

The Design of an Earthquake Public Information Program for Colorado.

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EXECUTIVE SUMMARY

This report summarizes the process of creating an earthquake public information program. The program is to inform the general public, including all ages, incomes and education levels, of any earthquake risks in Colorado as well as methods of preparation for an earthquake event.

An evaluation was done to assess the earthquake potential in Colorado. Further research was done to assess the most efficient ways of communicating any such potential to the general public. The earthquake risk in Colorado seems minimal, but there is not enough recorded history to ensure that a large scale earthquake will not occur. Five demographic groups were targeted including children, the media, home and building owners, renters and frequenters of "at risk" structures, professionals and the college-educated.

For each of the stated demographic groups a component was designed within the earthquake public information program. A timeline for the future implementation of each component, included in the following report, suggests that the proposed earthquake public information program could be activated over a five year period, at the end of which an earthquake awareness day could also easily be implemented.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
1.0 INTRODUCTION AND SCOPE	1
2.0 IS THERE REALLY A NEED FOR AN EARTHQUAKE PUBLIC INFORMATION PROGRAM?	3
2.1 Earthquake History	4
2.2 Fault Locations	6
2.3 Other Hazards	7
2.4 Conclusions	7
3.0 CONCLUSIONS	8
4.0 RECOMMENDATIONS	9
5.0 COMPONENTS OF THE EARTHQUAKE PUBLIC INFORMATION PROGRAM	10
5.1 Children's Poster Award Program	10
5.2 Media Kits	12
5.3 Earthquake Safety Pamphlets	14
5.4 Fact Sheets	17
5.5 Speaker's Bureau Presentation	20
6.0 ANNOTATED BIBLIOGRAPHY	21
APPENDIX	

FIGURES and TABLES

Figure 2.1	Seismicity of the United States	3
Figure 2.2a	Historical Colorado Earthquake Frequency	4
Figure 2.2b	Average Annual EQ Occurrences in the U.S.	4
Table 5.3.1	"At Risk" Structures	14

1.0 INTRODUCTION AND SCOPE

The single most common misconception of the general public about earthquakes is that earthquakes always cause huge cracks in the earth and mass destruction. What they do not realize is that thousands of miniature earthquakes called tremors are detected all around the world every single day. This knowledge would not be accessible to us if it was not for the invention of seismographs. A seismograph is an ultra-sensitive apparatus that allows seismologists to detect even the slightest of tremors in units of Richter.

This project was intended to prepare a public information program for which to inform and educate the general public, including the media, about the dangers of earthquakes and their secondary hazards, and to recommend ways to mitigate these dangers. Clearly from the problem statement, the final product of this project will give sufficient awareness and information to the media and the public regarding:

1. earthquake dangers, fault locations and historical occurrences
2. earthquake related hazards
3. mitigation techniques

This written report contains a proposed earthquake public information program. The main task was broken up into five separate but related areas. Each area is intended to target a specific demographic group.

1. The establishment of an annual, statewide middle school poster award program focused on enhancing public awareness of geologic hazards that exists in Colorado. Clearly intended to reach the younger aged group, particularly school children.
2. The design of a "media kit" which provides the media and others with accurate earthquake and mitigation information before the event, as well as timely information immediately following the natural disaster.
3. The design of earthquake safety pamphlets to be published and distributed to persons who own, live in, work in, or frequent unreinforced masonry and adobe buildings. This section will benefit persons who own homes or buildings located in earthquake prone areas.

4. The design of one or two page fact sheets that provide the general public and local governments with information relating to earthquakes and methods of mitigating potential damages.
5. The design of a speaker's bureau presentation on Colorado earthquakes, associated risks and mitigation techniques. This would be a reference section from which speakers could efficiently extrapolate information, in order to prepare a presentation on the subject of earthquakes.

Research was done to assess the need of the general public for an earthquake public information program. It was important to evaluate the potential for occurrence of large-scale earthquakes within Colorado. This was done based on studies of Colorado's earthquake history as well as general fault locations. Once the earthquake potential of the state was understood, it had to be communicated to each demographic group, or target audience. Further research was then done for each section to evaluate the individual needs of each target audience. Each section was designed according to the research performed on both Colorado's earthquake potential and the needs of the target audiences.

2.0 IS THERE REALLY A NEED FOR AN EARTHQUAKE PUBLIC INFORMATION PROGRAM?

Most people living in Colorado do not realize that an earthquake of significant magnitude could occur in their lifetimes. Earthquake potential can be evaluated based on two main criteria: 1) earthquake history and 2) fault proximity. Following is a discussion of the earthquake potential in Colorado as well as other geologic hazards.

2.1 Earthquake History:

Figure 2.1 shows all of the earthquakes that have occurred in the United States from 1975 to 1995. Colorado is not within a region of high earthquake frequency; however, numerous quakes have been recorded within the state since 1975.

Seismicity of United States: 1975 - 1995

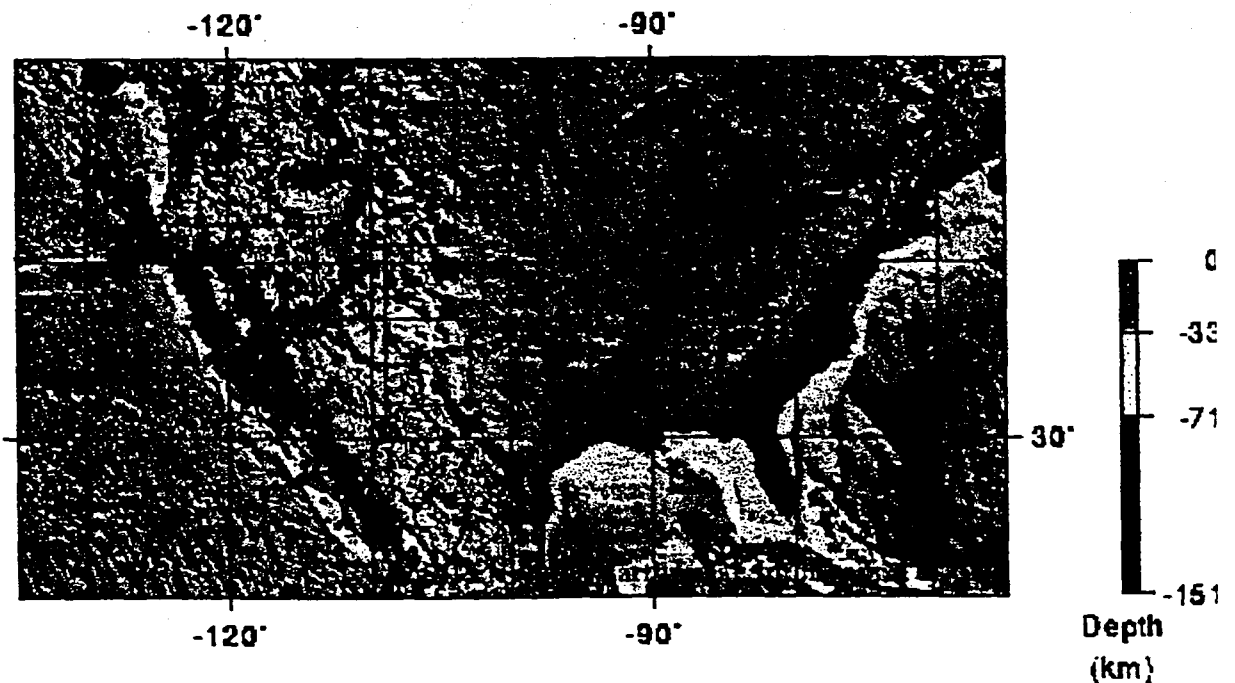


Figure 2.1 This map shows the epicenters of all earthquakes in the United States from 1975 to 1995. The relative sizes of the circle is a representation of the relative size of the quakes. (USGS. website)

Figure 2.2 shows two plots of varying scales. The scale variations are such that the shapes of the curves are the same; meaning that Colorado has a similar pattern for earthquake history; but the US experiences such a large number of quakes annually that

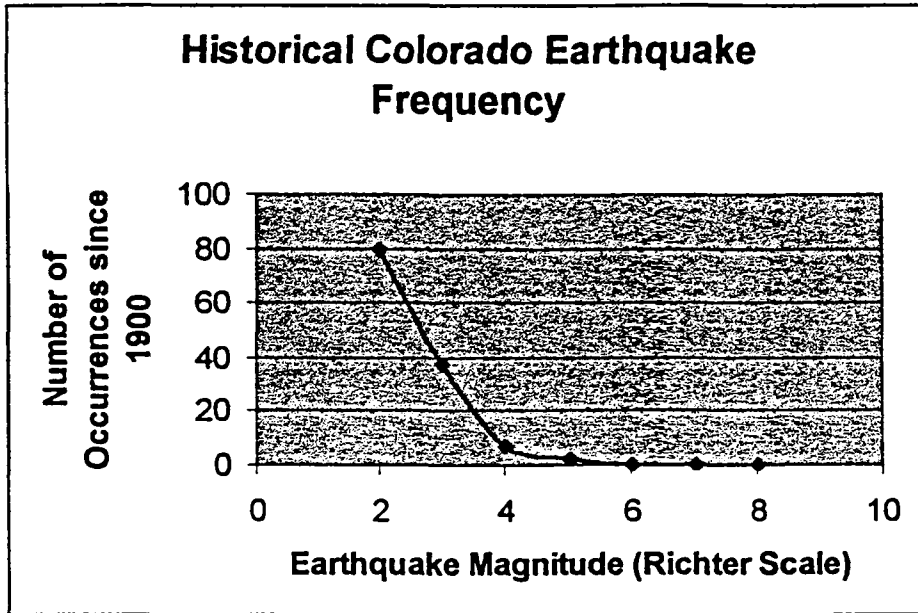


Figure 2.2a

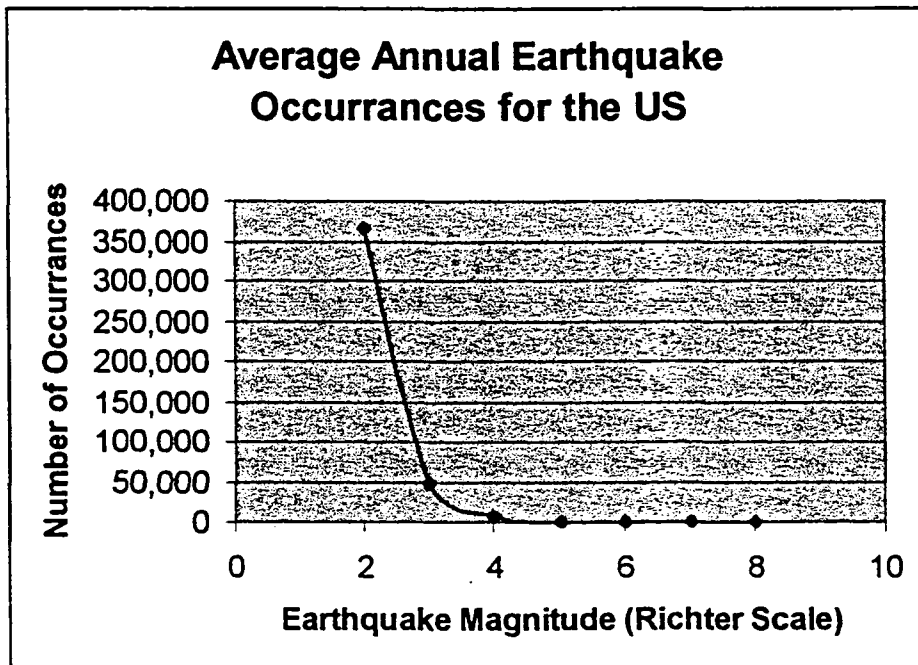


Figure 2.2b

Figure 2.2: a) This is a plot showing the frequency of earthquakes of various magnitudes throughout Colorado's recorded history. (37)

the entire recorded history of Colorado is insignificant in comparison. This does not mean, however, that a damaging quake will not occur in Colorado.

