Natural Hazard Research

THE ENVIRONMENTAL HAZARDS OF COLORADO SPRINGS

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SUMMARY

This paper evaluates the various risks posed by the many hazards affecting the area in and around Colorado Springs, Colorado. It is designed to be a working document for persons living in the area to aid them in determining the acceptability and suitability of a given location for a given use. In addition, it is also intended to be used as a guide by other geographers, planners, developers in preparing similar surveys of hazards impinging on other locations.

The paper includes discussions of the hazards posed by floods, various geological phenomena, weather anomalies, air pollution, and hazardous waste. Besides giving spatial and historical accounts of these hazards, existing and potential mitigation measures are also examined.

ACKNOWLEDGMENTS

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PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers be used as working documents by those directly involved in hazard research, and as information papers by the larger circle of interested persons. The series was started with funds from the National Science Foundation to the University of Colorado and Clark University, but it is now on a self-supporting basis. Authorship of the papers is not necessarily confined to those working at these institutions.

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INTRODUCTION

Why This Study?

This paper has two objectives: to meet a local need and to set an example for geographers, graduate students, planners, or others who may wish to assemble a comprehensive set of information on hazardous locations in their own communities.

The population of Colorado Springs is rapidly growing. While the environment is not particularly more hazardous than that found in many other American cities, until this document was completed, there was no over-all assessment of the relative risks faced by the population. We set out to document potential hazards in several categories so that the information could be used by officials, homeowners, and potential home buyers. In addition, we felt that our work could serve as a model for other cities/regions wanting to conduct similar analyses. (Such projects do not necessarily require a major grant, but they might be very time consuming if Colorado Springs records are any indication of other communities' record keeping.)

Why had no one previously conducted an assessment of hazards in Colorado Springs? It isn't that Pikes Peak planners are not doing their jobs. Rather, it is that they are overwhelmed by the number of development proposals they must review, and that there has been little opportunity to assess comprehensively the cumulative impacts of proposed and approved developments. The planners are so busy responding to developers' requests that there is little time for or interest in stepping back from day to day decision making to devise a comprehensive land-use plan which takes hazards into account when analyzing sites for development. Many other sunbelt growth areas are probably experiencing a similar lack of planning. We do not argue that the lack of comprehensive planning is intentional. However, community leaders in a position to require more planning analysis from developers have not done so. The lack of comprehensive planning means that planners are issuing building permits based on inadequate information.

Two similar studies have been completed (Hewitt, 1971; Cooke, 1984). Both of these works point out that to date most research has examined single hazards. Hewitt called for more comprehensive ecological studies, but few planners, geographers, or students have undertaken them. He points out that a natural hazard of any sort is a function both of the physical event itself and the state of human society. This definition specifically includes the adjustments adopted to cope with the hazard as well as the state of preparedness of the population. The concept of a flood of a given magnitude or frequency causing a specific amount of damage is by itself misleading. Any volume of damage reported or expected is a function of both the natural event or physical cause and the prevailing or anticipated magnitude of the problem due to the state of the affected society (1975, p. 5).

Thus, from an ecological perspective it becomes clear that hazard and disaster potential relate as strongly to the normal activities of a community as to the particular nature of the extreme event. It follows that events for which there are no precedents in a population can create the greatest emergencies. In any given locality, a specific disaster can be so rare that it is difficult to persuade people, even on a nation-wide basis, that an accumulation of such unprecedented occurrences can represent an appreciable problem.

The mitigation of such rare but potentially devestating hazards is the ultimate goal of this study. If the report enlightens even a few prospective home buyers, planners, students, politicians, home builders, or teachers, we will have made at least a bit of difference.

The Origins of the Study

The Local Context. In the past, official policy has leaned toward *caveat emptor* (let the buyer beware) when possible hazards exist. For example, a home buyer would have to search through a variety of widely scattered documents in order to ascertain whether or not a prospective home was in an area of swelling soils or abandoned coal mines, as so many Colorado Springs houses are.

However, in 1983 a call for an assessment of the hazards of the city was included in the original Comprehensive Plan presented to City Council after a series of task forces developed the plan. The original plan called on the city to identify all natural hazards, such as steep slopes and dangerous soil conditions, and establish design guidelines for development in such areas. The plan also stated that channelization or similar modifications to watercourses should only be considered to ensure public safety or to avoid possible excessive costs of maintaining streams and drainageways in their natural state.

City Council revised the wording and intent of the above criteria in its final draft of the plan. These criteria were changed so that only a review of hazard areas is necessary with the *possibility* of requiring a land suitability study prior to the approval of development in an area of concern.

The Colorado Context. In Colorado a progressive law was passed to aid the battle against geologic hazards. House Bill 1041 provides for the identification and designation of geologic hazards and the adoption of guidelines at the county level to deal with these hazards. The bill provides local governments with needed information about the identification of the hazards themselves and the qualifications necessary for those workers determining the extent of hazard (Rogers *et al.*, 1974).

The Federal Context. Federal government agencies offer a wide range of programs to help local and regional officials deal with natural hazards. Within this paper, the federal response to the hazards facing Colorado Springs will be dealt with in the separate discussions of the various hazards.

The Myths About Natural Hazards in Colorado Springs

A helpful way to illustrate some of the problems in hazard management in Colorado Springs is to examine some of the prevailing beliefs or 'myths' held by people in the community. Most of these myths have little or no real basis when viewed in light of current hazard knowledge, local ordinances, and federal hazard policy.

"If we don't find out about dangers, there aren't any." The attitudes of some public officials in Colorado Springs are ambivalent at best. The prevailing philosophy appears to be that if an assessment of the hazards facing Colorado Springs is not available, then it follows that Colorado Springs has few natural or technological hazards to worry about.

"If we don't acknowledge hazards, we will not be liable for damages." This attitude assumes that the city is only liable for that about which it has knowledge. In light of past litigation, we doubt that this is the case for Colorado Springs or any other local government. In the national context, the issue of liablity does loom large. However, communities are finding that it is their responsibility 1) to enforce local hazard ordinances, 2) to have accurate maps of hazard areas, and, 3) to inform citizens about environmental risks.

"The government cannot tell land owners what they can and cannot do with their land." This argument is consistently raised by the city council, city planning office, and even by concerned, honest citizens. There is no basis to this argument for at least three reasons. First, landowners are constantly restricted. One cannot distill whiskey, operate a gambling casino, or place a steel fabrication plant in a residential neighborhood. Second, the assumption that someone who purchases land deserves to make a profit on that purchase is false. Land speculation is a risky business; in cases in which permits are granted for development on hazardous land, developers may make a fast profit, but after the hazard occurs, an individual or some government agency must bear the burden of recovery. Third, while many persons in Colorado Springs believe it is against the law to "take" property owners' rights by restricting land use through zoning or by refusing building permits, the courts consistently uphold a community's right to protect its citizens in spite of an individual landowner's interest. In fact, as reported by Kusler (1980), "No state supreme court has invalidated sensitive area regulations due to insufficient regulatory powers, and a successful challenge is unlikely in light of the array of general and specific enabling and home rule powers available in the states."

"It won't happen here." At the local level the odds seem rather small for a 1% or a 100-year magnitude hazard event. However, at the federal level, where all taxpayers are affected, hundreds of moderate to severe disasters occur annually, causing billions of dollars worth of damage and taking many lives. A community such such as Colorado Springs cannot afford to risk the lives and property of its citizens by relying on the blind notion that the community will not suffer significant hazard damages in the near future. Few local planners think that a disaster will happen in their town, but one will happen somewhere. The costs of preparation and wise hazard management may be perceived to be great, but they will pay for themselves many times over in reduced hazard damages when a major disaster does occur.

Uses of This Paper

The paper is divided according to hazard. It is intended to be a resource. Users should consult the references, ask questions of local officials, update the contents, refer to state and federal sources listed in the bibliography. The information is as accurate as is possible considering the scale of the maps used to analyze the hazards, the rapid annexation of additional land to the city, and the difficulty of accurately determining boundaries of hazard zones.

Mitigation of natural hazard phenomena is not an unwarranted expense; it is the most economically feasible approach to rational land-use policy. As Baker and McPhee (1975) have stated, there are several social benefits which derive from hazard mitigation. First is the substantial reduction of the risk to the population and to the economic investment in an area. Second is the reduction in public and private relief, evacuation and rehabilitation costs. Third is the reduction in expenditures on expensive protective structures. The long-term benefits of hazard mitigation pay off. This paper shows where mitigation measures are overdue and suggests practical and, in some cases, reasonable means for reducing losses.

