or reduce the probability of the event, or reduce its severity of consequences, either prior to or following a disaster/emergency.

Mitigation Plan: A systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards typically present in a defined geographic area, including a description of actions to minimize future vulnerability to hazards.

Modified Mercalli Intensity Scale: The Modified Mercalli Intensity Scale is commonly used in the United States by seismologists seeking information on the severity of earthquake effects. Intensity ratings are expressed as Roman numerals between I at the low end and XII at the high end. The Intensity Scale differs from the Richter Magnitude Scale in that the effects of any one earthquake vary greatly from place to place, so there may be many Intensity values (e.g.: IV, VII) measured from one earthquake. Each earthquake, on the other hand, should have just one Magnitude, although the several methods of estimating it will yield slightly different values (e.g.: 6.1, 6.3).

Monsoon: A monsoon is any wind that reverses its direction seasonally. In the Southwestern U.S., for most of the year the winds blow from the west/northwest. Arizona is located on the fringe of the Mexican Monsoon, which during the summer months turns the winds to a more south/southeast direction and brings moisture from the Pacific Ocean, Gulf of California, and Gulf of Mexico. This moisture often leads to thunderstorms in the higher mountains and Mogollon Rim, with air-cooled from these storms often moving from the high country to the deserts, leading to further thunderstorm activity in the desert. A common misuse of the term monsoon is to refer to individual thunderstorms as monsoons.

Objectives: Defined strategies or implementation steps intended to attain the identified goals. Unlike goals, objectives are specific, measurable, and have a defined time horizon.

100-Hundred Year Floodplain: Also referred to as the Base Flood Elevation (BFE) and Special Flood Hazard Area (SFHA). An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year.

Planning: The act or process of making or carrying out plans; the establishment of goals, policies, and procedures for a social or economic unit.

Power / Utility Failure: A power/utility failure is defined as an actual or potential shortage of electric power or the interruption of electrical power that significantly threatens health and safety. Many communities are vulnerable to many localized, short and long-term energy emergencies. Power shortages or failures do occur and may be brought on by severe weather conditions, such as blizzards, ice storms, extreme heat, thunderstorms, or events such as war, or civil disturbance.

Probability: A measure of how often events of a particular magnitude are expected to occur. Probability describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered. May also be measured in terms of the chance that an event will be exceeded (or not exceeded) over a specified period of time. Frequency is a related term.

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Q3 Data: The Q3 Flood Data product is a digital representation of certain features of FEMA's Flood Insurance Rate(FIRM) product, intended for use with desktop mapping and Geographic Information Systems technology. The digital Q3 Flood Data are created by scanning the effective Flood Insurance Rate(FIRM) paper maps and digitizing selected features and lines. The digital Q3 Flood Data are designed to serve FEMA's needs for disaster response activities, National Flood Insurance Program activities, risk assessment, and floodplain management.

Radiological Accident: A radiological accident is a release of radioactive materials. It can occur where radioactive materials are used, stored, or transported. Potentially nuclear power plants (fixed nuclear facilities), hospitals, universities, research laboratories, industries, major highways, railroads, or shipping yards could be the site of a radiological accident.

Radon: Radon is a naturally occurring radioactive gas that is odorless and tasteless. It is formed from the radioactive decay of uranium. Uranium is found in small amounts in most rocks and soil. It slowly breaks down to other products such as radium, which breaks down to radon. Radon also undergoes radioactive decay. Radon enters the environment from the soil, from uranium and phosphate mines, and from coal combustion. Radon has a radioactive half-life and about 4 days; this means the one-half of a given amount of radon will decay to other products every 4 days. Some of the radon produced in the soil will move to the surface and enter the air. Radon also moves from the soil and enters the groundwater.

Repetitive Loss Property: A property that is currently insured for which two or more National Flood Insurance Program losses (occurring more than ten days apart) of at least $1000 each have been paid within any 10-year period since 1978.

Richter Magnitude Scale: A logarithmic scale devised by seismologist C. F. Richter in 1935 to express the total amount of energy released by an earthquake. While the scale has no upper limit, values are typically between 1 and 9, and each increase of 1 represents a 32-fold increase in released energy.

Risk: The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage beyond a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: A process or method for evaluating risk associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure, and consequences.

Sabotage: Sabotage is the deliberate destruction of property, dismantling of technology or other interference or obstruction of normal operations. "Sabotage" is normally considered an act related to war; similar acts during "non-war" conditions would be considered a terrorist act.

Special Events: An event of such a magnitude, media visibility, or importance that may require extraordinary preparations by government and possible response by emergency response agencies. Such events may be considered an opportunity or target for activist or terrorist activities.

Strike: A strike is an organized work stoppage carried out by a group of employees for the purpose either of enforcing demands relating to employment conditions on their employer or of protesting unfair labor practices. A strike may be engaged to obtain improvement in work conditions, higher wages or shorter hours, to forestall an adverse change in conditions of employment, or to prevent the employer from carrying out actions viewed by workers as detrimental to their interests.