The earthquake history of Colorado has been recorded since the late 1800's, however not with the same precision used in present times. Quakes have occurred across the state with a high concentration being focused around Denver. Historically speaking, however the plains East of Denver have been relatively inactive. (See figure 2.3)

The last major quake to occur naturally (disregarding the 1960's quakes caused at the Rocky Mountain Arsenal) occurred in 1981. According to Stover, et al., and based on the Modified Mercalli Intensity Scale for measuring earthquakes (which has been replaced by the Richter scale), the 1981 quake was a IV. The following is an excerpt of the official description of such a quake, which relates to approximately a 5 on the Richter scale:

"Felt indoors by practically all, outdoors by many or most: outdoor direction estimated. Awakened many or most. Frightened few, slight excitement Buildings trembled throughout...."

This scale is descriptive and suggests potential structural harm. From this it can be seen that the earthquake threat is real in Colorado. The largest quake ever experienced in Colorado was approximately a 6.3 on the Richter Scale (about a VI on the Intensity Scale).

Seismicity of Colorado 1800 - 1995

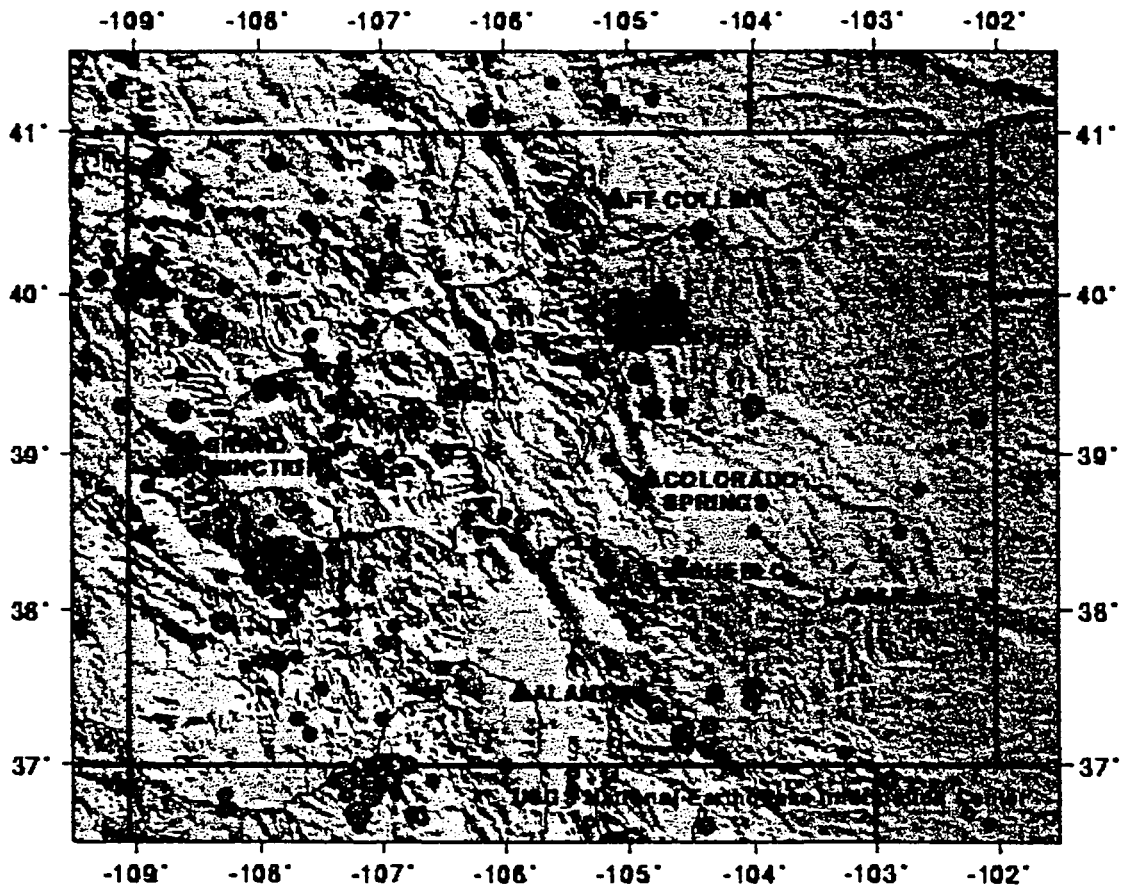


Figure 2.3 This map shows the epicenters of all earthquakes in Colorado since 1800 to 1995. The relative sizes of the circle is a representation of the relative size of the quakes. (USGS, website)

2.2 Fault Locations:

Faults are geologic discontinuities along which earthquake motion occurs. The proximity to a fault will increase risk of danger to earthquake motion. Several major faults and countless smaller faults occur in Colorado associated with the Creation of the Rocky Mountains.

A nearly continuous fault runs along the foothills of the front range. Several

smaller faults occur throughout the central mountains and another large fault cuts the western slope. The eastern plains of the state are virtually fault free. (33)

2.3 Other Hazards:

There are three main natural geologic hazards found in Colorado. All three have direct correlation to Colorado's weather. The first is a flash flood. These occur rapidly and die out just as quickly. Occurring locally, and usually triggered by heavy thunderstorms, these are sudden floods of large volume and short duration.

The two other natural geologic hazards found in Colorado are rock falls and mudflows and slides. A mud flow/slide is caused by overly saturated soil and can be triggered by earthquake motion. They tend to occur in arid regions, such as Colorado, with little vegetation cover to protect the soil. A rock fall is when rocks fall freely from a cliff or steep slope. The frequent freezing and thawing of water in cracks within the rocks leads to the separation of the rock from the main rock mass of an existing slope.

2.4 Conclusions:

Within Colorado there is some likelihood that a large-scale earthquake will occur. When compared to California or Utah, it seems that chances of large scale damage is slim; however, the occurrence of a quake, having a magnitude of 6.6 on the Richter scale, within the last one hundred years is evidence that there is earthquake potential in Colorado. Due to the relative inactivity of earthquakes within this state, Coloradans give little thought to earthquake safety and preparedness. The proposed earthquake public information program will inform the people of Colorado of the degree of earthquake danger in Colorado as well as ways to prepare for any future events.

3.0 CONCLUSIONS

At the beginning of September, this team was presented a problem by the Colorado Office of Emergency Management. That problem was to develop an effective earthquake information program that would educate and inform pertinent elements of society. Each member focused on the research of educating five main areas: school children, government officials, media, professional groups and homeowners. Materials have been developed that will be effective in educating these five groups of citizens of the general public. The Colorado Office of Emergency Management to educate the state can use the material as part of a public information program.

Many of the citizens in Colorado are unaware of the threat earthquakes pose to Colorado. Many do not think a damaging earthquake will ever happen in their lifetime. From past history, we know that earthquakes do happen in Colorado and there have been relatively large damaging earthquakes in the state. By using the material produced by our team, we can spread the knowledge and tools to help reduce the vulnerability of our state to the threat of earthquakes. The state of Colorado must always be prepared for an earthquake, so a disaster can be avoided. Local governments, businesses, and every community can take action to reduce earthquake hazards by being prepared for such an event. Knowledge is the key to mitigating the effects of a damaging earthquake and this earthquake program will help distribute that knowledge.

4.0 RECOMMENDATIONS

The material developed by our team could form an Earthquake Public Information Program that could effectively be used in the promotion of an Earthquake Awareness Day. Due to time constraints, we were unable to research more into this notion. All elements of society could get involved on that day in educating the state of the hazard earthquakes pose to Colorado. The media could develop news stories on the history of earthquakes in Colorado, the procedures one should take during an earthquake, and inform the public of other safety precautions that could be taken to mitigate the effects of an earthquake. Schools could use the day to have a mini-poster contest, to conduct science experiments, and to educate the public on what to do if an earthquake were to strike. On this day, managers of rental buildings could distribute the safety pamphlets to their tenants and the fact sheets could be posted or distributed throughout the state. And lastly, a government official could deliver a speech on how the state of Colorado, specifically the government, will handle the possibility of an earthquake and its secondary hazards. Developing an Earthquake Awareness Day could effectively inform and educate the majority of the state of Colorado, especially those areas most prone to a damaging earthquake.

The Earthquake Awareness Day would need to be investigated further in order to find sponsors for the event, to get approval from the state, and to develop more ways to encourage public involvement in earthquake awareness. A tentative timeline for implementation of this program, including the earthquake awareness day, is two to five years. This allows time to fully organize and develop an effective awareness program.

5.0 COMPONENTS OF THE EARTHQUAKE PUBLIC INFORMATION PROGRAM

Each of the components that were developed for this Earthquake Awareness Program is detailed in this section of this report. It was our objective to educate many areas within the general public, therefore, each of the components are targeted at specific demographic groups.

5.1 Children's Poster Award Program:

A poster award program has been requested as a component of the public awareness program our team has designed for Fred Sibley and the Colorado Office of Emergency Management. This component looks at the various research sources and how the poster award program was designed.

Developing Children's Awareness:

Children comprehend and retain information very differently than adults. This raises the issue of how and to who to best convey the message at hand.

Audience (age group):

The state of Colorado mandates a science/geology program beginning at the fifth grade level, continuing through eighth grade. (5)

How Children Learn Science:

There are three categories of learning. The first is to stimulate children to look for the puzzling, the mysterious, and the remarkable in commonplace experiences. Observation is a key principle in this category. Another category encourages children to find meaning in the seemingly random and chaotic events in the sky, and on the earth, etc. This would directly relate to the geologic hazards of Colorado. The last category encourages children to make connections and relate their personal experiences to what they are learning. (4)

Tools of the Trade:

Teachers prefer information in pamphlet form or in-service materials. They also feel that a poster design contest is not helpful or necessary in the development of awareness in children of Colorado's geologic hazards. (5) Teachers agree that a program with a strong

science based curriculum is much more effective when teaching children. A poster award program could be used as a supplementary element.

Education experts encourage many visual aids hands-on experiments, and open class discussions. This is best suited for science curriculum due to the nature of how it enables children to use both hemispheres of their brain, resulting in better comprehension. Hands-on experiments are also an effective learning resource. (1,2)

Implementation Recommendations for the Children's Program:

Compliance with the science teachers and board of education's requests and requirements is recommended. Awareness of the existing hazards in Colorado's geology may be incorporated into the already existing fifth through eighth grade science curriculum. The individual schools must be contacted, beginning with the school's principal. From there, it can be decided if the program must first be presented the district superintendent. Following is a proposed set of steps for the implementation of a poster award program. (21)

1. A list of the principals from the designated schools should be requested from the Colorado Board of Education.
2. From these principals, a list of the teachers should be requested.
3. Mid-summer, before the desired school year the program is to be implemented, a mailing should - be sent to the principals and the teachers. This should be used as a reminder and a confirmation invitation.
4. A curriculum that has been developed should be mailed to the teachers. This should include the materials and guidelines for the program. (Appendix A)
5. After completion, the posters can be judged by a group of volunteers, and possibly conduct an awards ceremony for the children in which Colorado's governor is present.
6. The awards can be state treasury checks beginning at fifty dollars for the first prize winners.
7. The expected project costs range from \$700-\$1000; this includes all materials and prizes, staff time is excluded.

