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# The 1999 Colorado Springs, Colorado Landslides – Federal, State and Local Government Response; Public Involvement; and Future Long-term Risks and Challenges

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## Abstract

In the spring of 1999, heavy rain precipitated landslides in over 12 developed areas in Colorado Springs. The landslide damage and destruction exceeded $80 million dollars.

A combined federal, state and local response included active participation by property owners in an open and transparent public process. The resulting federally funded mitigation project was a success, but this can only be considered an interim objective for an inherent serious local problem.

Colorado Springs is normally an arid environment but high moisture years, like 1999, can result in activation of new landslides and reactivation of existing landslides. Residential neighborhoods continue to expand and encroach in areas where a combination of topography and the underlying Pierre Shale present significant long-term stability challenges.

## Introduction

Previous to this project, a federal disaster landslide mitigation project has only been done one or at the most two times in the United States. In 1999, dozens of owners of residential properties had property damaged or destroyed by landslides at more than 12 separate geographical locations. There is no landslide financial assistance program available to owners from any level of government (local, state or federal), so it was a coincidence that a program materialized and as a result 27 owners received federal assistance. Annually, in 2005 dollars, in the United States landslides cause $3.5 billion in damages and the loss of 25-50 lives.[2]

## Background

Colorado Springs is an arid, almost desert environment with an average rainfall of less than 16 inches (40 cm). Humidity levels are usually very low and frequently in the single digits. In contrast to this historical data, the 1990's was one of the wettest decades on record for much of Colorado. Several wet years resulted in new landslides or reactivations of existing landslides within Colorado Springs. In 1995, two small landslides occurred in southwestern Colorado Springs destroying 2 homes and damaging one other home (Regency Drive and Penhurst Place). These landslides precipitated changes in the land development planning process and as a result, the Colorado Springs

City Council adopted a Geologic Hazard Ordinance in 1996 which required site specific investigations in areas that are considered prone to geologic hazards.

Colorado Springs lies along the Front Range, which is the easternmost portion of the Rocky Mountains. See Figure 1. Colorado Springs is mountainous on the west and prairie on the east, has a population of 361,000 (2000 Census) and is approximately 186 square miles (482 square km). The City's elevation is 6,035 feet (1,840 meters) above sea level but western parts of the city are over 9,000 feet (2,744 meters). Pikes Peak, at 14,110 feet (4,302 meters), is locally the highest natural terrain feature and is just west of the City.