FLOOD HAZARDS

> A fellow was building an apartment house in the flood plain. One day, while watching the construction, a geographer asked the builder whether he knew that the property where he was putting his new apartment house was in the flood plain. The builder answered, "Of course. In the 1894 flood, the water was ten feet deep right where we are standing." "Well then," asked the geographer, "aren't you worried about the long term value of your investment in the building?" "No," the builder replied. He only intended to own the building for six months, and the risk of a flood during that time was extremely small (White, 1975).

Floods pose the most severe potential hazard for Colorado Springs in terms of loss of property and loss of life. The main axis of the city runs along a usually placid stream called Monument Creek. Because of the semiarid climate in this part of Colorado, the creek normally has only a small quantity of water flowing within its banks. At times, however, intense thunderstorms or heavy and prolonged rain can cause the creek to flood severely--most recently in 1935 and 1965. During those devestating floods, millions of dollars of damage were incurred and many lives were lost.

Urbanization and Flood Plains

More than one-sixth of all urban land in the United States lies in the 1% flood plain (Goddard, 1976), and more than half this land was developed by 1974. Such development can effect changes in stream hydrology which in turn can cause severe increases in flood potential. Many researchers have documented the actual impacts that paving streets, lining drainage channels, and reducing permeable surfaces have on flood magnitude. These by-products of urbanization all shorten rainfall runoff time, resulting in earlier and higher concentrations of storm runoff in stream channels than would otherwise occur. Even small debris such as grass clippings or dumped garbage accumulating in an unmaintained channel can reduce channel capacity during high water and transform a small flood into a major one.

When a flood plain is developed, the value of the property which must be protected from floods increases. The greater the development, the better the cost/benefit ratio for a dam or other structural flood control device, and ironically, the sense that the dam protects developed property enhances future flood plain encroachment. Yet, many urban areas face severe flood hazards either because potential floods might exceed the design capability of structural flood control measures or because development is so extensive that spillways, essential for maintaining flood control, can no longer be used.

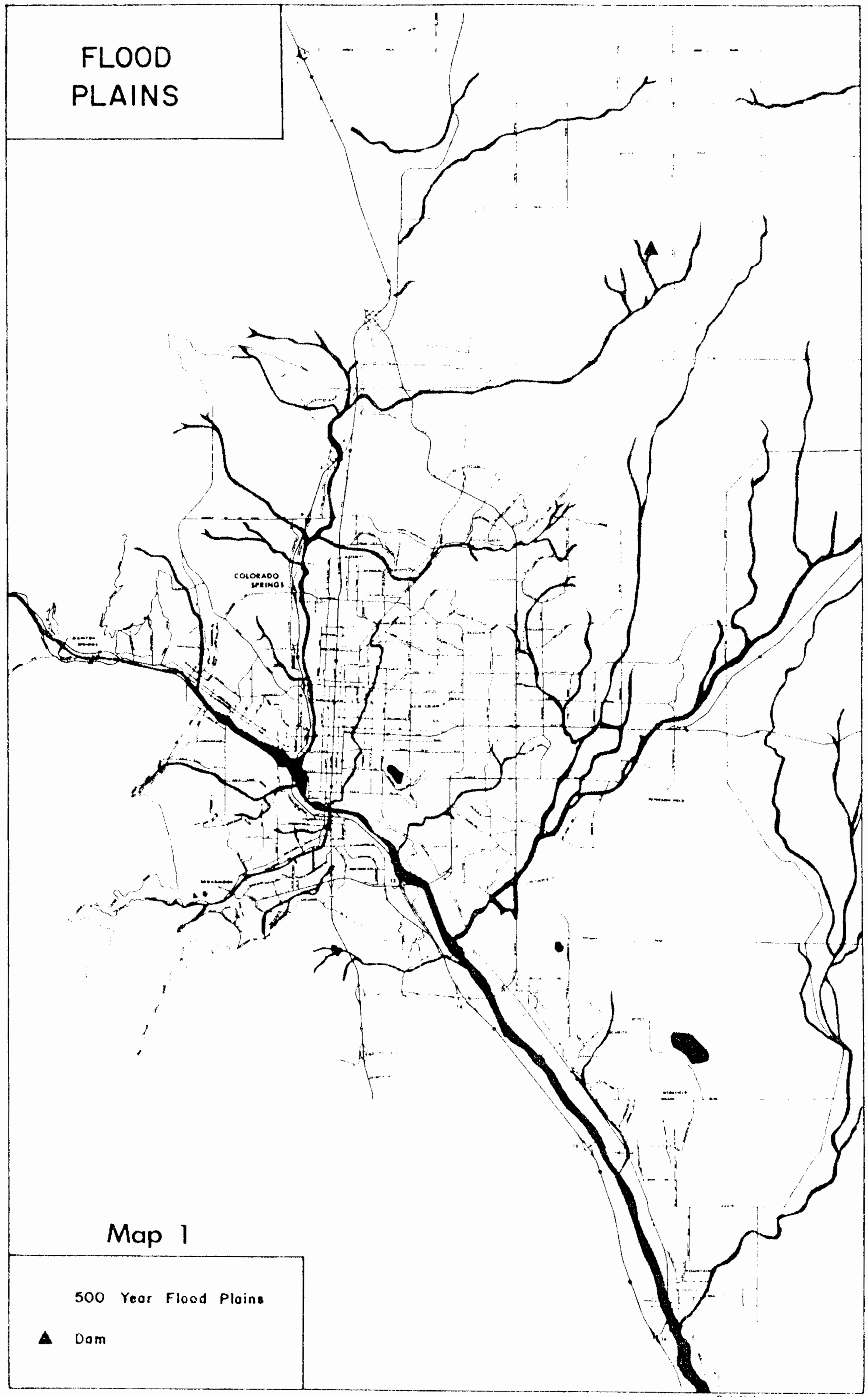
National Flood Insurance Program

The passage of the National Flood Insurance Act in 1973 enabled property owners in certain flood plain areas to purchase federally subsidized flood insurance. To avoid the possibility that the availability of flood insurance would lead to further development of flood plains, communities which participated in the program were required to pass flood plain regulations.

A flood plain ordinance was first passed in Colorado Springs in 1972. In 1985 Colorado Springs is expected to approve Flood Hazard Boundary Maps to assist in the enforcement of the flood plain ordinance and will thus enter the regular phase of the Flood Insurance Program (Map 1).

Urban Drainage and Flood Control

Regional flood plain management--i.e., basin-wide planning--is essential for successful flood mitigation. Floods and streams do not conform to political, jurisdictional boundaries, and flood plain managers must take into account the implications of upstream and downstream changes in the flood plain.


FLOOD PLAINS
COLORADO SPRINGS
Map 1
500 Year Flood Plains
Dam
C J Huber

Thus, intergovernmental management allows communities to work together toward common goals such as region-wide warning systems or structural flood control works. For example, since 1969 Denver has had an active Urban Drainage and Flood Control District that manages the metropolitan area's flood control efforts, warning systems, and beautification projects. This agency has been instrumental in ameliorating severe flooding problems throughout the Denver Metro area. Smaller communities like Colorado Springs might also benefit from the development of similar districts which would coordinate flood hazard mitigation efforts.

Public Awareness

Civic groups, including the League of Women Voters of the Pikes Peak Region, have tried to increase public awareness of the flood hazard by conducting public forums and participating in decision-making processes leading to policy and structural changes in the flood plain. The League's 1984 consensus statement reads:

> In the future, only non-structural uses such as agriculture, recreation, open space or wildlife sanctuaries should be allowed in the 100-year floodplains. Parking lots are not considered acceptable uses in the floodplain. Similar restrictions are desirable in the 500-year floodplains. Channelization and other alterations of natural floodplains should be minimized. There should be strong regulatory city and county floodplain ordinances exceeding National Flood Insurance Program minimum standards. Ordinances should be strictly enforced with a minimum of variances. Provisions should be made for informing potential buyers that property is located in a floodplain. Cooperation in floodplain management among governmental bodies is essential. Mechanisms such as the National Flood Insurance Program, building codes, land use planning and the comprehensive plan should be used in such management where appropriate (Land Use Committee, LWPPR, 1983).