Please see **Appendix A** for the actual teacher's packet that can be used as the information given for the poster award program curriculum.

5.2 Media Kits:

The media of Colorado are an important source of information for the general public. The media can be especially useful in providing valuable information in case of an emergency, such as fires, blizzards, and even earthquakes. In order to improve the media's sources of information, for earthquakes in particular, a media kit has been proposed. A sample media kit is provided in **Appendix B**. The kit can be placed in a file as reference for news stories on procedures before, during, and after an earthquake.

Analysis:

After discussions with personnel from several types of media, specifically the Denver Post, KUSA 9News and KOA Radio, information was gathered and organized into the media kit. Information contained in a kit includes: safety tips, hazards of earthquakes, background information on the Richter and Intensity scales, as well as a current list of contacts at government agencies. The best way to mitigate the effects of a damaging earthquake is to prepare for the emergency. With information on how to prepare for an earthquake included in the media kit, the media can prepare the people of Colorado for this natural disaster. Also, if information about what to do during an earthquake is given by the media before a disaster strikes, the damaging effects can be lessened. Another area of information that will help the media's understanding of an earthquake situation is knowing how to interpret the strength or size of an earthquake. Therefore, tables of the Richter scale and Intensity scale are included in the media kit. A list of area contacts from government agencies will give the media a resource to find even more information for earthquake emergencies, including technical information.

Implementation and Distribution of the Media Kits:

There are a couple of ways this media kit could be distributed, through the mail or over the Internet. The advantages of distributing the kit through the mail are that select media stations can be chosen to get the information, a hard copy will be on file with the media, and the Colorado Office of Emergency Management can be sure that the media receives the selected information. Mailing the media kit would have the cost associated

with buying postage for distribution, copying and paper. Another disadvantage is that it would be more difficult to update the information.

The other possibility of distributing the media kit is over the Internet. In the age of technology, this may be a useful tool in catching the media's attention. A web page could be prepared and include the important information provided in the kit. The web page could be linked to other sites the media use in research for news stories, such as sites on earthquakes or other geologic hazards. The use of a web page would make it easy to update the information, but the production and upkeep of a web page would require time and the possibility of the information not being distributed to all the media in Colorado.

However the kit is distributed, it will provide the media with a file of earthquake information. The media is given the authority on when and how to use this information. If used throughout the year, it can help inform the public and mitigate the results of an earthquake in the state of Colorado.

5.3 Earthquake Safety Pamphlets:

The objective of this sub-project was to prepare a pamphlet aimed at anyone that owns or frequents any structure with potential for collapse during an earthquake event, specifically unreinforced masonry, adobe or concrete type buildings. This section has evolved into two separate pamphlets, though. One will target building owners and the other will target those who frequent "at risk" buildings.

The criteria for what makes a structure "at risk" are discussed, including the earthquake history of Colorado as well as fault locations. Certain types of construction materials are more susceptible to collapse. These materials are discussed along with various methods of reinforcement. Also included in this text are methods of reducing physical harm in case of an earthquake event.

An analysis of the targeted groups was performed, and is detailed herein. Potential methods of pamphlet distribution are discussed as well.

"At Risk" Structures:

Earthquakes create shear stresses, which are lateral. Lateral stresses can cause collapse in brittle structures. Forces due to shear stress can cause the lower levels of a structure to become unstable and collapse which in turn causes the collapse of the upper levels (14).

The following list summarizes structural risks:

Table 5.3.1: Adapted from Lagorio. 1990

- 1) unreinforced masonry bearing walls
- 2) non-ductile concrete frame
- 3) pre 1940 reinforced concrete systems
- 4) pre 1940 steel framed systems
- 5) mixed construction (any combination of wood, masonry, concrete, steel)

Unreinforced masonry bearing walls are interior or exterior walls that bear a load and are constructed of bricks, cinder or concrete blocks and/or adobe. Non-ductile concrete structures were constructed prior to the use of pre-stressed, reinforced concrete systems. These were used from 1940 to 1970, (19). Pre-cast, tilt-up or reinforced masonry systems are all slightly more resistant to cracking than the previously mentioned materials, but failures are likely to occur if extreme shear stress conditioned occur.

All structures constructed prior to 1940 are considered to have high risk potential. Until 1934, California did not even have a seismic building code, nor did the rest of the country. The twenty-seven western states, including Colorado, have since adapted the Uniform Building Code. This code contains a complete set of standards and specifications including seismic codes based on California's seismic history. Buildings of mixed construction are at risk due to potential cracking in the masonry and concrete components. Large open rooms without columnar supports are also particularly susceptible to collapse.

Reducing the Risk:

There are many things that can be done to strengthen buildings against seismic stresses. In some older structures and in buildings with pre-cast and tilt-up structural systems the individual components, i.e., the floor, ceiling, walls, etc., are not anchored to one another. This allows for a great deal of additional motion to occur during an earthquake event. Anchoring or tying the components of a structure can reduce its susceptibility to collapse. (19)

Bracing a structure is another effective form of remediation. The use of vertical shear walls or frames as well as diagonal bracing is quite common in earthquake prone areas. Horizontal diaphragms are also used to absorb lateral shear stresses. All of these methods are used adjacent to unreinforced wall to create a more ductile, buffer zone.

An extreme measure that is some times used in extremely prone areas involves the removal of upper levels of a building to reduce the load on the bearing walls. (19)

Base isolation is a newer method specifically for smaller structures. It allows the structure to "ride the wave", which could be quite damaging to multi-story buildings. This is likely the most economic method of mitigation for homeowners. (19)

Disaster Drills:

If an earthquake event occurs while a person is within any of these "At Risk" structures some precautionary measures should be taken. In short: Drop, Cover and Hold! (22) **Appendix C** shows a model pamphlet in which this safety technique is displayed.

Implementation of the Safety Pamphlets:

Two pamphlets are to be distributed; one will target building owners and the other will target those who frequent or rent space within “at risk” buildings. Appendix C.a and C.b show preliminary examples of these pamphlets.

Every building must conform to the specific building codes that are in effect at the time of the building’s construction. The older codes are not as safe as those presently being used, especially those older than 1940. Until 1940 seismic code was not a part of standard building codes (19). Active research needs to be done in order to find out the identities of the owners of all structures built prior to 1940 and pamphlets sent to them.

When homeowners and businesses decide to expand their structures they must obtain a permit from their local governing body, usually a building inspector specific to their municipality (12). Permit issuers, or building inspectors should be required to give safety pamphlets to parties that have need for the information.

After the purchase of a building, the purchaser usually seeks to insure his new property. The insurance process often requires an inspection of the building (12). If the inspector finds that the building is an “at risk” structure, he could be persuaded to give a safety pamphlet to the building owner. This may even expand the earthquake insurance market for the company.

Those who frequent “at risk” buildings are more difficult to inform in some cases, because hundreds of people may frequent a building in one day. For this reason a broader approach must be taken. Displays of the pamphlet could be required in high traffic areas, or the cafeteria. This responsibility lies with the building owner; he should be required to initiate a standard “disaster drill” program in case of an earthquake event. Such a program should be implemented through direct contact from the owner and the lesasers/renters of space within the structure.

Costs will be minimal for preparing and distributing the pamphlets. Paper and printing cost \$0.10 per page for black print and copies with color can cost up to \$1.00 per page. Each pamphlet will be one page in length.

5.4 Fact Sheet:

Research:

The information contained in the proposed fact sheet is developed from what one might find in earthquake fact sheets that other State and Federal agencies have published. It is however, tailored toward what the citizens of Colorado need to know about earthquakes. In developing the outline and information that is contained in the fact sheet many sources have been researched. Sources obtained for developing an outline and useful information for any fact sheet like this, were found on the Internet. In particular, web sites from the American Red Cross ("Earthquake Disaster Services") and the FEMA ("Fact Sheet: Earthquakes") were particularly helpful in giving safety plans for mitigative purposes, and how one should react during an earthquake, along with being a general outline for development of this fact sheet. There are many references obtainable from libraries, which also have similar information. These sources were found to have extensive information on mitigation and safety techniques. These aforementioned sources were developed for areas, such as California, where the potential for catastrophic damage is high. While the threat that earthquakes pose to Colorado can be potentially large, the vast majority of earthquakes have magnitudes that are much less than what one could expect in other regions.

Audience:

This fact sheet is intended to provide the general public and local governments with information relating to earthquakes and the secondary hazards often associated with them. In particular, it is intended to be a guideline for those persons and governmental bodies that are within areas of Colorado at highest risk for earthquake damage. These areas include: the Southwest corner of the State, such as Ouray, Montrose, Hinsdale and Mineral counties, the Front Range and Denver Metro Areas, along with the Mountainous region of Colorado (from north to South)

Outline:

The fact sheet begins by presenting a need to know. This section gives a brief history of earthquakes in Colorado and those areas at highest risk. The fact sheet then begins to

outline the hazards which are present and that one should be aware of whether it be inside ones home, business or hazards one might encounter in the out of doors. The fact sheet then relates measures one should undertake to minimize or negate these hazards. It points out that along with the private sector securing personal property, that local governments should be aware of and minimize those hazards which they are responsible for. After establishing what efforts should be completed prior to an earthquake, the fact sheet provides measures one should and should not take when an earthquake occurs. It points out that being aware of safe places within ones home or business will expedite them reaching a safe place when the event occurs. Places where one might find refuge in the out of doors is then explained along with procedures one should take if driving an automobile. The fact sheet then explains what dangers may have been created from the earthquake and what one should be aware of to minimize loss of life and personal property. The fact sheet concludes with ideas for obtaining information, which one might need in after an earthquake occurs. Along with local media outlets, government agencies and World Wide Web sites are given which may increase the information one can acquire.

Implementation of the fact sheets:

The distribution of a fact sheet such as this is a crucial consideration in the ultimate success of implementing a public awareness program. Making sure that the persons living in potentially affected areas are aware of the earthquake threat, before such an event, will be the measure of the value of this program. Rejecting other options that are inhibited by expense, the proposed means of distribution are multi-leveled and relatively inexpensive. Since this program will be initiated from the State level, it is proposed that State facilities be utilized in the distribution of these fact sheets. . Placing the fact sheets at Department of Motor Vehicle and Motor Vehicle Licensing offices may be the best alternative. The chance that at least one member of every household to come into contact with the fact sheets here would be very high. Since these offices are only visited biannually (if at all for motor vehicle licenses), or every five years for DMV, providing this information through these offices would be a slower method than through mailing. The trade off for this slow distribution is the nominal cost in distribution. The audience would be captive while

waiting to be taken care of in these situations, and if placed prominently could reach a great many people.

Taking advantage of the Internet in this day and age is an avenue that should be explored. Using this tool to distribute information would be of nominal cost. The limiting factor here is in the number of people in which it would be available to. The number of households, which have access to the Internet, would not assure mass distribution. The user must seek out the data presented on the Internet. Earthquakes are not a widely perceived danger in Colorado; therefore those seeking this information would be few and, in turn, would make distribution through this method sporadic. To alleviate this, the web page could be linked to searches on related topics, or state agencies causing curiosity in the browser and increasing the fact sheets readership. The advantage of such an Internet site would be that the information could be updated when an earthquake has occurred. This could be an additional way to inform the public, along with the media, of action that are underway to return their lives back to normal, steps they should undertake to make their homes safe or likelihood of aftershocks.

