10 Geologic, Seismic, and Soil Hazards

Humboldt County is located within a seismically active area of California. It is in the two highest seismic risk zones of the Uniform Building Code, and Cape Mendocino (offshore the county) experiences the highest concentration of earthquake events in the continental United States. In addition to causing ground shaking, an earthquake can trigger other natural disasters such as fire, landslides, and flooding, resulting in loss of life and extensive property damage. Seismic hazards in the county include earthquake ground shaking, surface fault rupture, liquefaction, and tsunami potential in the coastal zone areas. Geologic hazards not specifically related to earthquakes include landslides and soil stability. The first sections describe bedrock geology and geologic hazards more fully; the second section addresses policy issues. The Appendices include the policy evaluation worksheets.

10.1 BEDROCK GEOLOGY

Two geologic provinces cover Humboldt County: the dominant Coast Ranges province in the central and southwest sections of the county, which is comprised mainly of the Franciscan complex inland and sand and other alluvial deposits closer to the coast; and the Klamath Mountains province in the northeast, which is comprised generally of older rocks, many of which are sedimentary (e.g., sandstone, chert, slate, and schist). The South Fork Mountain Ridge generally divides the two provinces. Bedrock types throughout the county are shown in Figure 10-1. The predominant rock types are the Franciscan Complex and schists, covering over a million acres in the county, and the Tertiary-Cretaceous Coastal Belt rocks, covering 340,000 acres. The Franciscan Complex is a suite of rocks that originated on the deep sea floor and were later pushed up against the continental margin along the coast of California, through plate tectonic forces.

Table 10-1 provides a breakdown of rock types by planning watershed (as defined in Chapter 1). Please note that bedrock geology is poorly mapped in some parts of the county. Therefore, assessing site stability is not possible without a specific site geologic investigation.

The following sub-sections provide summary descriptions of the geology of each planning watershed. Additional geologic data is provided for the planning watersheds in Volume II of this report.

EEL RIVER BASIN

The Eel River basin is a mountainous area uplifted in recent geologic time (post-Miocene) and underlain by a deformed, faulted, locally sheared, and, in part, metamorphosed accumulation of subducted continental margin deposits. About 99 percent of the bedrock underlying the basin is sedimentary and metasedimentary.

Table 10-1: Bedrock Types by Planning Watersheds

	Watershed											
Bedrock Type	*Cape Mendocino*	*Eureka Plain*	*Lower Eel*	*Lower Klamath*	*Lower Trinity*	*Mad River*	*Middle Main Eel*	*Redwood Creek*	*South Fork Eel*	*South Fork Trinity*	*Trinidad*	*Van Duzen*
Cenozoic Sedimentary Rocks												
Quaternary Alluvium non-marine, marine	0.01%	36.7%	24.5%	0.03%		7.9%					13.5%	6.9%
Extensive sand dune deposits		4.2%	1.1%			0.4%						
Plio-Pleistocene nonmarine, Pliocene nonmarine				0.9%	0.3%			9.6%				
Pliocene marine	4.1%	36.6%	22.3%			3.6%	2.5%		8.1%			8.5%
Paleocene marine	4.0%	4.6%	7.3%				11.0%		45.7%			18.0%
Cenozoic Volcanic Rocks												
Tertiary intrusive rocks						0.1%						
Mesozoic-Paleozoic-Precambrian Sedimentary and Metasedimentary Rocks												
Tertiary-Cretaceous Coastal Belt rocks	90.4%		20.1%						11.9%			
Franciscan Complex	0.8%	17.9%	22.9%	29.1%	1.6%	83.1%	85.9%	38.2%	33.8%	20.7%	54.0%	65.3%
Franciscan schist				26.2%	6.8%	4.8%		51.9%		13.7%	32.5%	
Jurassic Marine				17.8%	43.1%					28.5%		
Paleozoic marine, undivided				5.9%	16.4%					28.7%		
Cenozoic-Precambrian Plutonic, Metavolcanic, and Mixed Rocks												
Mesozoic granitic rocks				7.8%	26.2%					7.4%		
Mesozoic volcanic and metavolcanic rocks; Franciscan volcanic rocks										0.2%		
Ultramafic rocks, chiefly Mesozoic	0.2%		0.2%	12.2%	5.6%		0.6%	0.2%	0.5%	0.7%		1.4%
Undivided pre-Cenozoic metasedimentary and metavolcanic rocks	0.5%		1.5%									
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: California Geological Society and Humboldt County, 2002.