Flood Events

Colorado Springs and El Paso County have experienced several historical floods of significance. Some, as would be expected, affected more than one drainage area. In particular, the flood of May, 1935 was widespread and included Sand, Fountain, and Monument Creeks. The June, 1965 flood caused damage along both the Sand Creek and Fountain Creek drainages. Most of the flood-producing storms over the Monument Creek watershed occur during the summer months of May through August. In the immediate Colorado Springs area, floods are characterized by high peak flows, moderate volumes, and short durations.

Although the most recent flood in Colorado Springs occurred in 1965, the Big Thompson flood of 1976 was frightening to Colorado Springs residents even though it occurred about 130 miles northwest of the city. An unusual combination of conditions led to a flash flood which killed more that 140 people and caused more than $25 million in damages. A similar meteorlogical event is always a possibility in the Colorado Springs area and could be far more devastating than the Big Thompson flood since many more people and much more property are at risk in the Colorado Springs area.

Moreover, the potential for flood damage is on the increase. The rapidly increasing population is encroaching on many of the smaller intermittent feeder streams to Monument Creek as well as on Monument Creek itself. Fountain Creek, which flows through Ute Pass and Manitou Springs, also poses a very serious problem and has been called one of the two worst potential flood disasters in the state by FEMA officials (October, 1983, personal communication).

Sand Creek. Recorded flooding of Sand Creek spans a period of 55 years. In August, 1915, flooding resulted in considerable property damage and the loss of three lives. There was extensive damage during the May 30, 1935 flood as well. A new bridge was badly damaged, Galley Road (north of Highway 40) was nearly washed out, and another bridge was completely carried away. On

June 18, 1965, Sand Creek overflowed its banks one-half mile south of Fountain Boulevard. One bridge was washed out and another swept away. Drennan Road and the Bradley Road cutoff were also washed out, and agricultural land and stockwater dams were badly damaged. Extensive damage was again caused by the July 25, 1970 flood, during which 1.24 inches of rain fell in a two hour span. Resultant damages totalled approximately $50,000. Roads and bridges were badly damaged in the Kelker Road area, and the Aque land bridge was washed out. Powers Boulevard was also washed out, and Fountain Boulevard sustained shoulder damage. One life was lost (Soil Conservation Service, 1973).

Since 1962, gradual progress has been made in flood mitigation along Sand Creek. At that time, subdivisions were planned with specific allowance for greenbelts along the creek. In 1971, proposals were submitted for installation of storm sewers, extension of the length of bridge structures, and widening of the green belt, rip-rap, and concrete lining. In March of 1972, low-level aerial photography was used to gather additional flood hazard information. This data helped in the computation of water surface profiles and flood hazard area outlines (at a scale of 1:200 with four-foot contour intervals). An additional study of the Sand Creek area undertaken at the time analyzed hydrologic conditions. Both analyses used runoff computations based on existing land use as well as computations reflecting projected developments in 1990. Ten- to fifty-year floods were plotted as a result of this study. A further study conducted in 1973 showed that 82% of land in the area was open space, but projections for 1990 anticipated that 78% of the land would be residential with 56% of that in 5-acre tracts.

<u>Fountain Creek</u>. The first recorded major flooding on Fountain Creek occurred June 10, 1864, with a discharge estimated at 40,000 cubic feet per

second. Another flood occurred on July 25, 1885, beginning with a cloud burst north of Colorado College and initial flooding in Monument Creek and Shooks Run. Flooding on June 3, 1921 seriously flooded the country surrounding Fountain while the town itself was spared. Severe damage occurred below the mouth of Spring Creek. On May 30, 1935, flooding again occurred, severely damaging the area along Monument Creek. All bridges were destroyed, and flood waters spread out and covered a mile wide area, leaving the town of Fountain without water. During the severe flood on June 17, 1965, water crested at eight feet on Sand Creek, putting a roller coaster bend in the bridge at the Sand-Fountain Creek confluence. Another wall of water completely washed out the bridge and filled Santa Fe Drive with turbulent muddy water, drowning several persons caught in their cars at the Harrison interchange. At the peak of the flood, the waters were 10 to 12 feet deep and a mile wide. (Corps of Engineers, 1984).

Flood hazard mitigation efforts for Fountain Creek have included placing a recording gauge just below the mouth of Little Fountain Creek in March of 1940 and monitoring it until 1952. In 1964, the recording gauge was located at Carson Boulevard bridge and Fountain Creek. In 1967, the Colorado Springs/El Paso County evacuation/operations plan was implemented along with a warning system to be used in case of heavy rainfall.

Monument Creek. Monument Creek also has a long history of flooding, including the June 10, 1864 flood which caused the loss of thirteen lives (discussed in the section on Fountain Creek). The flood of July 25, 1885 destroyed the Huerfano Street wagon bridge and Colorado bridge when flood water overflowed the tracks of the Denver and Rio Grande railroad. Some squatters' tents and cabins were also badly damaged. On August 2, 1886, intense rainfall in the Monument Creek and Templeton Gap drainage areas resulted in an estimated peak discharge of 40,000 cubic feet per second in Monument Creek. The area-wide flood of May 30, 1935 damaged property along Monument Creek severely. Excessive rainfall during a short period of time over an area of less than 100 square miles in the Monument Creek basin resulted in approximately $1,769,000 in damages that included destruction of all bridges with the exception of the Bijou Street viaduct. Eighteen lives were lost and many people were injured.

Following the 1935 flood, the city sponsored flood control work that included the construction of 2.6 miles of improved channel and guide levees on Monument Creek at the Templeton Gap outlet. The original design, planned in 1939, allowed for a peak flow of 50,000 cubic feet per second; however, this maximum has subsequently been reduced due to changes in the stream hydrology.

Small Drainages. In 1949, a concrete lining costing $1,172,000 was constructed at Templeton Gap. It is two miles long and was designed to handle a discharge of 14,000 cubic feet per second. In addition, a trapezoidal channel 10,590 feet long was built extending from Templeton Gap southwest to Monument Creek also with a capacity of 14,000 cubic feet per second.

At Peterson Field, stream water detention ponds were constructed at the air base to reduce peak flows from the upper 3.5 square miles of the drainageway. Other channelization has occurred in the area including the construction of concrete lined drainageways along sections of Bear Creek, Camp Creek, Douglas Creek North and South, Peterson Field drainage, Rockrimmon drainage, Sand Creek, South Shooks Run, and Spring Creek.

Dam Break Hazard

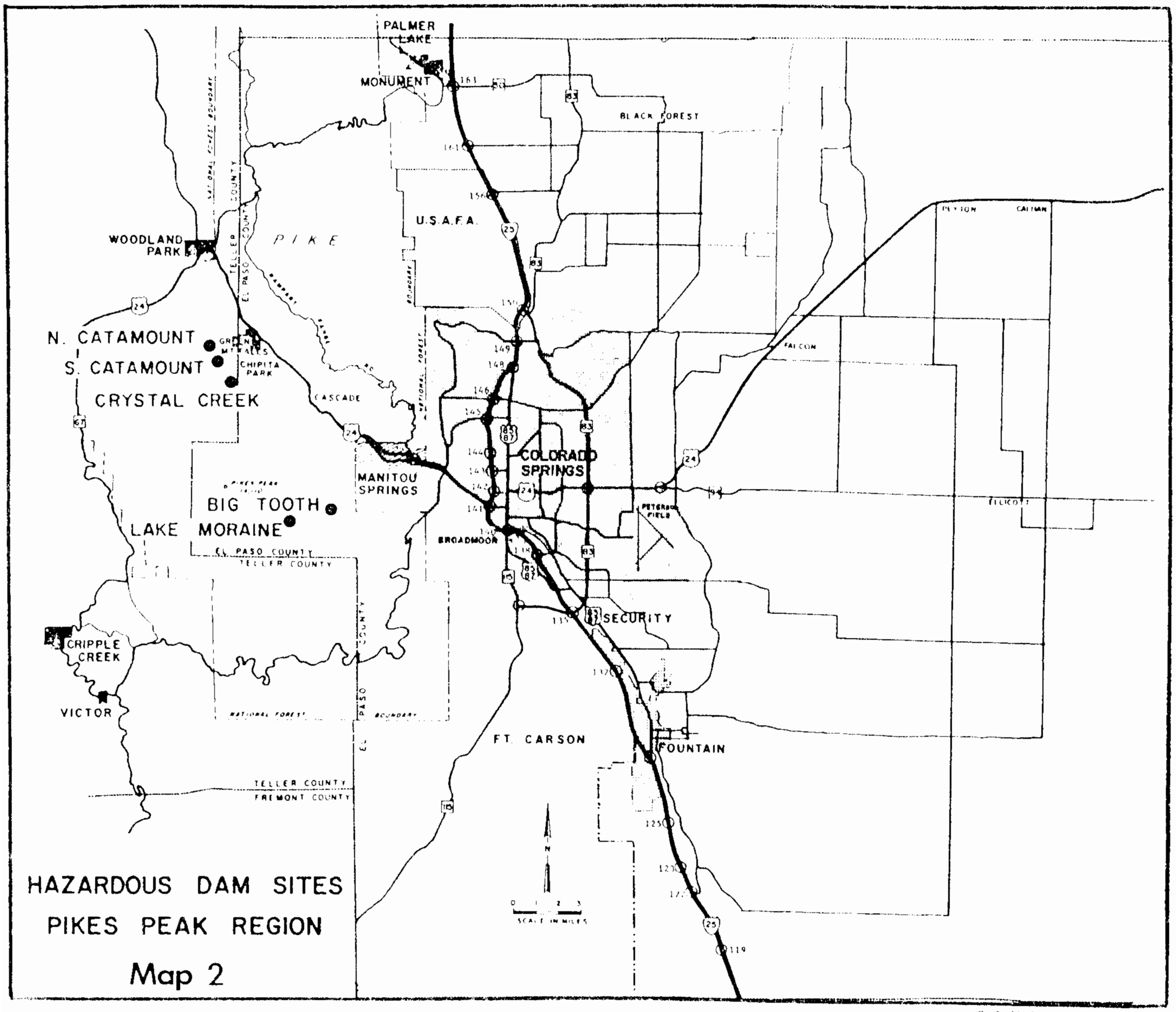
There are approximately 26 high and moderate hazard dams in El Paso County, and roughly 65% were built prior to the 1930s. The majority are earthen dams constructed entirely from mud, clay, and sand. These dams were built to supply water to Colorado Springs, not to control floods. Because the rains which cause most of the severe flooding in the region usually occur at a lower elevation than the dams, no protection should be expected from them.