5.5 Speakers Bureau Presentation:

The design of this speaker's bureau presentation was based on the feedback and ideas contributed by experienced speakers from the USGS. Since there is no specific format that a speaker should follow, he/she is free to choose whatever format he/she feels is appropriate. This area report is intended to be a guide from which information can be extrapolated from and henceforth, the speaker is free to develop his/her own brand of presentation. In this report, such facts as the history of earthquakes around the world, in the US and in the state of Colorado, as well as various hazards and mitigation techniques, are presented in a straightforward yet precise manner. The speaker could further elaborate as he/she wishes.

The speech was designed for an audience including mainly the professionals and academics within the general public. The main objective of this presentation is to make the audience aware that even though the risk of potential earthquakes in Colorado is small, the possibility of a large-scale quake still exists.

Again, targeting at the more educated and mature audiences will allow the speaker to further explain facts more clearly by incorporating technical terms such as "epicenter", "faults" and so on. To even further clarify the explanations, visual aids in forms of maps, charts and seismic readings were also included in this area report. That way a speaker would be unambiguous and will help the audiences to better understand the presentation material.

Finally, the cost of implementing the speaker's bureau presentation would merely include such expenditures as overhead slides and photocopying. After all, it is entirely up to the presenter and the technique that he/she chooses to implement while delivering the speech. **Appendix E** contains a copy of the speaker's bureau presentation.

6.0 ANNOTATED BIBLIOGRAPHY

- (1) **ABAG Earthquake Maps and Information.** <http://www.abag.ca.gov/bayarea/eqmaps>

ABAG is the Association of Bay Area Governments. This site contains information on mitigation techniques, various earthquake hazards and links to other potentially useful sites. Specifically, it contains a quiz on general earthquake knowledge, which could give helpful hints on the types of facts to acquire.

- (2) **American Red Cross. "Safety-Earthquakes"** <http://www.crossnet.org/disaster/safety/earth.html>

The American Red Cross disaster services homepage for earthquakes is a well summarized, basic list of precautions that should be taken before, during and after an earthquake strikes. This site also includes hazards to eliminate in the home and information on a disaster supply kit. It explains basic mitigative techniques and other general preparations.

- (3) **Anderson, Joyce, Denver Post Citydesk.** Phone Interview. November 7, 1997.

Used as a reference on what type of information would be useful for the Denver Post Newspaper, such as contact list at various emergency agencies.

- (4) **Berke, Phillip 1951. Planning for Earthquakes: Risk, Politics, and Policy.** Baltimore, MD and London:

The John's Hopkins University Press.

This book summarizes several case studies done in various earthquake prone areas. It also details policies implemented in these areas as a result of the potential hazards. This will be a useful reference with respect to post-quake actions, both physical and political.

- (5) **California Governors Office of Emergency Services. "Ready to Ride it out?"**

(a) <http://www.best.com/~trbu/oes/resources.html>

This site was used to promote an earthquake awareness program in California. A good site to look at the ways California educates all ages of people. This could be useful when working on the final project.

(b) <http://www.best.com/~trbu/oes/newsmedia.html>

This site is provided by the Office of Emergency Services for the media to use as a reference for story ideas and events that will be taking place during the awareness month. May give some in-site to what programs might catch the media's attention for the final project.

- (6) **California Office of Emergency, 1995. "On Shaky Ground: Living With Earthquakes on the North Coast."** http://glinda.cnrs.humboldt.edu/earthquakes/shaky_ground.html

This web site was put out by the Humboldt Earthquake Education Center at Humboldt State University, in California. The information in the site was recommended to the Center by the California

Office of Emergency. There was a lot of information at this web site, including what to do before, during and after an earthquake. It also had information on an emergency supply kit that every household should have.

- (7) **Center for Earthquake Research and Information at University of Memphis.**
"Earthquake Facts and Follies." http://www.ceri.memphis.edu/www/public_info/public_info.html

This web site was researched for a table about the Richter Scale. It included other information on misconceptions people have about earthquakes. This site gives more information on how to survive an earthquake.

- (8) **California Technical College.** "Earthquake ABC's". <http://www.scec.gps.caltech.edu/eqabc.html>

This site reviews the basics. It explains what earthquakes are and what causes them. It is very straightforward and easy to follow. This is a good example of communicating awareness.

- (9) **Drabek, Thomas E.** 1983. Earthquake Mitigation Policy: The Experience of Two States. Boulder, CO:
The University of Colorado.

This book details the situations of two states that have experienced earthquakes and still face potential quakes. It explains their mitigative efforts on a state level. This was useful as a guide for group project layout and implementation.

- (10) **EQE International, 1995.** "EQE Earthquake Home Preparedness Guide"
<http://www.eqe.com/publications/homeprep/aftereqk.htm>

EQE is an engineering/planning company specializing in earthquakes and structural engineering. Information from this guide included what to do after an earthquake.

- (11) **Federal Emergency Management Agency, 1997.** "Fact Sheet: Earthquakes."
<http://www.fema.gov/fema/quakef.html>

This site contained a three page fact sheet on earthquake hazard information. Information listed in this fact sheet included hazards to check for in a home, disaster supplies, procedures before, during and after an earthquake, and a good definition for mitigation. This is a source that guided us in the production of a fact sheet.

- (12) **Freimann, Jill.** High school teacher and owner of an "at risk" structure. October 1997.

Mrs. Freimann recently had to file for a permit through the city of Golden in order to build a deck onto her home. She was a good place to start in order to find the information about the Colorado building code policies. She also has a great deal of experience with the process of insuring an "at risk" structure.

- (13) **Goodell, Gary.** Chief Building Official, Boulder County. October 1997.

Mr. Goodell provided a great deal of information pertaining to Colorado and its building code policies. He directed me to the Uniform Building Code used by the twenty-seven western states.

- (14) **Gere, James M.** 1984. Terra non-Firma: Understanding and Preparing for Earthquakes.
New York City, NY: W.H. Freeman and Company.

This book contains useful information for community planning and engineering design in earthquake prone areas. Building codes for new construction as well as reinforcement of existing structures is discussed.

- (15) **Healy, Jane M. Ph.D.** Your Child's Growing Mind. pp. 116-124., Doubleday and Company., Inc., New York, 1987.

This is a parents' guide to understanding how their child's mind functions. It goes through the many stages of development giving insight and description as to what tools and techniques are most effective to a child's education. The portion on the ages from eight to eleven years of age was helpful in preparing the children's program. It discussed how classrooms should be structured in order to get the best out of each individual child.

- (16) **Holt, John.** How Children Learn., pp.169-189., Pitman Publishing Corporation., New York., 1967.

The author is a child psychologist type who investigated specific case studies and also did independent research on his own.

- (17) **International Conference of Building Officials.** 1991. Uniform Building Code. Whittier, California:ICBO.

This book contains the minimum requirements for safe construction of any building. An entire section dedicated to masonry structures and another to seismic standards.

- (18) **Kirkham, Robert M. 1981.** Earthquake Potential in Colorado: A Preliminary Evaluation. Denver, CO: Colorado Geological Survey, Department of Natural Resources.

The body of this report is more technical than is useful, however many of the maps and appendices could be helpful. The report contains maps showing all potential earthquake hazards in the state of Colorado, which will be helpful in choosing target areas.

- (19) **Lagorio, Henry J. 1990.** Earthquakes: An Architect's Guide to Nonstructural Seismic Hazards. Canada: John Wiley and Sons, Inc.

This book gives information on how to reinforce existing buildings in preparation for an earthquake. The text is technical, but the facts can be simplified.

- (20) **Los Angeles City Fire Department.** "Earthquake Preparedness Handbook." <http://www.cityofla.org/LAFD/eqindex.htm>

A lot of information on preparing for earthquakes and what to do after an earthquake occurs. Mainly used the information on what to do during an earthquake.

- (21) **Matulik, Mark.** *Telephone interview*, Monday, November 24, 1997 (afternoon) Senior Resource Specialist, Colorado Water Conservation Board.

Mr. Matulik was extremely helpful with ideas for the implementation of a poster award program. He gave many thoughts on what works and what does not. He has had many years of experience with poster award programs, which he was involved with through FEMA and the CWCB. He also gave information on funding and distribution approaches for various schools.

- (22) **Montana Division of Disaster and Emergency Services.** "Earthquake Safety in Old Masonry Buildings"

This pamphlet was used as an example for the earthquake safety pamphlets designed herein.

(23) National Earthquake Information Center.

- (a) "Frequently Asked Questions." <http://wwwneic.cr.usgs.gov/neis/general/handouts/faq.html>

Answers a variety of questions that are most frequently asked. Some answers may be useful in educating a variety of people.

- (b) "Colorado Earthquake Information."

<http://wwwneic.cr.usgs.gov/neis/states/colorado/colorado.html>

Sub websites at this address include the history of Colorado earthquakes as well as maps that give the location of earthquake occurrences in Colorado. The maps cannot be seen very well.

- (c) <http://wwwneic.cr.usgs.gov/neis/eqlists/eqstats.html>.

(24) Nelson, Mike, 9News Reporter. 9News Television. *Email messages.* October 18-24, 1997.

Mike Nelson was willing to send copies of the information on earthquake safety that they have on file. The pamphlet sent included information on safety tips for earthquakes.

(25) Newsroom, KOA Radio. *Phone interview.* November 7, 1997.

Additional information that the radio station would like to include in the media kit included a current list of contacts at the National Earthquake Information Center.

(26) NORSAR. "Earthquake Size." <http://www.norsar.no/Earthquake/EarthquakeSize.html>

Background information on the Richter Scale and the Mercalli Intensity Scale. Includes the abridged form of the Mercalli scale.

(27) Oliver, Leslie, Colorado Office of Emergency Management. *Copies of Disaster Information.* September 18, 1997.

Leslie mailed information that the Colorado Office of Emergency Management uses for informing the public of natural disasters that occur in Colorado.

(28) Person, Waverly. *Oral Interview.*

Mr. Person was a resource on the outline and format of the public bureau presentation, as well as the organization of facts that were incorporated in the speech itself. This was based on his previous experience.

(29) Plummer, Charles C., and McGeary, David., *Physical Geology*, 6th ed., pp. 200-201. 188-192., Wm.C. Brown Publishers, Australia, 1993.

This is a textbook from a college level physical geology course. It gives many useful descriptions and information concerning the geology of Colorado and the existing hazards. It also aided in the figures found in the report.

(30) Saul, Wendy., *Science Fare*, pp. 90-93., Harper and Row, Publishers, New York. 1986.

The author of this book has compiled various information on how children learn the most from science. It gives ideas for experiments, discussions, field trips, etc. It also describes what children's interests in science are at various age levels.

- (31) **Skinner, Brian J. and Porter, Stephen C.** The Blue Planet. John Wiley & Sons Inc. USA, 1995

A whole chapter in this book was dedicated to the discussion of earthquakes. A specific section focused on the various earthquake hazards. Mitigation techniques were also explained. A useful source for any technical information that may be needed in research.

- (32) **Southern California Earthquake Center, Los Angeles.** "Putting Down Roots in Earthquake Country." <http://www.scecdc.scec.org/eqcountry.html>

A complete guide on what to expect and how to handle putting roots down in California where earthquakes are likely. This site includes information on how to make your home safe, personal safety before, during and after an earthquake, earthquake myths, and even an earthquake game to practice "Duck, Cover and Hold."