Figure 10-1a: Northern Humboldt Bedrock and Faults (11x17)

Figure 10-1a: pg. 2

Figure 10-1b: Central Humboldt Bedrock and Faults (11x17)

Figure 10-1b: pg. 2

Figure 10-1c: Southern Humboldt Bedrock and Faults (11x17)

Figure 10-1c: pg. 2

The four planning watersheds in the Eel River Basin (South Fork Eel, Lower Eel, Middle Main Eel, and Van Duzen) are generally comprised of highly erodible rocks, including substantial amounts of Franciscan Complex rocks. Over 85% of the Middle Main Eel and 65% of the Van Duzen is Franciscan Complex. The Lower Eel and South Fork Eel planning watersheds contain some Coastal Belt rocks; both the Lower Eel and South Fork Eel are comprised of over 50% Cenozoic Sedimentary rocks.

KLAMATH-TRINITY BASIN

The Klamath-Trinity Basin, composed of the Lower Klamath, Lower Trinity, and South Fork Trinity planning watersheds, is the only basin with notable amounts of plutonic and metavolcanic rocks. The Humboldt County portion of the basin encompasses the North Coast Ranges province. In the North Coast Ranges, landslides and soil slips are common due to the combination of sheared rocks, shallow soil profile development, steep slopes, and heavy seasonal precipitation. Also, both the Lower Klamath and South Fork Trinity have substantial amounts of Franciscan Complex rocks. Jurassic marine sediments are the predominant bedrock type in the Lower Trinity planning watershed.

MAD-REDWOOD BASIN

The geology of the Mad-Redwood Basin is complex and variable. The basin includes the Mad River, Redwood Creek, Eureka Plain, and Trinidad planning watersheds, which all differ in their bedrock composition. Mad River, Redwood Creek, and Trinidad are composed primarily of Franciscan rock types, while Eureka Plain is mostly younger sedimentary rock.

CAPE MENDOCINO

About 90% of the Cape Mendocino planning watershed is underlain by Tertiary-Cretaceous Coastal Belt rock. A highly active tectonic setting (see below), combined with sensitive terrain and high rainfall amounts, make the Cape Mendocino one of the most erodible watersheds in the state.

10.2 SEISMIC HAZARDS

Primary seismic hazard concerns include potential ground shaking and ground rupture along the surface trace of faults. Secondary seismic hazards are caused by the interaction of ground shaking with soft or unstable soils, resulting in liquefaction, settlement, and landslides. Also, tsunamis are addressed in this section, as a secondary effect of seismic activity.

Another earthquake hazard, which locally can be more damaging than shaking alone, is failure of the ground. Rocks may fall from cliffs, steep slopes may slide, earth may flow downslope, and even flat ground may crack and tilt.

FAULTING AND SURFACE RUPTURE

A fault is a fracture in the crust of the earth along which rocks on one side have moved relative to those on the other side. Most faults are the result of repeated displacements over a long time period. A fault trace is the line on the earth's surface defining the fault.

Surface rupture occurs when movement on a fault deep within the earth breaks through to the surface. Not all earthquakes result in surface rupture. The Loma Prieta Earthquake of 1989 caused major damage in the San Francisco Bay Area but the movement deep in the earth did not break through to the surface.

Fault rupture almost always follows preexisting faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden displacements are more damaging to structures because they are accompanied by shaking.