Moreover, these dams age, becoming weak and cracked, and they are seldom repaired; dams in the state of Colorado are not officially inspected at any regular intervals. After the Big Thompson flood in 1976, the Colorado State Engineer's office began a state-wide inspection of all dams. However, this work has not been completed, and there are several dams in El Paso County that have not been inspected for more than twenty years.

High Risk Potential Dam Failure. Five dams (the South Catamount, North Catamount, Big Tooth, Lake Moraine, and Crystal Creek) pose a particularly severe hazard in El Paso County (Map 2). If these dams should completely fail, the maximum warning time for effected areas downstream would be 20 minutes; the minimum, only 2-3 minutes for people living below the Crystal Creek dam. These dams have been classified as high risk by the State Water Conservation Board because of the large populations and extensive property at risk below them.

Population at Risk. South Catamount dam is located 2 1/2 miles southwest of Green Mountain Falls, and it is anticipated that the peak discharge if it failed would be a minimum of 13,241 cubic feet per second. Fountain Creek would rise an estimated 10 to 15 feet above flood stage. Worse, should the South Catamount dam fail, the warning time to the public would be at best ten minutes.

Big Tooth and the Lake Moraine dams, located within five miles of the populated areas of Englemann Canyon, are approximately 1 1/2 miles apart, and both drain into Ruxton Creek. The peak discharge upon complete failure of



HAZARDOUS DAM SITES
PIKES PEAK REGION
Map 2

C.J. Huber

either dam would be approximately 7,000 cubic feet per second. The Colorado Water Resources Department has added an additional warning for both dams. They "expect significant overbank flooding with overbank velocities in excess of eight to ten feet per second. Extensive property damage and potential loss of life expected."

Crystal Creek dam is located .9 miles south and slightly west of Green Mountain Falls. It drains into Crystal Creek. The town of Green Mountain Falls is directly in the path of any flood waters if this dam fails. The warning time to the town in the case of complete dam failure is only two to three minutes. The peak discharge would be approximately 22,000 cubic feet per second.

These five dams are owned by the City of Colorado Springs and are visually inspected daily by caretakers who live nearby.

Mitigation. El Paso County has a warning system in case of heavy rainfall, snowmelt, or dam weaknesses. The plan, thus far untested, specifies steps to be taken in case of failure of any one of the dams. Each plan outlines who is responsible for notifying the media, law enforcement agencies, and the general public but contains no plan for evacuation. If a dam should fail and the general public needs to be evacuated, confusion is likely to result.

Although dam failure so far has not been a major concern for the people of El Paso County, the dams are old, they remain uninspected, and they are being used for purposes for which they were not designed (McWilliams, 1984). As the population in the affected areas continues to grow, the potential for loss of life and property becomes even greater.

GEOLOGIC HAZARDS

This chapter deals with the three most important and common geologic hazards in the Colorado Springs area: landslides, subsidence, and expansive soils (Maps 3 and 4).

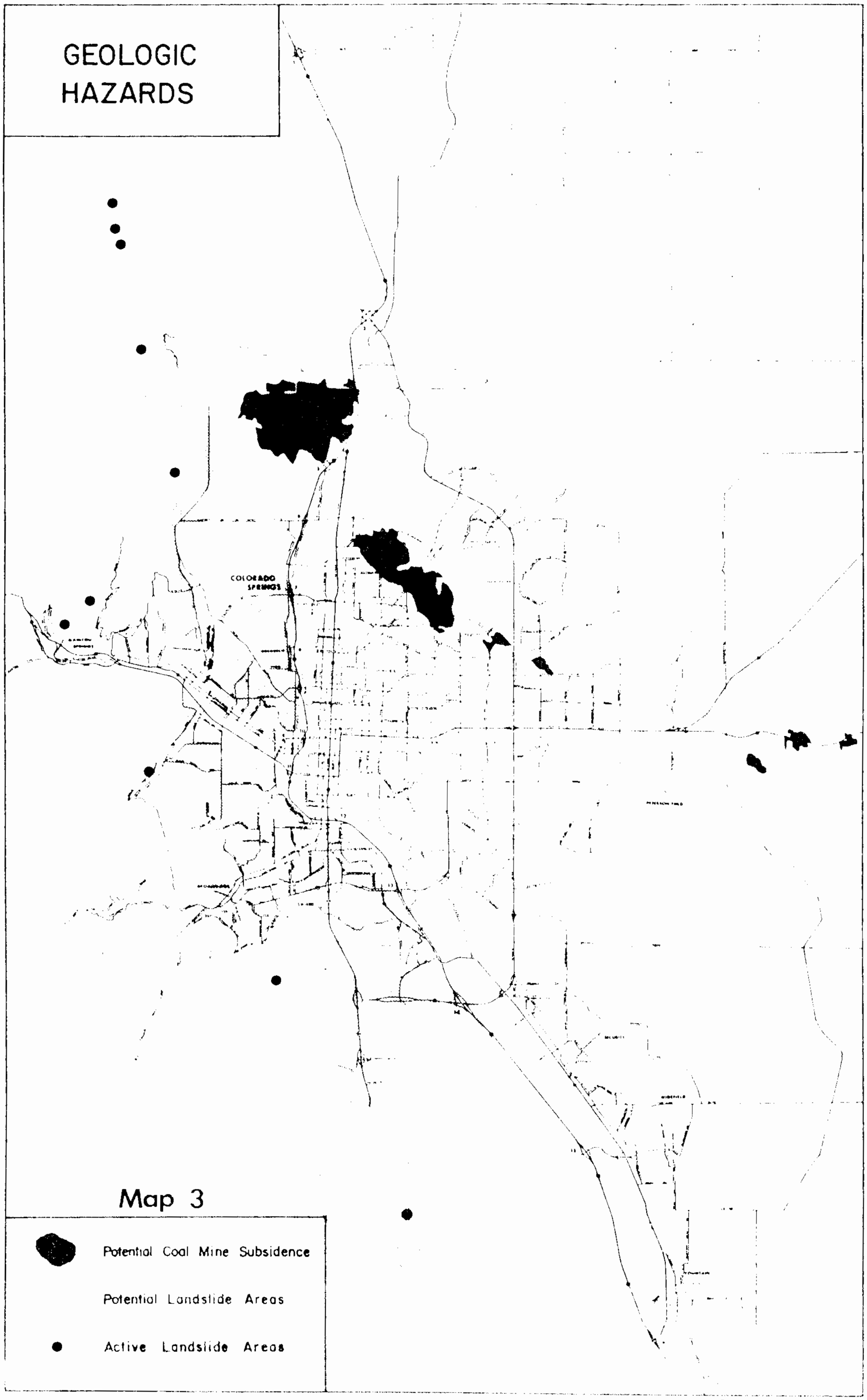
Landslide

Landslide is a commonly used term describing a particular type of mass wasting (the process by which large masses of earth or rock are moved downslope by gravity). Within the Colorado Springs area the specific types of mass wasting include rockfalls, rock slides, soil creep, earth slump, and debris flow.