- (33) **Spence, William.** 1996. Colorado's Largest Earthquake. Denver, CO: United States Geological Survey, Government Printing Office.

This is a pamphlet showing maps that relate Richter Scale with Intensity Scale, as well as describe the largest quakes in Colorado. There is also a map showing major faults in the state.

- (34) **Stover, C.W. et al.** 1984. Seismicity Map of the State of Colorado. Reston, VA: United States Geological Survey, Government Printing Office.

This is a map showing all major earthquake events in the state of Colorado from 1870 to 1984. It uses an Intensity scale rather than the Richter Scale, which is very descriptive and useful.

- (35) **Straley, Sara H.,** *E-mail interview*, Wednesday, October 22, 1997 (afternoon)
Email: Sstraley@jeffco.k12.co.us. Media Specialist, Kendrick Lakes Elementary, Jeffco.

She explained the children programs already mandated by the state, how the state has control over all school curriculums and what teachers find most useful in teaching any subject.

- (36) **Turner, Ralph H. et al.** 1991. Earthquake Threats: The Human Response in Southern California. Washington DC: United States Geologic Survey, Government Printing Office.

This book details information on governmental prevention and mitigative efforts in Southern California. This is a useful source for evaluating the role of the federal government.

- (37) **United States Geological Survey.** <http://quake.usgs.gov/hazprep/index.html>

A very useful site for finding other web sites dealing with earthquakes such as the Federal Emergency Management Agency, American Red Cross, California Office Emergency Management, and the National Earthquake Information Center. This site was mainly used to look for these other sites.

- (38) **United States Geological Survey.** Earthquake Information Package.

The information contained in this package was extremely helpful. It contained charts and data of the entire history of earthquakes in Colorado, dating back all the way to the 1880's.

APPENDIX A: CHILDREN'S POSTER AWARD PROGRAM

The following appendix is an example of the teacher's inservice material packet and the poster award program guidelines.

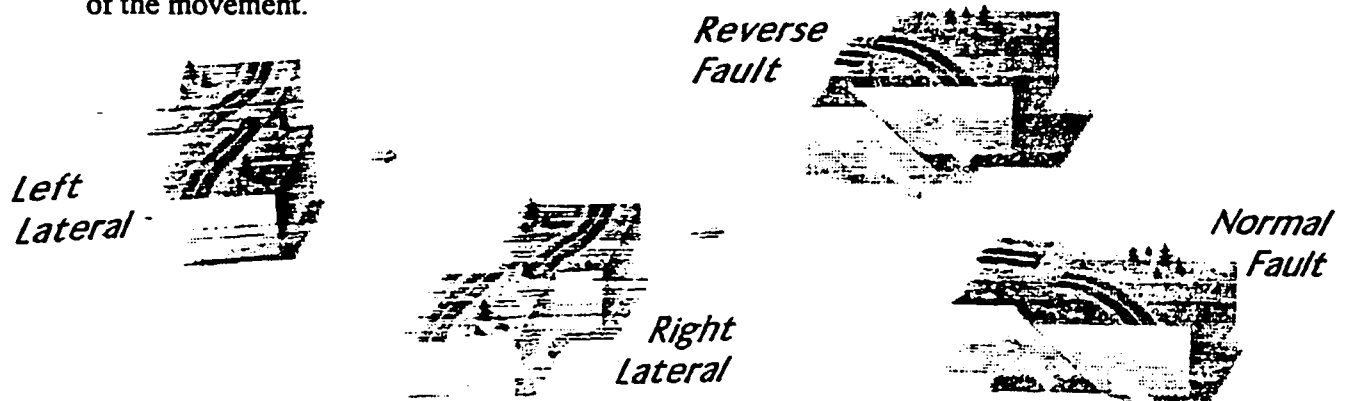
Poster Award Program Supplementary Curriculum

By educating children concerning the basic “what’s, why’s, and how’s” of earthquakes and other geologic hazards found in Colorado, perhaps a clearer, less frustrating and frightening understanding of such events can be attained. The following information is to be used as a general guideline as to how the information can be presented to the children in a classroom setting.

Earthquake Background Information

An earthquake is caused by a sudden slip on a fault line. The process is much like snapping your fingers. The rocks underground push against each other, just like your fingers. When the pressure finally becomes strong enough, the rocks slip across each other, causing a lot of noise and shaking.

These diagrams illustrate various types of faults. The arrows show the directions of the movement.



An earthquake begins at a point called the epicenter. This is where the rocks actually slip. However, the epicenter is always located on or very near a fault line. A fault is two sections of the Earth’s crust, which are pushing against each other with a lot of energy.

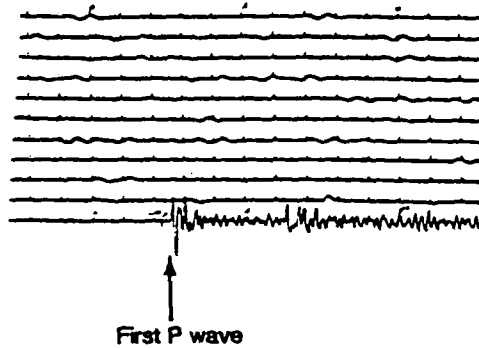
Sometimes faults are very easy to see. The Rocky Mountains are a clear example that there is strong geologic activity in Colorado. The earthquakes occurring here happen due to normal and reverse faults. This basically means that the earth is moving in an upward or downward motion. The most susceptible regions are those closest to the

mountains. The Eastern Plains of Colorado need not be concerned with the dangers of earthquakes.

Once the fault has started slipping, the movements through the earth are called waves. There are two types P-waves and S-waves:

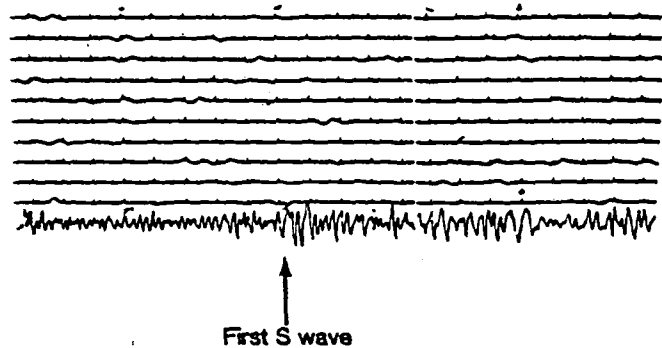
Primary Waves (p-waves)

These squeeze and stretch rocks and can travel through fluid. They are first to be recorded.



Secondary Waves (s-waves)

These waves shake the rocks up and down and side.



The P and S waves are used to measure how strong an earthquake is. A machine called a seismograph measures wave patterns. Once the seismograph records the wave patterns, the Richter Scale is used to determine how intense the earthquake was. The scale ranges from 1-12. The following list explains what each number means.

Richter Scale

- 1-felt only by a very few
- 2-felt by few, especially on upper floors in buildings
- 3-similar to a passing vehicle
- 4-felt by many outdoors

- 5-buildings and trees shake
- 6-felt by all; plaster cracks on walls and buildings
- 7-bricks loosen; difficulty standing
- 8-damage to weak structures
- 9-pipes crack; buildings collapse
- 10-huge ground cracks, landslides
- 11-most structures destroyed
- 12-total destruction; surface waves seen on ground

Colorado has only experienced approximately a six or seven on the Richter Scale. There has never been any earthquake in history that has been more than an eight on the scale.

Earthquakes usually last less than one minute. However, just because there is no shaking, the danger is not completely gone. Earthquakes can also trigger landslides, avalanches, floods, and even fires. These geologic hazards will be discussed further in a later segment. There are also possibilities of aftershocks, which are less intense versions of the preceding earthquake.

Earthquake Safety

The best way to be safe in case of an earthquake is being prepared. Here are some tips for being safe at home or at school. During an earthquake, at school, hiding under a desk or a sturdy table will help protect against falling debris. At home, standing in a doorway is the safest place to protect against falling walls and ceilings.

A disaster kit is also a necessity in order to be safe and prepared. The following is a list of supplies to include:

Earthquake Disaster Kit

- First aid kit and essential medications
- Canned food and can opener
- At least 3 gallons of water per person in family
- Protective clothing, rainwear, coats, bedding/sleeping bags
- Battery-powered radio, flashlight, and extra batteries
- Special items for infants, elderly, or disabled family members
- Written instructions for how to turn off gas and water if necessary

When the earthquake is over, the best thing to do is remain calm. Make sure you and your family is not hurt. Remember that help will soon be on its way once the earthquake has stopped.

Geologic Hazards Background Information

Colorado's weather changes rapidly, one minute the sun may be shining, and the next there may be a severe thunderstorm with torrential rainfall. These sudden changes of weather most often contribute to Colorado's natural geologic hazards.

Geologic Hazards Found in Colorado

There are three main natural geologic hazards found in Colorado. All three have direct correlation to Colorado's weather. The first is a flash flood. These occur rapidly and die out just as quickly. Occurring locally, and usually triggered by heavy thunderstorms, these are sudden floods of large volume and short duration.

A prime example is the occurrence in Big Thompson Canyon, Colorado in 1976 (see Figure 1). The volume of rain, which fell in such a short duration, was so immense that the soil was unable to soak up the water, causing the Big Thompson River to exceed its banks. Many lives were lost and multi-million dollar damage was done (see Figure 2).

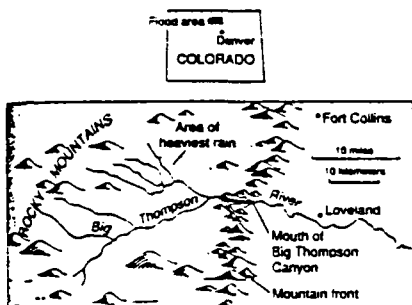


Figure 1



Figure 2

The two other natural geologic hazards found in Colorado are rock falls and mudflows and slides. A mud flow/slide is caused by overly saturated soil, usually associated with floods (see Figure 3). They tend to occur in arid regions, such as Colorado, with little vegetation cover to protect the soil. A rock fall is when rocks fall freely from a cliff or steep slope. The many highway and river undercuts in the mountains and foothills of Colorado are prime areas for rock falls to occur.

The climate of these areas also contributes to rock falls. The frequent freezing and thawing of water in the rocks cracks directly lead to the separation of the rock from the main mass on the existing slope (see Figure 4).

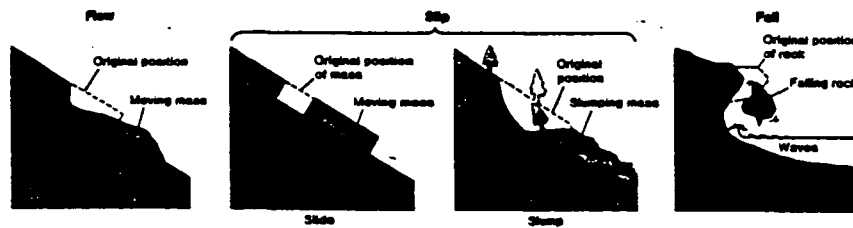


Figure 3

Figure 4

Raising Children's Awareness

Adults are not solely affected by the mass destruction and devastation which Colorado's geology presents. The entire community is involved in a natural disaster. This includes children.

Flash floods, mudslides, and rock falls are very dangerous, and have the tendency to occur without much notice. A child's awareness of such events and of the necessary precautions involved could quite possibly save their life.