The offshore and coastal regions of Humboldt County contain one of the most geologically complex areas in California. Three major faults, including the San Andreas, the Mendocino fracture zone, and the southern end of the Cascade subduction zone, all meet in what is known as a "triple junction." Three major plates of the Earth's surface are defined and separated by these faults: the Pacific plate, the Gorda plate and the North American plate. As a result of this unique geologic setting, the North Coast is vulnerable to several types of earthquakes from a variety of sources. Because a triple junction has to accommodate plate motion in several directions, its faulting is varied and its seismicity is high. The geometry of the triple junction's renders it unstable, and requires that it change with time. Because much of this area lies under the Pacific Ocean, geological information is limited.

Most faults located onshore are oriented in a southeast to northwest course. Figure 10-1 depicts major faults in the county. The major systems are described below.

San Andreas Fault

The San Andreas Fault system is located south of the triple junction (just offshore of the southern section of the county), where the Pacific plate is moving at a rate of about two inches per year to the northwest (relative to North America). The irregular sliding motion, which is almost entirely horizontal, deforms the rocks along the plate boundary until the rocks can no longer withstand the strain. Then, when the rocks shift, energy is released along the fault, causing earthquake shaking.

Falor-Korbel (Mad River) Fault

This fault zone trends northwest-southeast through the central region of the county. Its northern end is on the coast near McKinleyville and the fault trace roughly parallels the Mad River.

Trinidad and Big Lagoon Faults

The Trinidad Fault is located near Trinidad, extending northwest to the coast near Trinidad State Beach. The Trinidad fault is potentially capable of generating an earthquake with a moment magnitude of 7.3. The Big Lagoon fault bisects Big Lagoon, north of Patrick's Point State Park.

Cascadia Subduction Zone

The forces are very different north of the triple junction, where the Gorda plate and its northern extension, the Juan de Fuca plate, collide with the North American plate. The Gorda plate slowly descends beneath the North American plate along the Cascadia subduction zone that extends approximately 750 miles north to the Canadian border. It is the first of a string of subduction zones to ring the Northern Pacific. Downward and eastward motion of the Gorda plate along this subduction zone, beginning at least 6 million years ago and continuing today, produced the volcanic Cascade Range in Washington, Oregon, and northern California.

Near its southern end, the subduction zone curves onshore, exposing nine major thrust faults along the Humboldt County coastline in the vicinity of Cape Mendocino. Thrust faults differ from the horizontally-moving San Andreas fault. Geologists have shown that during the last million years the rocks on top of this group of North Coast thrust faults have been pushed a mile or more to the northeast relative to the rocks beneath.[1]

The major active fault zones in this area include the Cookskie and Petrolia shear zones. The Cookskie Shear Zone is a poorly defined section of sheared and broken rock that extends easterly from Punta Gorda, and the Petrolia shear zone is a similar structure extending southeast through Petrolia toward along the Mattole River.

Until recently, scientists did not consider the Cascadia subduction zone as a major earthquake threat. Prior to the April 1992 Cape Mendocino earthquake, the Cascadia plate boundary was not known to have produced a major earthquake during the past 150 years. New evidence, however, indicates that the subduction zone is active and capable of producing great earthquakes (magnitude 8 to 9). Great earthquakes there may occur as often as every 300 or 400 years, on average. There is good evidence that the last great earthquake on the Cascade subduction zone occurred about 300 years ago. The probability of such an earthquake occurring in the next few decades has not been estimated, however.[2]

ALQUIST-PRIOLO SPECIAL STUDIES ZONE

The Alquist-Priolo Special Studies Zones Act of 1972 is the primary State legislation related to earthquake fault zones. The Act is intended to reduce fault rupture hazards by regulating development near active faults and preventing construction of buildings used for human

[1] Website: Humboldt County- Shaky Ground (http://sorrel.humboldt.edu/~geodept/earthquakes/shaky_ground.html)

[2] David Oppenheimer, Paul Reasenberg, Steve Walter, Nan Macgregor-Scott, Barry Hirshorn, and Allan Lindh, U.S. Geological Survey. "Seismicity Report for Northern California, the Nation, and the World for the week of April 23 - 29, 1992."