Mass wasting occurs in response to gravity exerting a downward pull on rock and soil. Resistance to the pull is most often overcome when water is introduced into the soil and rock, reducing friction and causing a loss of cohesiveness. The water also contributes to the collapse by adding to the weight of the material. Heavy rainfall, snowmelt, or the introduction of water by artificial means can all lead to increased landslide activity.

In addition, earthquakes and human activities may also cause landslides. Earthquakes can trigger instantaneous slope failure by increasing shear stress and reducing shear resistance. Human activity can directly lead to slope failure when hillside excavation, such as roadcuts, oversteepen and unbalance a slope.

Although virtually all geologic formations in the Colorado Springs area are subject to slope failure if the right conditions are present, most activity occurs along the foothills in steep terrain underlain by shale and mudstone of the Dakota Group, Benton and Pierre Shales, Laramie Formation, and


GEOLOGIC
HAZARDS
COLORADO
SPRINGS
Map 3
Potential Coal Mine Subsidence
Potential Landslide Areas
Active Landslide Areas
C. J. Huber

Dawson arkose. Mass wasting in the Colorado Springs area is largely limited to clearly defined areas where problems have a high degree of predictability. Defining these areas can be accomplished by examining present conditions and understanding past landslide events in a particular region (Map 3).

As continued development and population growth occur in Colorado Springs, more persons and property will be subjected to the effects of mass wasting. Developments such as Cedar Heights and High Point Centre in the foothills area are likely to suffer from landslides, rockfalls, and soil creep due to the steepness of the slopes in those areas.

Rockfall. Rockfall is perhaps the most evident mass wasting event in the Colorado Springs area. Most of these landslide occurrences are recognized by landslide deposits; less than 1% of them are observed as they actually occur. Rockfalls have occurred near the Sunbird/Popes Bluff area, along Douglas Creek, and in the west side of the city. Additional rockfall deposits have been found at the following locations:

1) Cheyenne Mountain. These deposits--the most extensive in the area--are from an event 500,000 years ago that may have been triggered by an earthquake. Deposits extend from the base of the mountain across Highway 115 into Fort Carson.

2) Along Highway 115 and within Fort Carson. These deposits are found along the steep slopes on the west side of the highway and on the side of "Agony Hill" southwest of Butts Army Air Field.

3) North of Glen Eyrie near Castle Concrete Quarry.

4) Southwest of Mt. St. Francis.

5) West of the Air Force Academy. Four deposit areas occur along the face of the Front Range.

6) Bear Creek.

7) Ute Pass near French Creek.

Rock Slide. This type of mass wasting occurs when a mass of rock breaks free as a block along a bedding plane and slides downward. The area where this type of failure is most prevalent is along Highway 24 in Ute Pass. The construction of the highway itself has effected the area by oversteepening the toe of the slopes and causing several slides.

Soil Creep. Soil creep is characterized by a slow movement of unconsolidated materials in a downslope direction. The rate of soil creep is dependent on the slope and the amount of water present. Soil creep is most often noticeable when tree growth is altered by the moving soil, causing a characteristic "pistol butt" appearance. Such trees are present along some sections of Cheyenne Mountain and in the Black Forest area.

Slumping. This type of mass wasting has occurred in the Garden of the Gods along 31st Street and in the Mesa section south of Fillmore and North of Uintah. Slumping usually occurs when a slope is oversteepened either through natural processes such as stream erosion or through human activities such as excavation or road construction.

Debris Flow. These events commonly start as rockfalls or rockslides in steep canyon areas, especially when unconsolidated material is loosened during heavy rainfall. Debris flows behave as heavy fluids and have an astonishing capability to transport large boulders, trees, and other heavy objects. Some of the steep canyons south and west of the Broadmoor have experienced debris flows in the past.

Hazard Mitigation

Mitigation of landslide hazards can be divided into five categories:

1) Change of slope shape. An oversteepened slope is the main cause of slope failure, so grading the slope to alter its shape and angle can reduce the failure hazard.

2) Water drainage control. Water saturation is directly related to slope failure since moisture reduces resistance and cohesion and increases stress by adding weight. Drainage tiles and channels can lower the risk of failure.

3) Control and retaining structures. Such mitigation includes the use of retaining walls, anchors, buttresses, and piles.

4) Special treatment. This technique might include planting vegetation to control erosion, covering the slope in cement, or removing the slope.

5) Avoidance of landslide areas. Avoidance of the hazard may be the best mitigation practice if at all possible. This is especially true in areas of rockfall and debris flow hazards.

Hillside Overlay Zone

In 1983 the City of Colorado Springs adopted a hillside zoning ordinance covering the portion of the city most seriously affected by steep slopes. Those areas lying within the overlay zone which are to be developed must meet certain additional criteria over and above the normal standards for grading and construction. The ordinance is intended not only to mitigate landslides, but also to ameliorate other environmental concerns such as expansive soils and erosion. Specifically, these objectives are (City of Colorado Springs, 1983):

1) To conserve the unique features of hillside areas.

2) To provide safe and convenient access to hillside areas.

3) To minimize water runoff and soil erosion problems caused by development.

4) To assure proper development types compatible with the hillside areas.

5) To assure limited taxpayer liability attributable solely to development on hillside areas.

The ordinance itself requires a land suitability analysis, a developement plan, a master facilities plan, a grading plan (with erosion control and reclamation provisions), and maintenance guarantees for all developments in the designated areas.

There are three general approaches to hillside development control: the density approach, the soil overlay approach, and the guiding principles approach. This last is the one actually used by the City of Colorado Springs.

The guiding principles approach is the most flexible of the three and allows great latitude for enforcement. However, this is both a strength and a weakness. If the flexibility is used to design specific criteria to suit individual situations, the guiding principles approach is a sound way to direct hillside development. If, on the other hand, this flexibility leads to watered down criteria and multiple zoning regulation variances, this approach can become little more than another emaciated zoning ordinance. Care must be taken to ensure strong enforcement of the ordinance and proper punitive measures if the ordinance is violated.

Subsidence

The Front Range has a long history of coal mining dating back to 1859 with an estimated 900 mines having been opened and developed since then. Of those, more than 50 mines, all presently inactive, were opened in the Colorado Springs area (Amvedo and Ivey, 1982).

The Local Hazards. Within Colorado, the Colorado Springs area probably has the highest potential for subsidence and related damage because the region includes several fully developed areas located over very shallow mines. Approximately 2400 acres of the city (Lucas, 1983) are undermined by inactive coal workings.

There are two major areas of Colorado Springs known to be above inactive coal mines--Rockrimmon and Cragmor-Country Club (Map 3). The Rockrimmon area is characterized by relatively deep mining 250'-500' below the surface while the Cragmor-Country Club area contains much shallower mines with some only 30' below the surface. There were 22 mine subsidences classified as emergencies in Colorado Springs between 1979 and 1983 (Cantwell, 1983) with most of them occurring in the Cragmor-Country Club area; all together they have cost the

Office of Surface Mining $767,000 (Cantwell, 1983). Several more subsidences have occurred since that time. The potential for future subsidence events and resulting damage continues to be high as development continues over both undermined areas. Cragmor-Country Club, for example, has approximately 3,000 people living over undermined areas, and projected development will only increase the population at risk.

To understand the problem of abandoned mine subsidence, it is necessary to understand the mining processes utilized to extract coal in the Colorado Springs area. The seams of coal present in the Colorado Springs field ranged in thickness from 1' to 14', and the mining technique utilized in all mines was the room and pillar method. The "pillars" are unmined coal left in place to act as a support for the roof during the mining process. The "rooms" are the voids left when coal is mined out between pillars (Myers, 1983). Entry to most mines in the Colorado Springs area was through inclined openings driven down the dip of the coal beds (Amvedo and Ivey, 1982). A few mines were entered through vertical shafts with the Klondike mine shaft being the deepest--extending 500' below the surface (Amvedo and Ivey, 1982).