Poster Award Program

The implementation of the poster program corresponds to the following steps:

1. A list of schools and/or districts needs to be developed. The program, however, has been developed to be implemented statewide. There are hazards that pose risks to all areas of Colorado.
2. A list of the principals should then be requested from the Colorado Board of Education. The principals will serve as a first point of contact.
3. An informative letter must be submitted to each principal, explaining the aspects of the program. Also, request a list teachers whom will be directly involved with the program, if the program is agreed upon. The teachers will be the second point of contact.
4. It is suggested that the teacher's mailings be distributed mid-summer, before the desired year of implementation. This will serve as a reminder and as a final confirmation.
5. The developed curriculum should then be distributed among the confirmed schools.
6. All materials, such as poster paper, entry tickets, and all teacher information should be supplied at this time.
7. Once the students have designed their posters, the judging may then begin. Each school should have top three winners from each grade level targeted. Then, the judging can slowly be widened to include the entire state if desired. It is a possibility that a calendar of some sort may be compiled from the top 12 winners in the state.
8. If the program is statewide, the state awards ceremony should include Colorado's governor as the award presenter.
9. The awards can be state treasury checks beginning at fifty dollars for the first prize winner, at the state level. Each subsequent level will receive prizes of less value, perhaps gift certificates, or simply award certificates.
10. The expected project costs may range from \$700-\$1000. This does not include staff time.

APPENDIX B: MEDIA KIT

The following appendix is an example of the media kit recommended to be distributed to the media of Colorado.

EARTQUAKE

MEDIA

ART

PREPARE A PLAN

There are no signs or warnings when an earthquake hits and it can shake for several minutes. Being prepared in advance can reduce the dangers of serious injury or loss of life.

1) Teach everyone to "duck, cover, and hold"

DROP and take COVER under a sturdy piece of furniture and HOLD on until the shaking stops.

2) Identify safe spots in every room, such as sturdy desks and tables, and interior walls.

3) Teach everyone who could be home alone how to turn off the gas—but only if they smell gas or hear a leak.

4) Establish an out of area contact to be called to relay information.

5) Store supplies in a disaster kit.

Identify Hazards in the Home

- Fasten shelves securely to walls.
- Place large or heavy objects on lower shelves.
- Store breakable items in low, closed cabinets with latches.
- Hang heavy items away from beds and couches.
- Repair any deep cracks in ceilings or foundations.
- Keep the hallways clear.
- Stay away from kitchens and garages where most dangerous items are stored.

Disaster Supply Kit



Once an earthquake is over, one must live with its aftermath. Knowing first aid and having supplies available will make life more comfortable after an earthquake.

- Drinking Water
 - First Aid Kit and Manual
 - Canned food and can opener
 - Protective clothing, rainwear and bedding or sleeping bags
 - Battery-powered radio, flashlight, and extra batteries
 - Special items for infants, elderly, or disabled family members
 - Written instructions on how to turn off gas and water if authorities advise you to do so.
 - Sturdy shoes
 - Flashlight and extra batteries
 - Emergency Cash
 - Comfort items for children such as games, crayons, and outgrown teddy-bears.
-

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-

EARTHQUAKE SAFETY TIPS

DURING AN EARTHQUAKE:

- If you are in a **HIGH-RISE BUILDING**,
 - Move against an interior wall and protect your head with your arms.
 - Do not use the elevators.
 - Do not be surprised if the alarm or sprinkler systems come on.
 - Stay indoors.

- If you are **OUTDOORS**,
 - Move to a clear area away from trees, signs, buildings, electrical wires, and poles.

- If you are on a **SIDEWALK NEAR BUILDINGS**,
 - Duck into a doorway to protect yourself from falling bricks, glass, plaster, and other debris.

- If you are **DRIVING**,
 - Pull over to the side of the road and stop.
 - Avoid overpasses, power lines, and other hazards.
 - Stay inside the vehicle until the shaking is over.

- If you are in a **CROWDED STORE OR OTHER PUBLIC PLACE**,
 - Do not rush for exits.
 - Move away from display shelves containing objects that could fall.

- If you are in a **WHEELCHAIR**,
 - Stay in the wheelchair.
 - Move to cover, if possible, lock your wheels.
 - Protect your head with your arms.

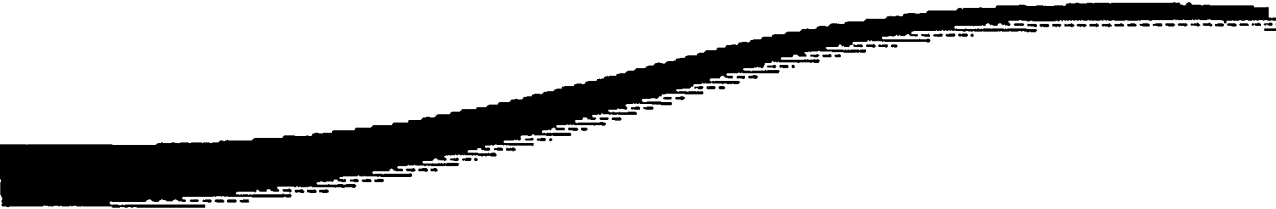
- If you are in the **KITCHEN**,
 - Move away from the refrigerator, stove, and overhead cupboards.

- If you are in a **STADIUM or THEATER**,
 - Stay in your seat and protect your head with your arms.
 - Do not try to leave until the shaking is over, then leave in a calm, orderly manner.
 - Avoid rushing toward exits.

- If you are in a **MOUNTAINOUS AREA**,
 - Be alert for falling rocks and other debris that could be loosened by the earthquake.

After the Shaking Stops



- Be prepared for aftershocks.
 - Check for injuries and give first aid as necessary.
 - Remain calm and reassure others.
 - Avoid broken glass.
 - Check for fire. Put out any small fires.
 - Check gas, water and electric lines. If damaged, shut off service.
 - Replace all telephone receivers and use for emergency calls only.
 - Tune to the emergency broadcast station on radio or television.
- 

RICHTER SCALE

The Richter scale measures the size of the earthquake at the epicenter. A value of 3.0 was set for an earthquake 100 km away that would cause a 1 mm deflection on the recording paper of a seismograph.

Description	Magnitude
Great	8.0 +
Major	7.0-7.9
Large (destructive)	6.0-6.9
Moderate (damaging)	5.0-5.9
Minor (slight damage)	4.0-4.9
Generally felt	3.0-3.9
Potentially Perceptible	2.0-2.9
Imperceptible	<2.0

SOURCE: _____

Mercalli Intensity Scale

The Mercalli Intensity Scale measures the level of seismic shaking over the affected area. The 12-point scale is shown below.

- I Not Felt
- II Felt by persons at rest, on upper floors.
- III Felt indoors. Hanging objects swing. Vibrations are like passing of a light truck.
- IV Vibration like passing of heavy trucks. Standing motorcars rock. Windows, dishes, doors rattle. Wooden walls and frames may creak.
- V Felt outdoors. Sleepers wakened. Liquids disturbed, some spill. Small objects are displaced and doors swing open and close.
- VI Felt by all; many frightened and run outdoors. Persons walk unsteadily. Pictures fall off walls and furniture may move. Weak plaster and masonry crack and trees are shaken.
- VII Difficult to stand. Noticed when driving a car. Hanging objects move, furniture may break, and there will be damage to weak masonry and chimneys. Plaster, loose bricks, stones, etc. may fall. Concrete irrigation ditches are damaged.
- VIII Steering of cars affected. Partial collapse of masonry, and some damage to reinforced masonry. Fall of chimneys, factory stacks, monuments, towers, etc. Frame houses may move on foundations if not bolted down. Cracks in wet ground and on steep slopes.
- IX General panic. Weak masonry is destroyed and others heavily damaged. Serious damage to reservoirs, and underground pipes are broken.
- X Most masonry and frame structures are destroyed with their foundations. Wooden structures and bridges may be destroyed. Serious damage to dams, dikes, and embankments. Large landslides. Railway rails bend slightly.
- XI Rails bend greatly and underground pipelines are completely out of service.
- XII Damage nearly total. Large rock masses are displaced and lines of sight and level are distorted. Objects are thrown into the air.

SOURCE: _____

CONTACT LIST

Waverly Person
National Earthquake Information Center
U.S. Geological Survey
(303)-273-8500 W

Pat Rogers, Ph.D.
Colorado Geological Survey
(303) 866-2611

Bob Kirkham
Colorado Geological Survey
(719) 587-0139

APPENDIX C: BUILDING SAFETY PAMPHLETS

Appendix C-a is a copy of a version of the Earthquake Safety Pamphlet targeted at the owners of “at risk” structures.

Appendix C-b is a copy of a version of the Earthquake Safety Pamphlet targeted at those who rent space in and frequent “at risk” structures.

Appendix C - a 1

Colorado Earthquakes:

The hazard does exist. Unlike California, however, Colorado does not prepare its citizens for earthquakes and their related hazards. In the last 100 years this state has experienced at least one damaging quake. The likelihood of another such earthquake event cannot be measured due

to the relatively short history of Colorado.

If a damaging earthquake event has occurred in the past, there is a chance that

it could occur again. Many Coloradans are

not aware of any earthquake hazard, and therefore, may not have taken safety

precautions against such an occurrence. This

pamphlet is designed to let you know, as a

Coloradan, and as a building owner, some

precautions that can be taken to safeguard

a building against earthquakes. Some types

of buildings are more "at risk" than others,

and these are the structures that need to be

safe-guarded.



"At risk" Structures include:

- unreinforced masonry buildings
- non-ductile concrete framed buildings
- any building constructed before 1940
- any building made of a combination of concrete, masonry, adobe, wood or steel



some ways to reduce the risk:

- be sure that the individual components, i.e., the floor, ceiling, walls, are anchored together
- vertical shear walls can be used to support existing walls
- diagonal bracing and horizontal diaphragms can also be used to strengthen existing walls
- base isolation is effective for smaller structures (perhaps a single family

home); this allows the building to "ride the wave" of an earthquake

extreme cases may involve reducing the weight on the load bearing walls of a structure, by removing its upper stories



If an earthquake should occur prior to safe-guarding your building, the following "disaster drill" should be followed:

- drop, cover and hold!
- stay within the building
- get under a table or desk
- stay away from any exterior walls
- stay near interior walls or doorways
- a seated fetal position is the safest



When the earthquake is over exit the building quickly and carefully!

EARTHQUAKES HAPPEN!



Even in Colorado



This map shows the epicenters of all the earthquakes recorded in Colorado since 1900.



Don't be caught unprepared! If an earthquake occurs in Colorado, make sure you are ready!!



Prepared for the
Colorado Department of Emergency
Management

For more information call:
(303) xxx-xxxx



Appendix C - b 1

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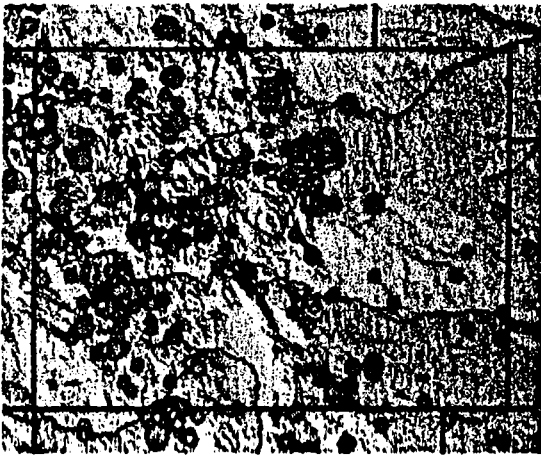
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- a seated fetal position is the safest

When the earthquake is over exit the building quickly and carefully!