occupancy on the surface trace of active faults. For the purposes of the Act, an active fault is one that has ruptured in the last 11,000 years. Surface rupture is the most easily avoided seismic hazard. The Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. The designated zone extends 200 to 500 feet on both sides of known active fault traces. According to the Act, no buildings intended for human occupancy may be constructed on or within 50 feet of an active fault trace. Development within an Alquist-Priolo zone is subject to a detailed geologic investigation. Alquist-Priolo zones are designated in the following areas:

- Shelter Cove, along the San Andreas fault system;
- On the Falor-Korbel (Mad River) Fault zone passing through the McKinleyville area;
- Fortuna area;
- Trinidad, along the Trinidad fault extending northwest to the coast; and
- Arcata.

In the future, if other fault traces are determined to be active, they will be designated as a Special Study Zone. Because of the small scale maps in this chapter, Alquist-Priolo zones are not shown. However, they are shown in Chapter 14, Summary of Constraints and Opportunities.

GROUND SHAKING AND STRUCTURAL DAMAGE

Because the fault systems in Humboldt County are considered historically active (i.e., movement on the fault has occurred in the last 200 years), they have the potential to cause future earthquakes, surface rupture, and ground failure. Surface rupture is the direct effect of activity along an active fault. However, most damage to structures is caused by ground shaking, which may occur throughout a wide area (not just along the fault line). A logarithmic scale is used to measure earthquake magnitude, where each unit of measurement represents an increase of about 30 times in the energy released.

Ground Shaking

Amplification is caused when a seismic wave moves through subsurface materials and is amplified to produce relatively higher horizontal and vertical motion. In contrast, bedrock has a tendency to dampen seismic waves and therefore reduce ground motion.

About one-quarter of all the earthquake energy released in California during historic times has occurred along the Humboldt County coast. The size, location, and frequency of past earthquakes give an indication of what to expect in the future. Strong earthquakes with epicenters onshore have recurred about every 20 years.

Since the 1870s, over 15 earthquakes with magnitude 6 and larger have occurred in the county. The largest of the historic earthquakes in this area, a magnitude 7.2 earthquake, occurred in 1923. Most North Coast earthquakes have been centered offshore in the southeastern portion of the Gorda plate. These earthquakes have a frequent recurrence, causing some damage to North Coast communities about every two years. Communities in the coastal region from Cape Mendocino to Eureka have been struck far more frequently than the rest of Humboldt County. Earthquakes have only rarely affected Northern Humboldt County in historic times. However, because the historic record is relatively brief, areas not affected historically may still be at risk. Because large earthquakes are a fact of life on the north coast, residents should take actions to prepare their families, homes, schools and workplaces for the next inevitable quake.

Recent earthquake activity includes several large-scale events in the Cape Mendocino area. In 1992, three powerful earthquakes rocked the Cape Mendocino area (magnitudes 7.1, 6.6, and 6.7). Injuries and damage occurred in the nearby towns of Ferndale, Petrolia, Fortuna, Rio Del, and Scotia, and the earthquakes were felt as far north as southern Oregon and over much of northern California. The earthquakes ranged in magnitude from 6.2 to 6.9.[3]

A strong earthquake struck the north coast in January 1997. The earthquake was located just off the coast in the Cape Mendocino region, about 1 mile NW of Punta Gorda or 6 miles SW of Petrolia. The magnitude was estimated in the 5.6 to 5.7 range. The earthquake was located on the Mendocino fault very near the Mendocino triple junction. It was centered at a depth of about 15 miles beneath the earth's surface. The earthquake was felt strongly in the Cape Mendocino region and southern Humboldt County.

Ground shaking is responsible for most loss of life and property damage during an earthquake and therefore, it is important to accurately evaluate shaking hazards as a basis for improving building designs and standards. Shaking intensity depends on distance from the earthquake source and on local ground conditions (soil type plus slope). Figure 10-2 illustrates potential ground shaking in the county, as assessed by the California Division of Mines and Geology (CDMG). The orange and red areas on the figure depict areas subject to the most severe ground shaking, due primarily to their proximity to active fault zones. In addition to faults, the presence of soft sediments in the area around Humboldt Bay contributes to higher intensity ground shaking.