Variables affecting subsidence potential include thickness of the mine void, extraction ratio (how much coal was removed), overburden thickness, and mining method. The Cragmor-Country Club area, because of its shallow overburden thickness, is especially susceptible to the development of sinkholes; many have appeared in the Country Club area (Cantwell, 1983). The greater overburden thickness in the Rockrimmon area will probably result in the development of subsidence troughs as opposed to sinkholes.

Another variable affecting subsidence is water. In the Colorado Springs area, groundwater can have a beneficial effect by acting as a support and providing buoyancy. The amount of support is determined by the permeability of the roof rock. If this water is removed, the loss of support can lead to mine roof instability and collapse (Myers, 1983).

<u>Hazard Mitigation</u>. Those areas eroded by coal mines need not be abandoned or rejected for development. There are at least five solutions and alternatives available to deal with the subsidence problem:

1) Acceptance of the risk. This is, in effect, the option currently being followed in Colorado Springs. A problem, of course, is that not all the participants involved are aware of the risk being taken.

2) Land use planning. Uses in those areas not yet developed could be limited to open space, land fills, or farming (Shelton and Prouty, 1976). This solution is of limited use in Colorado Springs because approximately 86% of the area above abandoned coal mines is either already developed or currently undergoing development (Myers, 1983).

3) Insurance. There are three subsidence insurance programs in effect in the United States--in Pennsylvania, West Virginia, and Illinois. Colorado is currently examining the possibility of implementing a similar program. A national effort, similar to the National Flood Insurance Program, could also mitigate the hazard.

4) Subsidence resistant construction. Structures can be constructed to be either extremely flexible or completely rigid to withstand the stresses caused by subsidence. Flexible systems allow a structure to conform to the new shape of a collapsed surface without showing the effects of the movement. Similarly, utility lines can be constructed using flexible line and telescoping material to avoid breakage during subsidence events (Myers, 1983). Rigid construction involves making foundations as rigid as possible to insure that buildings remain intact during subsidence. Through the use of jacks, buildings can then be restored to their previous level position.

5) Subsurface treatment. Subsurface treatment consists of filling the mined areas, eliminating the mine voids, and/or creating support. In Colorado Springs, the Office of Surface Mining has responded to emergency situations by filling voids. However, this solution has problems that limit its application, including:
   a) the need for accurate maps so backfilling holes will intersect voids,
   b) the need for large supplies of water and filling material, and
   c) the high cost of filling voids which requires a large number of holes to fill a relatively small area (Amvedo and Ivey, 1982).

Other methods of treating the subsurface involve eliminating the void through blasting or dynamic compaction. In the developed areas of Colorado Springs undermined by mines, this process would be extremely dangerous because the results are not predictable.

Mined Land Reclamation Division Recommendations. The Colorado Mined Land Reclamation Division supervised a study by Dames and Moore Engineers (Dames and Moore, 1985) which extensively analyzed the subsidence problem in Colorado Springs. They drilled 118 rotary holes and five full-length core holes to help determine the exact extent of the subsidence hazard in the city. The study found only six actual or possible cases of mine subsidence in the Rockrimmon area which is above the deep mines in the region; it found one incident of subsidence in Palmer Park, and it found over 2,400 sinkholes and cracks in the Cragmor and Country Club Estates area. Obviously, the highest hazard areas are over the shallow mines of Cragmor-Country Club Estates. One other high hazard area was found on the northeast border of the Digital Equipment Company's plant in Rockrimmon.

Dames and Moore recommends that vacant land over high hazard mine areas not be developed. Currently, the city does not regulate the development of such land. Therefore, either new regulations or intensive public education will be needed to preclude extensive development of these properties. If development is to occur, the areas should not be built on unless:

1) Detailed studies of the property show that more favorable conditions exist at that exact location than are outlined in the Dames and Moore study,

2) Significant measures are taken to ameliorate the hazard such as backfilling, adding slurry, and plugging mines, or

3) The structures are designed to withstand extensive subsidence.

Because the locations and severity of future subsidence cannot be exactly determined, the study recommends against a widespread program of trying to lessen the subsidence hazard to all existing structures in the hazard areas. What is recommended is a comprehensive insurance program designed to help those landowners affected by actual subsidence events.

Two other general recommendations are not to remove groundwater from mines since groundwater helps to support the overburden weight above mines, and to maintain complete and precise subsidence event records. These records could help determine subsidence rates and predict future characteristics.

Other Related Hazards. In addition to subsidence there are three other hazards associated with inactive mines--drainage hazards, mine/waste bank fires, and mine openings.

Mine drainage hazards can produce both physical and chemical risks. Physical hazards occur when the water volume exiting an inactive mine is large enough to cause significant erosion. Chemical hazards occur when the mine water is acidic or contaminated with metals or other pollutants. Currently, there are no known problems produced by water draining from coal mines in the Colorado Springs area. However, the effect on ground water quality has not been investigated and may prove to be a problem in the future.

Mine fire hazards are of two types: those in the mine itself or those in waste banks outside the mine. These fires can be started by any of several different agents including camp fires, natural events (lightning, forest fires, grass fires), and spontaneous combustion. Once started, they can be extremely difficult to control or put out. A fire has been burning south of Florence, Colorado since July, 1982, and some officials are worried that it may burn almost to Canon City before extinguishing itself. The U.S. Office of Surface Mines has already spent $300,000 attempting to control the blaze (Denver Post, 1983). Although no mine fires have occurred in the Colorado Springs area, the potential for ignition is always present.

Mine opening hazards are usually associated with inadequate warnings, fencing, or plugging. Openings easily accessible to large numbers of people (such as those in the Colorado Springs field) should be filled or plugged completely to prevent access. Openings farther away from development can be protected more simply with warning signs, fences, or locked gates. In the Colorado Springs area there are two mine opening hazards: one near the Wilson Ranch and one at the northern edge of the Cragmor-Country Club area (Amvedo and Ivey, 1982). A problem associated with mine openings occurred on April 13, 1979, when the airshaft of the Klondike mine (I-25 and Woodman Valley Road) reopened to a depth of 500 feet following surface subsidence. The shaft had been previously capped, but the surface plug deteriorated, leading to the reopening.

Expansive Soils

In the United States, expansive soil movement causes over two billion dollars in damage annually. This exceeds the combined average annual damage due to floods, earthquakes, hurricanes, and tornadoes. Colorado is classified as one of three states in the U.S. which has severe expansive soil problems.

The effects of swelling soils on structures were first recognized in the 1930s as brick increasingly replaced wood as a building material, resulting in more rigid structures. In 1938 the potential problem of building on swelling soils was officially recognized by the U.S. Bureau of Reclamation, and in 1959 a national conference was held at the Colorado School of Mines to discuss the problems of building on expansive soils--the first such meeting.