Subsidence: Land subsidence occurs when large amounts of ground water have been withdrawn from certain types of rocks, such as fine-grained sediments. The rock compacts because the water is partly responsible for holding the ground up. When the water is withdrawn, the rocks fall in on itself.

Substantial Damage: Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceeds 50 percent of the market value of the structure before the damage.

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Thunderstorms / High Winds: Thunderstorms are characterized as violent storms that typically are associated with high winds, dust storms, heavy rainfall, hail, lightning strikes, and/or tornadoes. The unpredictability of thunderstorms, particularly their formation and the rapid movement to new locations heightens the possibility of floods. Thunderstorms, dust/sand storms and the like are most prevalent in Arizona during the monsoon season, which is a seasonal shift in the winds that causes an increase in humidity capable of fueling thunderstorms. The monsoon season in Arizona typically is from late-June or early-July through mid-September.

Tornadoes / Dust Devils: A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds in excess of 250 mph. Damage paths can exceed a mile wide and 50 miles long. Tornadoes are one of nature's most violent storms. In an average year, 800 tornadoes are reported across the United States, resulting in 80 deaths and over 1,500 injuries. The damage from tornadoes is due to high winds. The Fujita Scale of Tornado Intensity measures tornado / high wind intensity and damage.

A dust devil is a small but rapidly rotating column of wind made visible by the dust, sand, and debris it picks up from the surface. They typically develop best on clear, dry, hot afternoons and are common during the summer months in the desert portions of Arizona. While resembling tornadoes, dust devils typically do not produce damage, although in Arizona they have done so.

Terrorism (Economic, Cyber, Nuclear, Biological, and Chemical):"Terrorism is the unlawful use of force or violence, or threatened use of force or violence, against persons and places for the purpose of intimidation and/or coercing a government, its citizens, or any segment thereof for political or social goals." (Department of Justice, Federal Bureau of Investigation). Terrorism can include computer-based (cyber) attacks and the use of weapons of mass destruction (WMD) to include chemical, biological, radiological, nuclear, or explosive (CBRNE) agents.

Transportation Accident: A transportation accident is an incident related to a mode of transportation (highway, air, rail, waterway, port, harbor) where an emergency response is necessary to protect life and property.

Tropical Storms / Hurricane: A tropical system in which the maximum sustained surface wind ranges from 34 to 63 knots (39 to 73 mph). Tropical storms are associated with heavy rain, high wind, and thunderstorms. High intensity rainfall in short periods is typical. A tropical storm is classified as a hurricane when its sustained winds reach or exceed 74 mph (64 knots). These storms are medium to large in size and are capable of producing dangerous winds, torrential rains, and flooding, all of which may result in tremendous property damage and loss of life, primarily in coastal populated areas. The effects are typically most dangerous before a hurricane makes landfall, when most damage occurs. However, Arizona has experienced a number of tropical storms that caused extensive flooding and wind damage.

Volcanoes: A volcano is a vent in the Earth from which molten rock (magma) and gas erupt. The molten rock that erupts from the volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Volcanic eruptions can be placed into two general categories: those that are explosive and those that are effusive resulting in gently flowing lava flows, spatter cones, and lava fountains. Many eruptions are highly explosive in nature. They produce fragmental rocks from erupting lava and surrounding area rock and may produce fine volcanic ash that rises many kilometers into the atmosphere in enormous eruption columns. Explosive activity can also cause widespread ash fall, pyroclastic flows, debris avalanches, landslides, pyroclastic surges, and lahars.

Vulnerability: Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power–if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

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Vulnerability Analysis: The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability analysis should address impacts of hazard events on the existing and future built environment.

Vulnerable Populations: Any segment of the population that is more vulnerable to the effects of hazards because of things such as lack of mobility, sensitivity to environmental factors, or physical abilities. These populations can include, but are not limited to, senior citizens and school children.

Wildfires: Wildfire is a rapid, persistent chemical reaction that releases heat and light, especially the exothermic combination of a combustible substance with oxygen. Wildfires present a significant potential for disaster in the southwest, a region of relatively high temperatures, low humidity, low precipitation, and during the spring moderately strong daytime winds. Combine these severe burning conditions with people or lightning and the stage is set for the occurrence of large, destructive wildfires.

Winter Storms: Winter storm is defined as a cold wind accompanied by blowing snow; freezing rain or sleet, cold temperatures, and possibly low visibility and drifting snow. The storms often make roads impassable. Residents, travelers, and livestock may become isolated or stranded without adequate food, water, and fuel supplies. The conditions may overwhelm the capabilities of a local jurisdiction. Winter storms are considered deceptive killers as they indirectly cause transportation accidents, and injury and death resulting from exhaustion/overexertion, hypothermia and frostbite from wind chill, and asphyxiation.

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