Structural Damage

Recent work by the United States Geological Service (USGS) on ground shaking severity has led to the preparation of new building codes for some areas. State regulations regarding seismic hazards are contained in Title 24, Part 2, California Uniform Building Code (UBC). Recordings conducted during the 1989 Loma Prieta earthquake confirmed previous USGS projections that ground shaking is much more violent on the soft sediments than on bedrock. According to the USGS, these records provided a firm basis for revising building codes to more fully reflect the need for extra strength in structures built on soft ground. Because earthquake-resistant design and construction are essential to reducing earthquake losses, these code revisions are a major step toward greater earthquake safety.

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[3] Ibid.

The extent of structural damage from ground shaking depends on several factors: the geology of the area (e.g., soil types), the duration and intensity of the fault movement, and the structure's design and construction characteristics. Buildings most vulnerable to ground shaking damage are older, unreinforced masonry buildings. Reinforced concrete structures constructed under less stringent building codes (prior to 1965), have a much higher chance of fracturing. Single family homes constructed of wood frames are one of the safest building types. Their ability to withstand large earthquakes can be further improved with foundation bolts, shear walls, and other strengthening devices.

LIQUEFACTION

When shaken strongly, unconsolidated sandy deposits that are saturated with water can liquefy and form a slurry. This process is called "liquefaction." The soil loses its capacity to bear the weight of buildings or to resist flowing downslope, even on nearly flat ground. Liquefaction may result in sinking, tilt, distortion, or destruction of buildings and bridges, rupture of underground gas lines and water mains, and cracking and spreading of the ground surface.

Figure 10-2: Probabilistic Ground Shaking, 10% Probability of Being Exceeded in 50 Years

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Liquefaction potential depends on groundwater depth and alluvial thickness. Research into the process and consequences of liquefaction in past earthquakes have linked liquefaction to certain hydrologic and geologic settings, characterized by water-saturated, cohesionless, granular materials situated at depths of less than 50 feet. The following types of areas are those identified as being favorable for liquefaction:

- Areas known to have experienced liquefaction during historic earthquakes.
- Areas of uncompacted fills containing liquefaction susceptible material that are saturated, nearly saturated, or may be expected to become saturated.
- Areas where sufficient existing geotechnical data and analyses indicate that the soils are potentially liquefiable.
- Areas containing young (less than 15,000 years) soils where there is limited or no geotechnical data.

Specific areas of high liquefaction potential are located near Humboldt Bay, coinciding with the presence of the bay's muds and sands.

TSUNAMIS

A tsunami, or large sea wave, may be produced by movement of the ocean floor resulting from either a nearby or distant earthquake. Tsunamis have historically been rare in California. Since 1812, California has experienced fourteen tsunamis with wave heights greater than 3 feet; six of these were destructive. Ten of these were generated by distant earthquakes near Alaska, Chile or Japan.[4] The worst damage in California resulted from the 1964 Alaskan earthquake. The harbor area at Crescent City was severely damaged by a tsunami produced by the Alaska earthquake, some 1500 miles away. Smaller tsunamis, though rare, have occurred along the North Coast. The coastal area that could be affected by a tsunami is shown in Figure 10-4. This area is called the tsunami "run-up zone."

A tsunami resulting from the April 1992 Cape Mendocino earthquake reached Eureka in about 20 minutes with wave heights of about one foot. The tsunami reached Crescent City in 50 minutes and was detected in Oregon, the San Francisco Bay Area, Santa Barbara, and Hawaii. Although not destructive, this event illustrates both how quickly a wave can arrive at nearby coastal communities and how long the danger period can last. The first wave arrived at Crescent City in less than an hour, but the highest waves, about one-and-a-half-feet, arrived nearly four hours later. Abnormally large waves continued for more than eight hours.[5]

Very large earthquakes in other areas of the Pacific Ocean may generate tsunamis. Waves caused by these earthquakes travel at hundreds of miles per hour, reaching California several hours after the earthquake. The International Tsunami Warning System monitors ocean waves after any Pacific earthquake with a magnitude larger than 6.5. If waves are detected,

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[4] Humboldt County – Shaky Ground Website (http://sorrel.humboldt.edu/~geodept/earthquakes/shaky_ground.html)

[5] Ibid.

warnings are issued to local authorities, who can order evacuation of low lying areas if necessary.