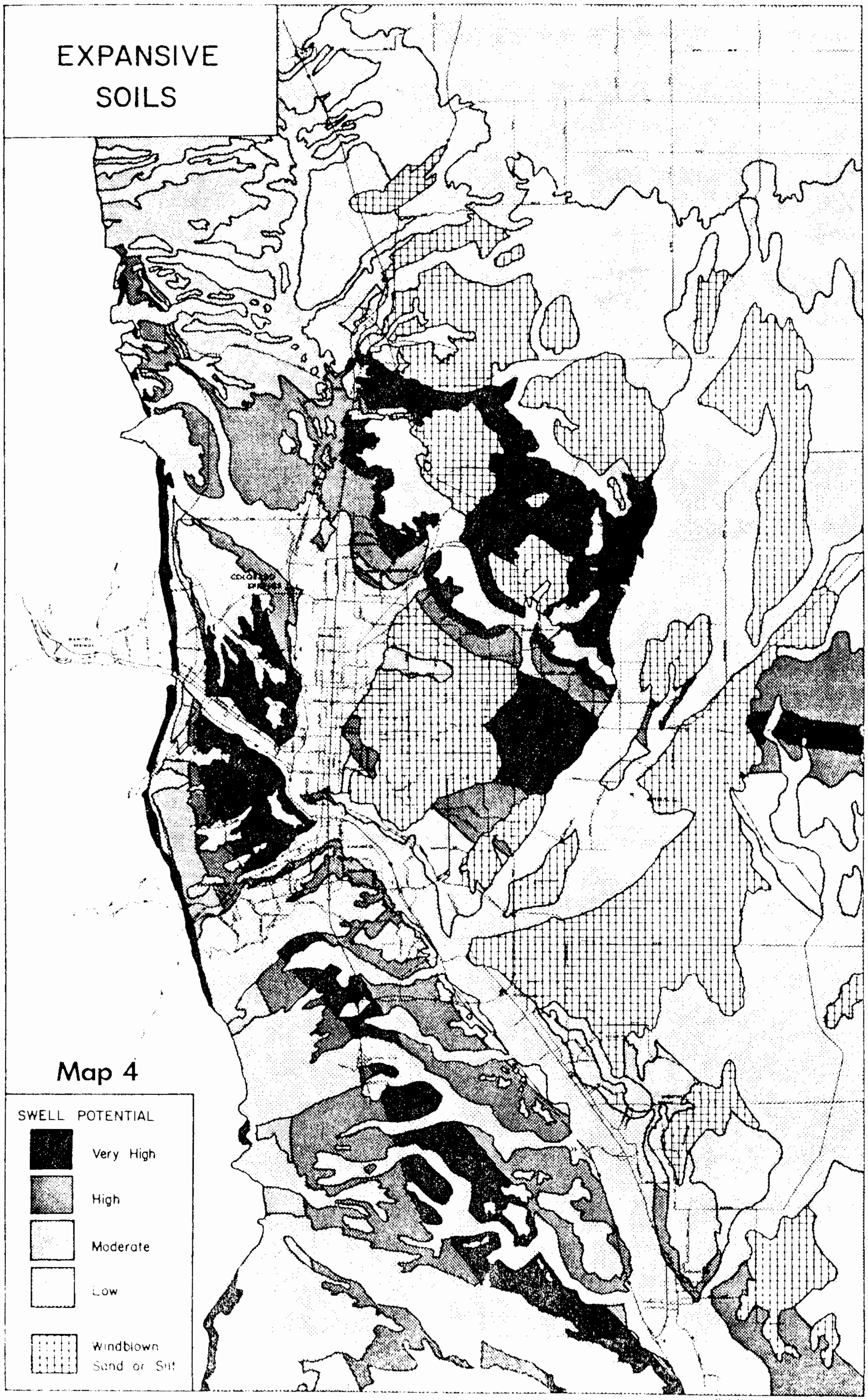
Expansive soils are ones that shrink and swell depending upon the water content of the soil. Such materials contain smectite minerals--clays which can absorb large amounts of water because of their lattice structures. There are two primary parent materials from which swelling soils may be derived: basic igneous rocks such as basalts and gabbros in which feldspars and pyroxenes decompose to form smectites, and sedimentary rocks which contain smectites.

The latter is the source of expansive soils in the Colorado Springs area which are derived primarily from Pierre shale and to a lesser extent from the Laramie formation.

Expansive Soils in Colorado Springs. A significant portion of the Colorado Springs area is underlain by potentially expansive soils (Map 4). Their presence is especially apparent in the western part of the city which contains large portions of the Chaseville-Midway soil complex. This soil lies at elevations ranging from 6100 to 7000 feet in slopes with angles of 5 to 50%. The Chaseville soil forms about 70% of the complex and is found on the steeper slopes and on ridge tops. The Midway soil makes up about 20% of the complex and contains most of the expansive material. Permeability ranges from rapid in the Chaseville to moderate/low in the Midway. This low permeability in the Midway soil exacerbates the expansion problem.

The City of Colorado Springs deals with the problem through building code restrictions. Construction within the city is governed by the Unified Building Code which is modified by the Pikes Peak Regional Building Code. Foundation restrictions are based on soil type, and soil samples can be required before approval of plans by the Regional Building Department, especially if expansive soils are suspected in the area.

Hazard Mitigation. The first step toward mitigating the problem of expansive soils is to identify the problem accurately. This can be done through soil testing and analysis by a certified engineer. If the soil is found to be expansive, there are several ways to ameliorate the problem. In fact, design techniques for managing smectite are sufficiently advanced that expanisve soils do not need to be considered a severe problem unless the mitigation techniques are ignored or not properly used. Millions of dollars are spent in Colorado every year to correct and repair damage resulting from


EXPANSIVE
SOILS
Map 4
SWELL POTENTIAL
Very High
High
Moderate
Low
Windblown
Sand or Silt

C J Huber

expansive soils which were not handled properly. Some of the methods which permit construction in smectite areas include:

1) Proper foundation design. Foundations must be used which are designed to concentrate the weight of buildings below the zone of moisture change. In addition, floating slabs can be used to allow floors to move independently of foundations.

2) Proper drainage design. Lots must be designed to have at least a six inch vertical fall within ten feet of buildings. Downspouts and splash blocks should be placed so that roof runoff will be carried at least four feet from buildings. In areas of heavy lawn watering, peripheral drains may be necessary to remove water from around foundations.

3) Proper landscape design. Backfill around new foundations must be compacted properly. Plantings and sprinkler systems should be at least four feet from foundations. As noted above, the most critical aspect of landscaping is to provide proper drainage.

4) Proper interior design. All paneling, drywall, and interior partitions added to basements and garages must maintain the freedom of vertical movement created by floating slabs.

Since the knowledge and technology does exist to lesson or eliminate the damage caused by expansive soils, their existence need not be a serious constraint on urban development. Proper design methods must be used, however, if serious and expensive damage is to be avoided.

METEOROLOGICAL HAZARDS

Severe weather is an ever-present hazard during all seasons in the Colorado Springs area. For the most part, moderate weather patterns prevail, but the Pikes Peak region can experience harsh extremes. Straddling the margin between the Great Plains and the Front Range of the Rocky Mountains, Colorado Springs is subject to the hazards of both zones, including thunderstorms, tornadoes, high winds, blizzards and other heavy snow storms.

Local Climate Hazards

Colorado Springs receives an average of 15.5 inches of precipitation annually, 80% of which comes between April 1 and September 30, mostly from heavy rains during thunderstorms. These heavy rains are usually localized and of short duration, enhancing the possibility of flash flooding (see Chapter 2); the incidence of thunderstorm days in the area is a high 60 days per year.

An additional major hazard from these summer thunderstorms is hail, which poses a very serious threat to property and crops. A single moderate hailstorm can cause millions of dollars of damage to property in the city.

Potentially, the most violent and destructive element of any severe thunderstorm is a tornado, and the Colorado Springs area can expect, on the average, three tornadoes per year. There have been 450 reported tornadoes in Colorado over the last 30 years with 2 resulting in deaths. Most of these occur during June, the peak month for tornado activity in Colorado, in the Great Plains (eastern) part of the state.

A fourth potential hazard associated with thunderstorms is lightning. Lightning kills more people in the United States than floods, hurricanes, or tornadoes, and because of the high number of thunderstorms in the Colorado

Springs area, residents and visitors run an above average risk of injury or death from lightning. The high rate of tourism and outdoor activity in the Pikes Peak region also increases the risk. In addition, lightning is one of the major causes of forest fires in the Rocky Mountain region.

Localized high winds may also accompany thunderstorms. These winds are affected by the topography of the Pike's Peak area which makes them difficult to predict and avoid. The most devastating winds, however, are usually associated with Chinook conditions during the late winter and spring. Chinook winds often reach 100 miles per hour with gusts even higher. The foothills area along the mountain front is the most affected zone in the city.

Winter storms are another major meteorological hazard. Snow can be expected from September through June, with the greatest quantities falling during the spring. At that time, frontal systems can develop and intensify east of the mountains with moisture from the Gulf of Mexico adding to the potential snowfall during upslope (easterly) wind conditions. El Paso County often experiences heavy snowfall. The largest snowfall in 24 hours was 18.0 inches, and the most snow in a month was 42.7 inches--both in 1957. Strong winds may accompany heavy snow creating severe drifting and complicating traffic and clean up operations long after the snow itself has stopped falling.

The Alert System

The National Weather Service (NWS) is the primary source of watches and warnings for hazardous weather in the Pike's Peak area. Its office is located at the Colorado Springs Municipal Airport (Peterson Field) where it receives and evaluates information from weather observation facilities at the airport itself, from the radar station at Limon, from private observers, and from other public sources (e.g., law enforcement officers). The National Oceanic and Atmospheric Administration also helps to disseminate weather information by providing weather radio broadcasts and telephone recordings to the general public.

When issuing an alert, the NWS reports to the Civil Defense system in the city. The Civil Defense system issues watches and warnings to local officials and to the media which in turn relay the information to the public. The Civil Defense system also decides if other warning measures, such as sounding warning sirens, are necesary.