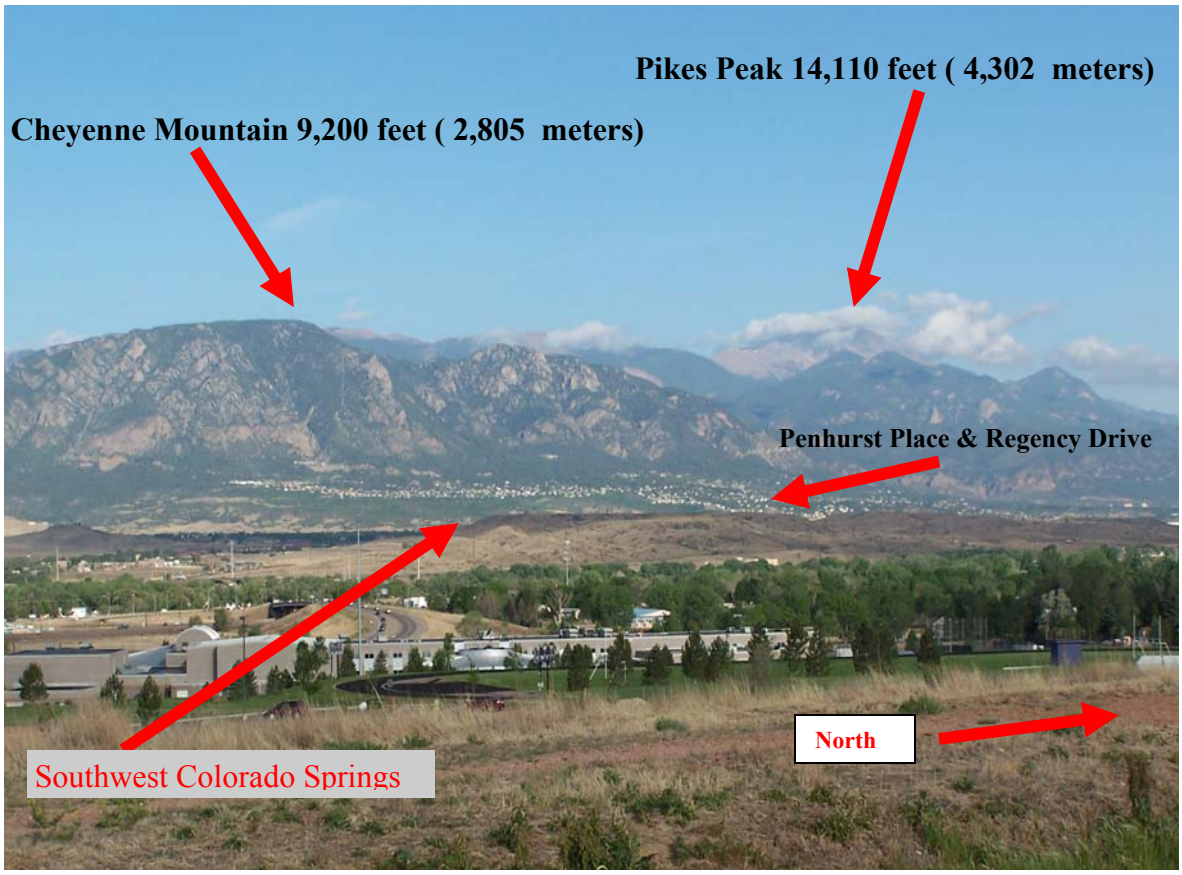


Figure 1: The Front Range is the eastern side of the Rocky Mountains and extends north and south from Colorado Springs. Colorado Springs includes mountains on the west and prairie on the east. The foothills present significant challenges because of the underlying Pierre Shale.

The geology of the area is complex. Colorado was submerged during the Cretaceous Period and this depositional environment resulted in the formation of several geological formations. Pierre Shale, a weak bonded overconsolidated clay, was one of these formations. The modern Rocky Mountains were created when they uplifted beginning near the end of the Cretaceous Period at about 70 million years ago. This uplift included the Pikes Peak area, caused the sea to recede, and rotated the formations above the intrusive granite. The Pikes Peak uplift resulted in 1 billion year old rock penetrating through the earth's crust and through much younger formations. On the perimeter of the

uplift, the granite did not penetrate the crust causing the overlying sedimentary rocks to rotate. Over time, the surface deposits eroded and today in western Colorado Springs, the Pierre Shale is frequently exposed during excavations. Along the Front Range Pierre Shale is a problematic material – it has expansive smectite clays and highly variable in situ engineering properties. As the overlying material eroded the Pierre Shale has rebounded which induces additional fissures into an already weak material. This further degrades the material's strength by allowing moisture to penetrate into additional fissures. In some cases weathered shale, in the presence of water disintegrates almost immediately.

Pierre Shale slopes that fail, in the Colorado Springs area, can have different characteristics. As examples, failed slopes can move as an entire mass exhibiting the typical scarps and tension cracks, while other failure masses misleadingly appear static except for less obvious active components that consist of small discrete underground streams that carry the disintegrated liquefied material towards the toe.

**1999 Presidential Disaster**

In April and May 1999, heavy and long duration rain events resulted in flooding in many Colorado counties and some cities. In southwest Colorado Springs, the precipitation in April and May 1999 alone exceeded 17.5 inches (44 cm). For the year this area received over 37 inches (94 cm) of precipitation. The damage and destruction from the flooding were of such a magnitude that these areas were declared Presidential Disaster areas on May 17, 1999 by President Bill Clinton.