10. 3 SLOPE AND SOILS STABILITY

Slope stability, which is a major concern in the county, refers to the susceptibility of slopes to landslides. Heavy rains, grading, or earthquakes can trigger landslides. Other contributing factors are type and structure of soils, slope steepness, water, vegetation, and erosion. Landslides resulting from ground shaking are most likely to occur on steep, unstable slopes.

Steep slopes, which are shown in Figure 10-3, occupy a large amount of the county, including 775,203 acres in the 30 – 50 percent range and 531,179 acres with over 50 percent slopes. Slope information for each planning watershed is shown in Table 10-2.

Table 10-2: Percent Slope by Planning Watershed

	Slope				
Planning Watershed	*0-15%*	*15-30%*	*30-50%*	*>50%*	***Total***
Cape Mendocino	8.5%	18.6%	35.6%	37.3%	**100.0%**
Eureka Plain	40.4%	28.1%	23.9%	7.6%	**100.0%**
Lower Eel	33.5%	23.9%	27.0%	15.6%	**100.0%**
Lower Klamath	7.5%	21.5%	36.1%	35.0%	**100.0%**
Lower Trinity	9.5%	18.2%	32.3%	40.0%	**100.0%**
Mad River	20.8%	34.5%	31.3%	13.4%	**100.0%**
Middle Main Eel	11.3%	35.4%	35.9%	17.5%	**100.0%**
Redwood Creek	12.7%	31.1%	42.4%	13.8%	**100.0%**
South Fork Eel	9.9%	32.0%	39.8%	18.4%	**100.0%**
South Fork Trinity	7.9%	23.9%	35.4%	32.8%	**100.0%**
Trinidad	32.5%	33.5%	25.5%	8.5%	**100.0%**
Van Duzen	16.0%	35.4%	33.2%	15.4%	**100.0%**

Source: California Geological Survey and Humboldt County, 2002.

Figure 10-4 shows areas of relative instability, based on soil types and geologic structure. Highly unstable areas are spread throughout the county and are not necessarily associated with the areas of steepest slopes.

There are many soil types in Humboldt County, several of which are subject to erosion and/or instability. Soils often found in landslide topography include mélange materials of the Franciscan Formation, which break down into a clay subsoil that tends to slip when wet.

Landslides include earthflows, debris slides and flows, and translational/rotational slides. Many landslides are complex and are subject to more than one type of landslide process. Landslides are not depicted on a countywide basis in this report, but both active and dormant slides are shown on the constraints maps in Chapter 14. Active slides are those areas that are presently moving or have recently moved, as indicated by the presence of distinct topographic features (e.g., sharp barren scarps, cracks, and tipped trees), and major revegetation has not occurred. Dormant slides have little evidence of recent movement; slide features have been modified by weathering and erosion and vegetation has been reestablished.

A common occurrence in Humboldt County, particularly in the Cape Mendocino watershed area, is high sedimentation rates because of the high tectonic uplift and stream incision rates into relatively weak bedrock units. This combination of forces has produced a high incidence of landsliding adjacent to stream channels, including large slump-earthflows and extensive zones of debris sliding. Additional details on stability issues in specific planning watersheds are provided in Volume II of this report.

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Figure 10-3a: Northern Humboldt Percent Slope (11x17)

Figure 10-3a: pg. 2

Figure 10-3b: Central Humboldt Percent Slope (11x17)

Figure 10-3b: pg. 2

Figure 10-3c: Southern Humboldt Percent Slope (11x17)

Figure 10-3c: pg. 2

Figure 10-4: Relative Slope Stability

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10.4 REGULATORY FRAMEWORK

Most regulatory agency attention has been devoted to earthquake preparedness. The primary regulation related to seismic hazards is the Alquist-Priolo Act, described above. At the County level, geologic standards are addressed in the existing Framework Plan and the new Grading and Open Space Ordinance.