**EARTHQUAKES HAPPEN!
Even in Colorado**



This map shows the epicenters of all the earthquakes recorded in Colorado since 1900.



Don't be caught unprepared! If an earthquake occurs in Colorado, make sure you are ready!!

Prepared for the
Colorado Department of Emergency Management

For more information call:
(303) xxx-xxxx

APPENDIX D: EARTHQUAKE FACT SHEET

The following appendix is recommended for use as the Earthquake Fact Sheet for the general public and local governments of Colorado.

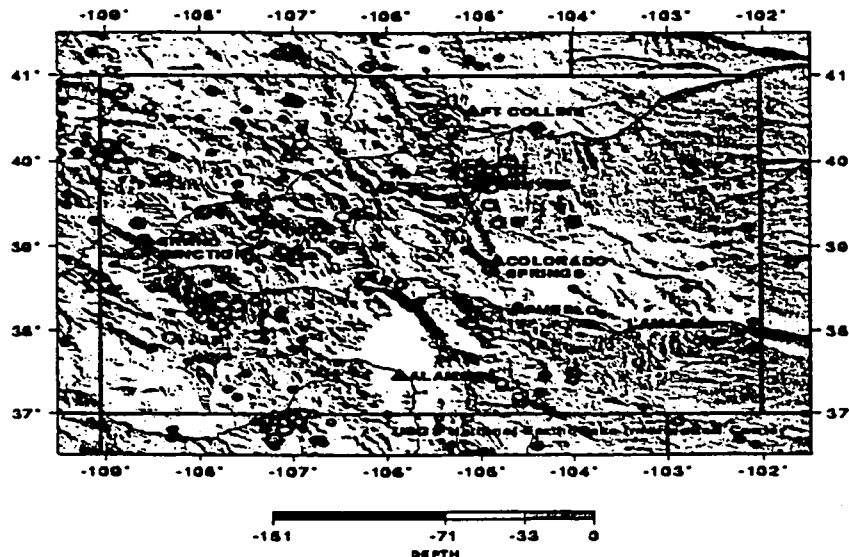
AN EARTHQUAKE FACT SHEET FOR COLORADO

Among all the natural disasters that we Coloradans may be affected by, we are probably least conscious of the threat that Earthquakes pose to us. Although public awareness is not high with regards to Earthquakes, the fact remains that over the past 20 years, Colorado ranks eleventh among the United States in number of Earthquakes. In the last 100 years Colorado has experienced hundreds of Earthquakes, one (west of Fort Collins) which is estimated to have been as much as 6.6 on the Richter scale. The vast majority of Earthquakes, that we might expect to occur within the State, are less than 4.0 on the Richter scale, and cause little or no damage with only very few people feeling their effects. There are however, faults that experts believe could produce Earthquakes as large as 7.5 on the Richter Scale. An Earthquake of this magnitude would cause great damage, collapsing most buildings, especially those of constructed of Adobe and Masonry.

As varied as Colorado's landscape is, so is the threat that Earthquakes pose to its citizens. Within Colorado there are distinct regions which have almost no history of earthquake activity. As one might guess,

Seismicity of Colorado

1800 - 1995



this region would consist of the Eastern Plains. The Northeast corner of the State exhibits relatively no signs of this threat and the Southeast shows only minimal history or features which could produce significant earthquake activity. Among those areas which pose the greatest risk, are the Denver and Front Range area, which has experienced a 4.3 magnitude earthquake as recently as 1981, and several which have been larger (6.0+) in the last century. The Southwest corner of the State has produce many earthquakes, several in the 5.0-6.0 range of the Richter scale this area includes Ouray, Montrose, Hinsdale, Mineral and Archuleta counties. The seismic activity that produced our most notable landscape features, the Rocky Mountains, has also created faults littering these same mountains. These faults leave the central mountains and Northeast area of the state with many sites that have, and will produce much seismic activity.

Being aware of the danger that earthquakes pose, learning how to mitigate dangers around you, and what to do during and after an earthquake can not only protect loss of personal property, but, it could also saves lives. Not only should the general public take responsibility, but local governments should also be cognizant of how they can mitigate dangers. Following are important procedures and things one should be aware of, to minimize loss of life and property when living with this threat.

Steps To Take Before An Earthquake

Private Sector:

- Secure all tall furniture, bookcases, appliances and floor lamps from falling over
- Secure pictures and overhead lighting to their surfaces
- Secure water heaters to framing of building
- Ensure that articles on shelves (bookcases, cupboards, utility shelving) are secure
- Inspect and fix any loose external flaws to buildings (eaves, gutters, masonry, etc.)
- Be aware of natural hazards where they present themselves and notify authorities of precarious rock formation which may pose a threat to structures or people

Local Governments:

- Ensure that zoning regulations are ample for areas near potentially active faults
- Inspect utility (water, gas, telephone) to ensure their lines of distribution are up to standard
- Inspect dams and reservoirs to ensure their integrity in the event of an earthquake

Steps To Take During An Earthquake

- Most importantly remain calm, so that you will be able to react logically and efficiently
- If inside:
 - ◆ Move under a heavy, well constructed piece of furniture (table, desk), or a substantial doorway
 - ◆ Cover face and eyes with your arm, using the other to ensure you remain where you are
- If outside:
 - ◆ Best place to be is in an open field
 - ◆ If among buildings, seek cover in a doorway and be aware of the possibility of falling debris and overhead power lines
 - ◆ If operating an automobile, one should calmly pull off the roadway, away from overhead passes and off of elevated portions of roadway

Steps To Take After An Earthquake

- Attempt to provide aid to others if qualified under the
- conditions that are present, else assist those who are qualified
- Assess damage and potential for harm from this damage
 - ◆ Gas and water lines should be turned off and if thought to be damaged one should contact appropriate utility provider for service
 - ◆ Brick and Masonry should be assessed for damage outside as well as inside
- Listen to news agencies for current information such as possible aftershocks, the USGS on the internet will provide important information as well
- ◆

APPENDIX E: SPEAKER'S BUREAU PRESENTATION

This appendix is an example of the presentation that can be kept on file by various organizations. The presentation is very self-explanatory and may be given by anyone experienced in public speaking.

SPEAKERS
BUREAU
PRESENTATION

LIST OF ILLUSTRATIONS:

- **Visual 1 - *World-Wide Earthquakes: 1900-1993***
Global distribution of areas prone to earthquake risks and magnitude scale.

- **Visual 2 - *Seismicity of the United States: 1899-1990***
United States distribution of earthquake sites and magnitude scale.

- **Visual 3 - *Trinidad, Colorado Earthquake, October 31, 1996, Magnitude 3.2 Lg***
The most recent seismograph reading of an earthquake which occurred in Trinidad, Colorado on October 31st 1996. It was recorded in Idaho Springs, Colorado and was recorded at a magnitude of 3.2 on the Richter Scale.

- **Visual 4 - *Colorado's Largest Historical Earthquake***
The location of an Epicenter in the Metro Denver area which caused the largest recorded earthquake in the history of Colorado. The earthquake occurred on November 7th, 1882.

- **Visual 5 - *Associated Earthquake Risks***
A list of primary as well as secondary earthquake hazards. The information was extracted from a book entitled "The Blue Planet".

- **Visual 6 - *Probable Mitigation Techniques***
A list of earthquake mitigation techniques. Derived from a book called "Earthquake Threat: The Human Response in Sounthern California, a compilation of the various earthquake mitigation techniques that could be implemented".

Introduction:

Salutation → e.g: good afternoon/evening or hi/hello

State the following:

1. Name
2. Rank
3. Organization

Title of Presentation:

The history of Colorado Earthquake, associated risks and mitigation techniques.

Body of Speech:

The single most common misconception that the general public has about earthquakes is that it does not occur until the earth starts to shake. There is a rough estimate that several million earthquakes occur annually. That means thousands occur each day. The reason why the public was never made aware of this fact is because most of the earthquake that occur around the world are so small that they may only be detected by ultra-sensitive seismographs. As more seismographs are set up all around the globe, more earthquake occurrence may be detected. However, the number of serious “shakers”, (those that carry a magnitude of 6.0 and larger) still remains relatively constant.

(Refer to Visual 1). Here is a world map that displays the area of which earthquake occurrence have been detected from 1990 to 1993. A major portion of the world’s earthquakes each year center around the rim of the Pacific Ocean, also known as the Ring of Fire. referred to by seismologists as the Circum-Pacific Belt. This is the most productive earthquake zone in the world. Currently, the U.S. Geological Survey’s National Earthquake Information Center or the USGS, stationed in Golden Colorado,

monitors about 18-19 thousand earthquakes yearly, all over the world. A sub-division of the USGS, known as the National Earthquake Information Center (NEIC) is the foremost collector of rapid earthquake information in the world and is responsible for notifying the emergency management agencies and for publication and dissemination of earthquake data. More importantly, the NEIC is the most accurate source for the world and the U.S. specifically, as far as determining the location and magnitude of significant earthquakes.

Thanks to the hardworking staffs of the USGS, a map of earthquake distribution was produced for the years between 1899-1990. (Refer to Visual 2). Here we can see that the most frequent earthquake locations lie on the Pacific Coast of California, Hawaii and Alaska. Other states, including Colorado have had their share of earthquakes but less frequent and less hazardous. It is estimated that roughly, 700 shocks have the capability of seriously damaging infrastructures when centered in a populated are. But fortunately, most of these potentially destructive earthquakes were centered in unpopulated areas, far from civilization. Eight of the ten largest earthquakes in the North American history, were recorded in Alaska. The other two were in New Madrid, Missouri and Fort Tejon, California.

On November 7th, 1882, the largest earthquake in the history of Colorado was recorded. The magnitude was estimated to be about 6.2 on the Richter Scale. It was the first ever earthquake to cause significant damage to Denver. The same earthquake also caused some damages to Southern Wyoming and was felt slightly in Utah and Kansas. The actual location of this earthquake was never determined but was postulated to have occurred in Western Colorado or Southern Wyoming. (Refer to Visual 3). The center of the earthquake or the Epicenter was never determined as well. But, seismologists believe

that it could have originated from the Front Range near the Rocky Mountain National Park.

As a result of the 1882 earthquake, Denver had her electricity cut off after an iron bolt that connected an engine-driving pulley was broken in two at the electric power building. Buildings trembled violently and residents ran out of the door in panic. Plaster fell and windows broke as far as Laramie, Wyoming. Observers also reported that the walls of the railroad depot in Louisville were cracked, and local houses sustained visible damages. 1967 was a disastrous year for Denver. Four separate earthquakes occurred that year alone, causing damages to Denver, Commerce City, Boulder and Northglenn.

(Refer to Visual 4). The most recent seismic reading that I have is of the one that happened on October 31, 1996 in Trinidad, CO. It registered a magnitude of 3.2 of the Richter Scale. However, this data was recorded in Idaho Springs but as you can see (refer to visual), it registered quite a shake (magnitude of about 2.5 ± 0.2).

According to the USGS, the latest earthquake in Colorado was dated early this year. With a magnitude of about 2.6, 2.7 and 2.5 respectively, three back-to-back earthquakes were recorded on January 8th, this year. The key thing to remember is that there are a lot of faults that have been identified all through out Colorado. But fortunately, a majority of them are inactive. Which still leaves the possibility of an earthquake happening in Colorado, to be very likely.