Initially, landslides were not recognized as part of the disaster for two reasons. In most cases the damage did not materialize and was not recognizable as a landslide until weeks after the disaster and secondly there was no federal mechanism that recognized damages that did not occur at the time of the disaster declaration. For flood damages there is an immediate cause and effect. High water marks, debris and other indicators make it easy to evaluate damages immediately in the aftermath of a flood. For Pierre Shale landslides in Colorado Springs it may take a week or even several months to develop to a point where the damage and or natural process are evident.

During the spring and summer of 1999, the federal government received a large number of requests for help from the public as well as local and state officials. As a result the Federal Emergency Management Agency looked for a way to provide assistance.

A combination of circumstances developed into an unexpected opportunity for the landslide victims. Congress took $230 million dollars from the U.S. Department of Housing and Urban Development (HUD) and gave it to the Federal Emergency Management Agency (FEMA) to fund the "Unmet Needs Program". FEMA's "Unmet Needs Program" was used to help states and local jurisdictions that had suffered disasters where previous aid was insufficient or jurisdictions were not eligible under other existing programs. Under the "Unmet Needs Program", FEMA funded 75% of the cost of approved projects. The remaining 25% came from the state or local jurisdiction. The

state and or local jurisdiction determine how the 25% cost-share is paid. In August 1999, the damages due to the failed slopes were over $50 million dollars. A more detailed estimate several months later estimated the damage at over $80 million. The estimates include the cost to stabilize the various areas as well as rebuild the affected structures.

In January 2000, Colorado Springs was approved for a landslide mitigation project subject to submission and approval of a preliminary application and final application. The preliminary application was put together in a matter of several days and submitted in early February 2000.

**FEMA Landslide Project – Initial Actions**

In early February 2000 the City's fire department worked 7 days a week to register owners of landslide damaged properties to ensure everyone affected had an equal chance of competing for the limited funds (initially it was $4.1 million without considering the required local 25% cost-share).

Acquisition of disaster properties is the federal government's highest priority mitigation because it avoids having to fund repetitive repairs to an affected property (over many years and repetitive disasters) and in the long-term, especially for landslides, is the most cost effective mitigation. Secondly, acquisition programs are very likely to be approved as long as the Cost-Benefit analysis shows that that the project is cost-effective. The Cost-Benefit analysis performed for this project compared the acquisition cost to the cost of repairs and work to stabilize the site. Since tie-back systems and other restraint systems are expensive the Cost-Benefit analysis was usually positive. The cost of a restraint system was included in the Cost-Benefit analysis with the assumption that for the long-term (20 years or longer) the restraint system stabilizes the area. The only feasible engineering solution, to most of the failed slopes, was a restraint system. Less robust mitigation measures (e.g. toe berms, retaining walls, and key trenches) were, in general, not viable.

Some residential areas formed Landslide Coalition Groups to help ensure that the neighborhood was represented in all actions related to the forthcoming project. In some landslide areas registered residents would withdraw their application because of their concern that the stigma of a landslide would adversely affect their property values, other residents associated flood or expansive soils damages with landslides and there were several areas where a local landslide was ignored through a lack of knowledge or oversight.

A minority of owners pursued litigation and other owners were convinced the local landslide was just a short-term problem that could be remedied and solved by performing permanent repairs after all slope movement stopped. Neither of these two avenues was productive for any owner.

As part of the final application a series of detailed site and structural inspections were performed to document conditions, gather data to support a public prioritization process,

and validate an applicant's claims with respect to the extent of damages. These detailed inspections were also used to identify life-safety issues (structural integrity of the structure, issues with utilities and other potential life-safety issues). Of approximately 80 inspected structures there were 35 structures identified as having been destroyed, damaged and or at high risk for short term destruction.