EARTHQUAKE PREPAREDNESS

Recent earthquake research has resulted in publication of advisory information for communities. After the 1989 Loma Prieta earthquake, the USGS increased its efforts to communicate earthquake-hazard information and research findings to the general public. In addition to preparing and distributing literature on earthquake preparedness, the USGS joined in partnership in 1997 with the Institute for Business and Home Safety (IBHS), an affiliation of insurance companies. The institute's mission is to reduce deaths, injuries, property damage, economic losses, and human suffering caused by natural disasters.

The USGS and IBHS have convened annual workshops on earthquake and insurance issues and published "Look Before You Build", which describes how safer land development can occur in quake-prone areas. A series of 13 USGS Fact Sheets, published from 1995 to 1997 under the overall title "Reducing Earthquake Losses Throughout the United States" explains earthquake hazards for the public.

Although seismic activity cannot be avoided, its impacts on communities can be minimized through hazard reduction and improved emergency response planning.

SEISMIC HAZARDS MAPPING ACT

The Seismic Hazards Mapping Act, passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides. Under the Act, the State Geologist is required to compile maps identifying seismic hazard zones, for protecting the public health and safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure and other seismic hazards caused by earthquakes. These maps are then submitted to all affected agencies for review and comment. Following this review, the State Geologist may revise the maps, as appropriate, and must provide Official Maps to affected cities, counties, and state agencies, and the appropriate county recorder.

To facilitate the process of designating seismic hazards zones, the Division of Mines and Geology established the Seismic Hazard Evaluation and Zoning Project (SHEZP). When the program began, the goal was to zone the principal urban areas of California by the year 2000 and major growth areas by the year 2010, keeping pace with urbanization thereafter. However, funding limitations have delayed the process. As of 2002, maps have not been prepared for Humboldt County.

HUMBOLDT COUNTY FRAMEWORK PLAN

Geologic standards are listed in Section 3292 of the Hazards and Resources Chapter, in the County Framework Plan. These standards establish requirements for geologic reports according to the Geologic Hazards Land Use Matrix (shown as Figure 3-5 in the Framework Plan). In general, preliminary engineering geologic and soils engineering reports are required for hazardous, essential (e.g., hospitals), or high risk developments. Reports are required to be prepared in accordance with the California Division of Mines and Geology guidelines for preparing such reports.

COUNTY GRADING AND OPEN SPACE ORDINANCE

In May 2002, the Humboldt County Board of Supervisors adopted ordinance revisions addressing grading, erosion control, geological hazards, and streamside management areas. In addition to implementing comprehensive regulations, the new ordinance establishes provisions for nonpoint source pollution from runoff water. The amendments further implement the goals of minimizing risk in geologically unstable areas and improving erosion control regulations.

The ordinance amendments include the following revisions:

- Update building regulations pertaining to incorporation of updated uniform codes (last updated 1977).
- Creation of a subsection within the Building Regulations pertaining to Grading, Excavation, Erosion, and Sedimentation, to provide additional guidance in application of erosion and sediment control measures.
- Modification of other sections relating to geologic hazards and processing of grading and building permits within or affecting Streamside Management or Other Wet Areas.
- Addition of Geologic Hazards Regulations, including the incorporation of "area of demonstration of stability" provisions.
- Streamside Management Ordinance, which serves to codify the Interim Implementation Standards for the Open Space Element of the General Plan (Applicable to the Non-Coastal areas only) (Resolution 95-53, April 25, 1995).
- Ordinance revisions addressing the topic of vegetation removal or other land disturbing activities (Section 316-25), and an ordinance revision needed to assure consistency between County regulations (affects sections of the Subdivision Ordinance 323-5 and 323-6).

Additional detailed information on the ordinance amendments is provided in Volume II of this report.