When there is mention of earthquake in the US, the first thought that would come to the public's mind would be California. Once again, the emphasis lies on the fact that earthquakes could happen anywhere, at anytime. Since no form of reliable earthquake prediction method is available presently, we are left with no early warning mechanism

what so ever. There is absolutely nothing that anyone nor anything could do to prevent major earthquakes from happening (at least not now). When it does happen, the devastation is costly. The bloodiest earthquake ever to be recorded was in 1556, which trembled the province of Shaanxi, China. That incident costed 830,000 people their lives. The most recent major earthquake catastrophe happened in Iran, in 1990. 52,000 people were estimated dead. The best armor to protect lives from earthquake risks is a well-defined knowledge of the risks associated with earthquakes.

(Refer to Visual 5). The effects of earthquake could be divided into two categories, (1) being the primary effects and (2) the secondary effects. The primary effects involve ground motion and faulting or direct effects, while the secondary effects cover damages indirectly caused by earthquakes. The six major destructions brought by earthquakes are:

1. Ground motion results from the movement of seismic waves, especially surface waves, through surface-rock layers and regolith. The motion can damage and sometimes completely destroy buildings and roads.
2. Where a fault breaks the ground surface, buildings can be split, roads disrupted, and any feature that crosses or sits on the fault broken apart.
3. Ground movement displaces such objects like stoves, breaks gas lines and loosens electrical wires, thereby starting fires. Ground motion also breaks water mains, making it difficult to put out these fires. In the earthquakes that struck San Francisco in 1906 and Tokyo and Yokohama in 1923, more than 90% of the building damages were caused by fire.

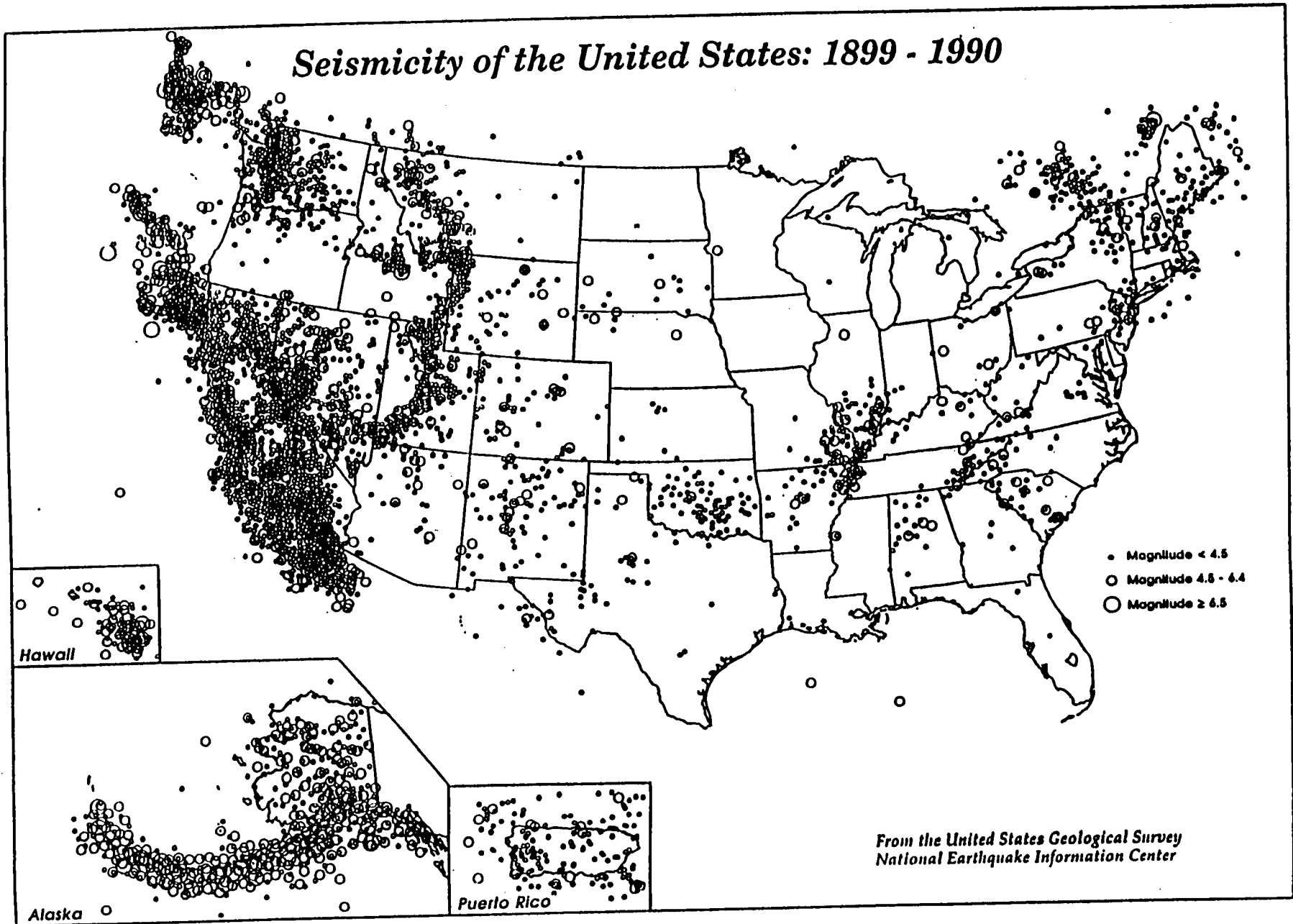
4. In regions of steep slopes, earthquake vibrations may cause regolith to slip and cliffs to collapse. This is particularly true in Alaska, part of Southern California, China and the hill areas of Iran and Turkey. Houses, roads and other structures are at risk of destruction by the rapid moving regolith.
5. The sudden disturbance of water-saturated sediment and regolith can turn seemingly solid ground to a liquidlike mass of quicksand. This process is called liquefaction, and it was one of the major causes of damage during the earthquake that destroyed much of Anchorage, Alaska, on March 27, 1964.
6. Finally, there are seismic sea waves, called tsunami, which are particularly destructive in the Pacific Ocean. Tsunami is a Japanese term that means, harbor wave. Although a regular wave at sea may not seem to be too catastrophic, but once it reaches land it can dramatically change its amplitude and be extremely lethal.

Since Colorado's risk of earthquakes is relatively low, little effort has been put into the area of earthquake mitigation. Nevertheless, the mitigation steps that the state of Colorado had adapted covers three areas: (Refer to Visual 6).

1. Structural Improvements → upgrading and enforcing building codes, reinforcing and destroying unsafe buildings, making dams and freeways safer.
2. Educating the public about earthquake safety and predictions and conducting earthquake drills and public buildings followed closely.
3. Achieving a state of emergency preparedness and readiness to handle problems after the disaster strikes—including the adequacy and availability of shelters and supplies, medical care, evacuation plans, and good communication systems.

Being blessed with a strategic Zone I placement instead of the more hazardous Zones II, III, or IV, Colorado need not be too disturbed of the possibility of an earthquake occurring in the state. Which is why attention on earthquake mitigation methods has never been a major priority.

Visual 2.



COLORADO'S LARGEST HISTORICAL

Visual 4.



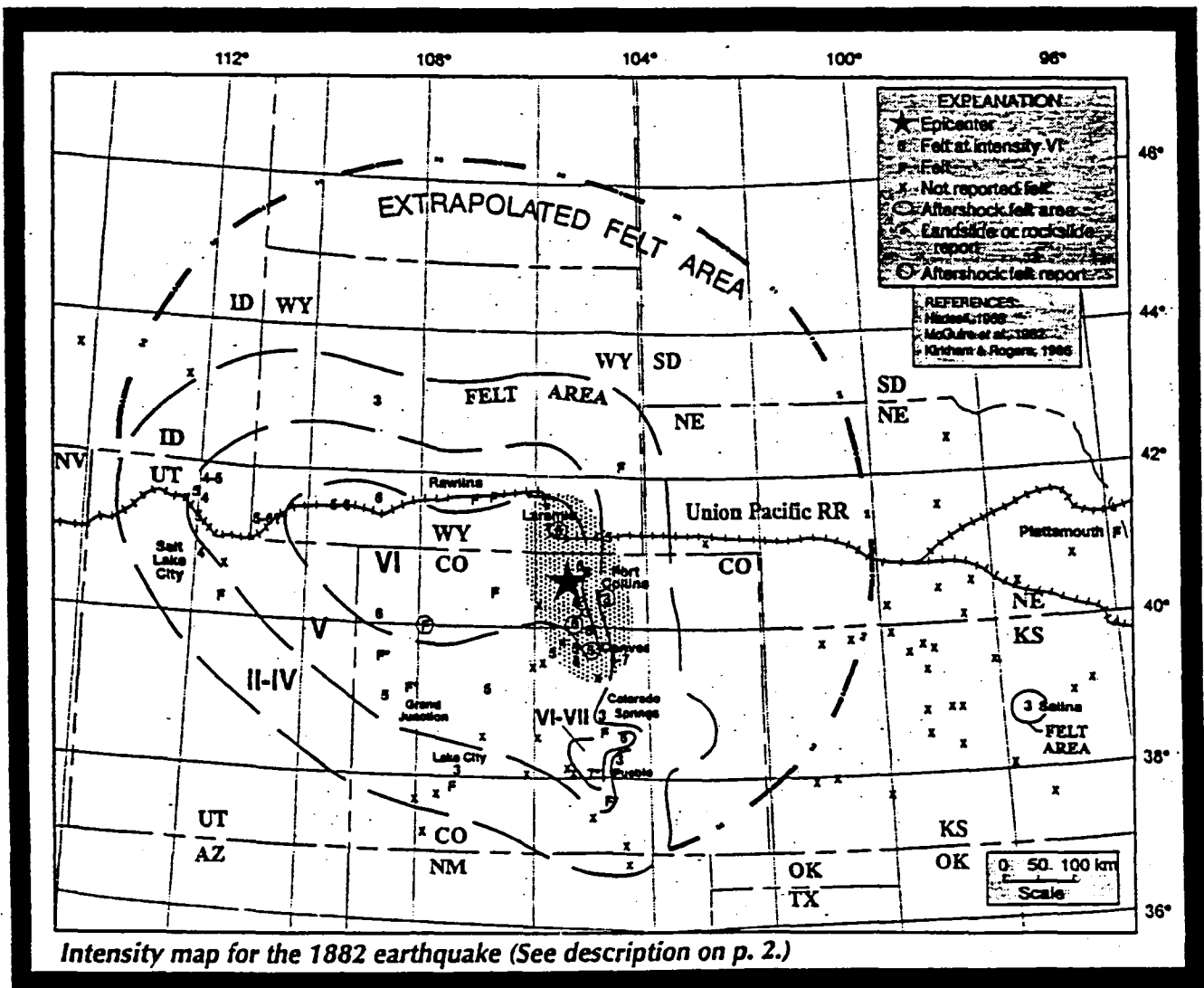
EARTHQUAKE

November 7, 1882

Probably in the Front Range, West of Fort Collins

Magnitude: 6.6 ± 0.6

A modern recurrence of such an earthquake could cause significant damage.



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ASSOCIATED EARTHQUAKE RISKS

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PROBABLE MITIGATION TECHNIQUES.

1. Structural Improvements → upgrading and enforcing building codes, reinforcing and destroying unsafe buildings, making dams and freeways safer.
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