In 2000, landslides were an emotional and sensitive issue with Colorado Springs citizens. In order to ensure that the process maintained public confidence, an independent neutral party (from outside the City) was needed to validate landslide location, damage and risk separate from the owners and the City's validation/inspection process. The Colorado Geological Survey (CGS) agreed to be the neutral and disinterested third party. During February and March 2000, the CGS investigated and produced special landslide maps and reports for each landslide area.

**Public Process, Stipulations and Ground Rules**

The public process was a significant strategic part of the entire project. Public meetings were held in late January 2000, and continued until late spring 2000. The public process evolved and matured very quickly. The initial public meetings disseminated information to ensure everyone was kept appraised of important information. These public meetings also served a purpose to eliminate rumors that inherently accompany any such program.

Colorado Springs also helped frame the parameters for the Buy-Out Program. Colorado Springs' stipulations included but are not limited to:

- Owners provide the federally required 25% cost share for their property
- Colorado Springs pays the required 25% cost-share on project wide expenses such as asbestos mitigation, CGS work, demolition and other related costs
- The program was voluntary. The City would not pursue eminent domain
- Properties must be clear of all liens and other encumbrances at the time of closing
- Owners pay all moving expenses and federal relocation assistance is not applicable to owners (the only exception were 4 renters who were eligible for relocation assistance)
- Owners cannot receive duplicate benefits for the same damage
- Appraisals were based on pre-disaster conditions with an effective date of 15 April 1999
- Owners must allow their structures to be inspected

A second series of public meetings were held to determine how to use the allocated federal funds ($4.1 million) in the most cost-effective manner and determine the priority of acquisition. The prioritization public meetings developed the following ground rules that included but are not limited to:

- An owner was only permitted to have one structure eligible for the Buy-Out Program.
- Owners must comply with all requirements by the announced suspense dates in order to remain qualified for the Buy-Out Program.

- The Program initially utilized four priority categories (priority 1 to 4) for prioritizing properties for acquisition. This was reduced to the highest two priorities (priority 1 & 2) as there were insufficient funds to cover all categories. Priority one structures were those structures that were destroyed, heavily damaged or at a very high risk for short-term destruction. Priority two structures were those structures that were at a moderate to high risk for additional damage or destruction.
- Within each priority category rental properties were placed at a lower priority than owner-occupied structures.
- Each of the 35 structures were placed in either priority one or priority two.
- Owners had to be the owner of record prior to the 1999 landslides

Some of the federal government stipulations included but were not limited to:

- The acquired properties could never be built upon again.
- The properties had to be inspected every two years by the State (Colorado) Hazard Mitigation Officer and certified that they were still vacant land. If any livable structure is constructed on these vacant properties Colorado Springs is liable for repaying the entire grant plus other costs to the Federal Government.

**Uninsured Landslide Losses**

In the United States, damages and destruction caused by landslides is typically not covered by insurance nor is there a federal landslide hazard insurance program such as the flood insurance program. Owners of property carry the risk for landslide damages. In this FEMA project none of the homes had landslide insurance. The consequences for many of the owners, had this FEMA program not materialized, was bankruptcy. In some cases mortgage companies would only provide limited relief by allowing deferment of mortgage payments for several months. Some mortgage companies would allow no relief and in one significant beneficial case, the mortgage company worked with the owner and accepted only a fraction of the principal which allowed the owner to obtain some cash at the time of settlement with the Buy-Out program.