10.5 POLICY ISSUES

This section focuses on geologic, seismic and soil hazard issues from a public policy perspective. In evaluating existing and future conditions, the County must consider the various policy options for the issues identified in Phase I of the General Plan Update, which are summarized in the Critical Choices Report. These key questions help frame the issues for policy options for biological resources. As background, the existing policies in the General Plan are presented, followed by a discussion of issues and policy options that respond to them. The policy evaluation worksheets are in the Appendix. These worksheets are provided as tools for members of the public to evaluate policy options and indicate preferences for accepting, modifying, or rejecting these options.

EXISTING POLICIES

The County General Plan establishes policies for general hazards as well as policies specific to geologic hazards.

GOALS

1. To reduce public exposure to natural and manmade hazards.

2. To ensure the continuity of vital services and functions.

3. To educate the community.

POLICIES

1. General

A. Regulate land use to ensure that development in potentially hazardous areas will not preclude preserving and promoting public safety. Potentially hazardous areas include, but are not limited to, steep slopes, unstable soils areas, on active earthquake fault lines, in extreme wildland fire areas, in airport flight path zones, and in flood plains and tsunami runup areas.

B. Development within the coastal zone shall minimize risks to life and property in areas of high geologic, flood and fire hazard, assure stability and structural integrity and neither create nor contribute significantly to erosion, geologic instability or destruction of the site or surrounding areas or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

C. Encourage the education of the community regarding the nature and extent of hazards.

D. Continue to provide for the maintenance and upgrading of disaster response plans.

2. Geologic

A. Provide for the identification and evaluation of existing structural hazards.

B. Provide for more detailed scientific analysis of natural hazards in the County.

C. Provide for implementation and periodic review of the Seismic Safety and Public Safety Element.

POLICY ISSUES AND OPTIONS

Each key question or issue raised in the Critical Choices Report that relate to geologic, seismic and soil hazards is discussed below. Based on County and public input, these policy options will be refined. Some of these options also will shape preparation of "sketch plans" (generalized land use plans for accommodating future development), while others will be implemented through zoning and subdivision regulations or other programs. Appendix B provides a worksheet for the public to evaluate these policy options.

ISSUE

- *How should Plan policies be updated to reflect the new projections for Cascadia Subduction Zone events?*
- *Should the County accept development in some higher risk areas if the owners are willing to indemnify the public from risks; for example, the Big Lagoon bluffs?*

The risk associated with earthquakes generated by the Cascadia Subduction Zone is similar to risks from other fault zones in and near the county, although the Cascadia Subduction Zone is thought to be capable of producing a higher magnitude earthquake (magnitude 8 to 9). To prepare for large earthquakes, the primary regulatory mechanism is the County Building Code. New building code standards being researched and developed by the USGS are valuable and can be reviewed when the County considers amendments to County codes to implement the new General Plan. Risk reduction can also be achieved through required site reviews, especially in areas of steep slopes, unstable soils, or other hazardous areas. In areas of higher risk, specific districts can be formed to allow limited development.

Option 10.1 Continue to require an independent registered engineering geologist to review reports submitted by applicants if exceptions to standards are requested. Such peer review is used in many jurisdictions where there is substantial seismic risk and geologic hazards require substantial engineering.

Option 10.2 Require formation of geologic hazards abatement districts in higher risk area to allow for cooperative funding of engineering solutions that benefit multiple property owners and to reduce the County's liability for high maintenance costs for public infrastructure and areas of public benefit. This policy can reduce the County's risk and provide a vehicle for approving development in higher risk areas, such as the Big Lagoon bluffs. State law allows such districts to be created with property owner approval.

Alternatively, the policy could be expressed more generally as simply requiring financial protection for the County and individuals as a condition of development approval in areas of higher geologic risk.

Option 10.3 Require geologic reports for all subdivisions with proposed building sites on slopes over 15 percent. By establishing this requirement, the County will have the opportunity to ensure that new development on sloped land incorporates proper engineering features and site design. The end result will be a reduction in risks associated with building on unstable slopes (e.g., landslides, increased erosion, soil creep).

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