**Organizations, Firms and Collaborators that made the Project Successful**

A number of non-profit/governmental organizations and private sector companies were used to perform many of the tasks required to execute this project. This includes but is not limited to:

- Colorado Urban Wildlife Institute – Biological Assessment for endangered species and related federal laws
- Environmental Consulting and Testing (asbestos testing)
- Asbestos abatement
- Appraisals – this was limited to one firm so all appraisals would be consistent
- Title work and real estate closings
- Surveying
- Structural engineering (for removal of one town home, while the adjacent attached structures' common walls were modified to become exterior walls)

- Colorado Springs Utilities – periodic gas leakage surveys, utility location services, air photos, map products and processing of demolition permits
- Pikes Peak Library District for photographs in their archives
- Pikes Peak Regional Building Department – processing of demolition permits
- Colorado Geological Survey
- U.S. Fish & Wildlife, Local Floodplain Administrator, Colorado Historical Society, Corps of Engineers, Colorado Springs Housing Authority, and El Paso County Department of Health and Environment (Air Quality) for compliance with environmental and other federal requirements.
- Rocky Mountain Community Land Trust - relocating 7 structures for affordable housing
- Colorado Springs Park and Recreation Department – Custodian of the vacant land
- Demolition
- Subcontractors for various scopes of work
- Small Business Administration – Disaster loans

**Project Results**

In late September 2000, the first homes were acquired. In May 2001, the demolition contract was let and demolition of the structures began.

There was a number of mitigation measures performed on these sites. The following types of earthwork were performed:

- By removing structures from failed slopes irrigation systems for grass were also removed - this eliminated a possible contributing factor to instability,
- Installation of drainage swales to divert runoff,
- Removal of thousands of yards (cubic meters) of material from failed slopes to unload the top of the slopes and reduce the driving force,
- Laying the failed slopes back to a lower angle and
- Finally, letting Mother Nature, the drought and other natural processes help stabilize these slopes.

Initially the program was to be completed in 2002, but because of its success FEMA and the State (Colorado) transferred unused funds on several occasions from other mitigation projects and thereby extended this project. 27 homes at 8 different locations were acquired which was more than the initial estimate of 21 homes. The last home was acquired and demolished in late 2003. The program was closed in March 2004. The remaining 8 structures of the 35 that were on the Buy-Out Program's prioritized list were eliminated for various reasons that ranged from the owner selling the property or an owner's failure/unwillingness to comply with projects' ground rules. The final cost of the project with the local cost share (25%) was just over $6.5 million.

## Research Project

Separate from this project is a small research project that the author began in 1995. The original research project's purpose was to investigate the Pierre Shale failures at Regency Drive and Penhurst Place to:

- Define engineering properties given that the properties are highly variable
- Determine the failure mechanism
- Develop a methodology for assessing long-term stability
- Develop criteria to address development, engineering and construction issues

This research project has expanded to include a number of slope failures that occurred in 1999. The project is still largely incomplete but each slope, especially Regency Drive and Penhurst Place are closely monitored. Colorado is in a severe drought and this has helped stabilize or slow down the rate of movement of the slopes. As funding becomes available, instrumentation is installed and survey control points are periodically checked.

In May 2000, a number of horizontal wick drains were installed in the Penhurst Place slope to intercept an underground lense of sand and small rock. This lense carries a significant amount of water into the failure mass and is estimated to contribute some but not all of the water that enters the failure mass. The drains performed well for the first year up until the water table dropped (because of the drought) below the wick drains' outlet elevation. This experiment is a long term experiment to determine if the wick drains may be viable candidates for long-term mitigation measures.

## Summary

The FEMA Landslide Project materialized due to an opportunity provided by the Federal Government. A total of 27 homes were acquired in 8 different locations. These homes were demolished or relocated and the sites can never be built upon again. An on-going research project is attempting to address the root causes of the landslide problem in order to better determine applicable engineering criteria. Landslide issues are an inherent natural feature and process in Colorado Springs and will again become a significant issue when significant precipitation occurs and the ground water table is replenished.

In perspective, Colorado Springs is not alone in this issue - other states and countries have the same issues.

## References

[2]Leahy, Patrick P. (2005), "Natural Hazards Science – Reducing the World's Risk", Presentation at the Landslide Preparedness for Disaster Prevention International Consortium on Landslides, Washington, D.C., October 13, 2005, http://www.usgs.gov/aboutusgs/docs/speeches/leahy_landslide_consot_2005.doc (June 1, 2006)