Hazard Mitigation

The NWS follows a systematic protocol concerning possible meteorological hazards and takes the following actions when a specific hazard is imminent:

1) Tornado and severe thunderstorm.

a) Issue a warning if:
- a tornado or a funnel cloud is sighted.
- a thunderstorm is observed by a law enforcement officer, a trained spotter, or the public (requires verification by radar).
- a Limon (Colorado) radar operator detects a tornado or severe storm.

b) Coordinate warnings with officials in the surrounding area.

c) Use the proper warning format to accelerate the distribution of the warning.

d) Call for additional help to guarantee proper coverage and confirmation of the storm.

e) Log all events and actions taking place during the storm.

2) High Wind Warning.

a) Issue a warning if:
- a sustained wind speed of 50 miles per hour persists for a half hour or more.
- a sustained or gusting wind reaches or exceeds 60 miles per hour.

b) Issue warnings to proper authorities and the public.

c) Issue aviation wind warnings when gusts are expected to exceed 35 knots.

d) Issue updated reports of peak gusts, wind speeds, damage, and time when warning is expected to expire.

3) Blizzard Warning.

a) Issue a warning if the following conditions are expected to persist for three hours or more:
-wind speeds of 35 miles per hour or more
-heavy falling or blowing snow with visibility less than one quarter mile

b) Notify proper authorities.

c) Update reports giving snow depths and the status of the warning.

4) Heavy Snow Warning.

a) Issue a warning if:
-six or more inches of snow is expected in 12 hours.
-eight or more inches of snow is expected in 24 hours.

b) Notify proper authorities.

c) Issue a statement as soon as possible outlining the endangered area and update periodically with the expected duration of the warning and snow depth reports.

Because meterological hazards can be short-lived, localized, and transient phenomena, it is impossible to always accurately predict where or when they will strike. Most efforts to mitigate the immediate effects of the hazards actually just involve establishing warning procedures about severe conditions. Other mitigation can involve planning for the results of these meteorological hazards, as seen in flood plain management procedures (Chapter 2).

AIR POLLUTION

Under the provisions of the original Federal Clean Air Act of 1970, the Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS). Standards were set for total suspended particles (TSP), carbon monoxide (CO), ozone (O_3), and nitrogen dioxide (NO_2), and these standards were then subdivided into primary and secondary levels. Primary standards were those designed to protect the public health and had to be addressed immediately. Secondary standards were those designed to protect welfare and had to be met as soon as possible (APCD, 1982a). Under the provisions of the 1977 Clean Air Act Amendments, states in which there were areas which did not meet the NAAQS had to prepare revised state implementation plans (SIPs) designed to assure compliance with the NAAQS by December 31, 1982. If these standards were not met, the EPA could block all or part of any federal funding to that state (James, 1983). Colorado contained four areas that did not meet the NAAQS, one being Colorado Springs.

State Provisions

In 1979 Colorado requested and received an extension that gave these nonattainment areas until December 31, 1987 to achieve the standards for CO in all four areas and for O_3 in Denver. That same year, Colorado adopted the Colorado Air Quality Control Act, setting forth the policy of the state:

1) To achieve the maximum practical degree of air purity in every area of Colorado.

2) To attain and maintain the NAAQS.

3) To prevent the significant deterioration of air quality where air quality exceeds national standards.

In order to achieve this goal, the Act established:

1) The Air Quality Control Commission (AQCC) with broad regulatory authority.

2) The Air Quality Hearings Board as an appellate authority.

3) The Air Pollution Control Division (APCD) of the Colorado Department of Health as an enforcement agency (State of Colorado, 1979).

The Colorado Springs Problem

In 1982 the Colorado Springs area did not meet the standards for CO and for primary and secondary TSP (APCD, 1982a). A monitoring of the eight-hour concentration of CO at I-25 and Uintah St. showed 16 parts per million (PPM)--nine PPM higher than the national standard and five PPM higher than the 1981 measurement. At 712 S. Tejon St. the CO pollution measured 13 PPM. Furthermore, the number of violation days at the Tejon station went from one in 1981 to three in 1982. At the I-25 site, the number of violation days went from four to fourteen (APCD, 1982b). The Colorado Air Quality Control Program reports that 96.3% of the CO concentration is related to vehicular exhaust, 3.4% is related to residential and commercial combustion, and 0.3% is related to other point sources.

Violations of both primary and secondary standards for TSP were also recorded in Colorado Springs during 1982. For example, 265 micrograms per cubic meter (ug/m^3) were recorded at 3730 Meadowbrook Boulevard over a 24-hour period. The national 24-hour standard for primary particulate matter is 260 ug/m^3--not to exceed more than one violation per year (APCD, 1982b). A violation of secondary particulate matter (202 ug/m^3) was also recorded at 3730 N. Meadowland Boulevard over a 24 hour period. The secondary TSP standard over a 24 hour period is 150 ug/m^3 and is not to be exceeded more than once per year (APCD, 1982b). Eighty-one per cent of Colorado Springs' annual TSP is attributed to "fugitive dust" (due to unpaved roads, land development, sand on paved roads, agriculture, construction, mining, aggregate storage, and cattle feedlots). The other 19% is attributed to point sources (4.7%), mobile sources (6.1%), and combustion (8.1%) (APCD, 1982a). In 1982 particulates ceased to be defined under Federal standards (Coy, 1983).

On June 10, 1982, the AQCC adopted the Colorado Springs plan element as submitted by the Pikes Peak Area Council of Governments (PPACG). The plan is directed toward attainment of the eight-hour CO standard by 1987. Colorado Springs has committed itself, by resolution, to three measures to be implemented at the local level and to a fourth to be implemented by the Colorado General Assembly. The local commitments are:

1) To maintain the existing bus service and to expand it as federal funds become available.

2) To encourage the use of Ridefinders, a carpool locator service, and to seek replacement funding for that service if future federal funding is reduced.

3) To make improvements in traffic flow--especially to contribute to the completion of Union Boulevard as federal funds become available.

Finally, the Colorado General Assembly is urged to retain the Colorado Air Program in order to achieve at least a 25% reduction of CO emissions (APCD, 1982a).

Critics, however, claim that a misrepresentative air quality model and the population growth of Colorado Springs will prevent the city from attaining the national carbon monoxide level by 1987 (Coy, 1983). Jim Easton, local air quality control chief, has suggested that the city council consider the air quality impacts of new developments when reviewing future development plans, since growth rates are exceeding the air quality model's expectations (Coy, 1983).

Metro Denver implemented a plan that would attain both the ozone and the one-hour and eight-hour CO standards by 1987. Adopted by the AQCC on June 11, 1982, the Denver plan contains measures advocating:

- Doubling the number of Park-n-Ride lots
- Establishing light rail transit (or expanding the bus fleet)
- Metering freeway ramps
- Establishing exclusive bus ramps (associated wtih ramp metering projects)
- Developing traffic signal projects

- Erecting display signs at drive-throughs
- Improving parking management
- Expanding the Colorado AIR Program
- Creating Share-A-Ride Days
- Enforcing warranties
- Conducting rideshare research
- Conducting gasohol research

It is encouraging to see such an extensive plan implemented in Denver, but at the same time, it is discouraging to see Colorado Springs rely on its limited measures when computer modeling suggests that pollution levels are not declining as rapidly as expected under current controls (APCD, 1982a).

Granted, to date, Denver's air quality is worse than that of Colorado Springs. However, in June, 1983, Wanda Landerdale of the State Air Pollution Division sent the PPACG a memo warning that 1982 figures showed that Colorado Springs was not demonstrating continuous progress toward achieving the national standard by 1987 (Coy, 1983). The Colorado Air Quality Data Report of 1982 shows that air pollution, particularly carbon monoxide, is actually _on the rise_ in Colorado Springs. Almost surely the air quality of Colorado Springs will continue to decline until strict measures, such as those introduced in Denver, are implemented in the Pikes Peak Region.

Possible Mitigation Measures

Since the largest share of air pollution in the Pikes Peak Region is contributed by autos (PPACG, 1977), it important for Colorado Springs to explore ways to curb vehicular use or at least reduce total vehicular miles traveled. With future development planned for the fringe areas, it seems impossible for Colorado Springs to attain the 8-hour CO standard unless strict measures are enacted in the areas of:

- Mass transit
- Traffic flow improvement
- Episodic "Share a Ride Days"
- Environmental impact statements for new developments
- Climatic design and planning

Such measures, as with other pollution control strategies, will require the direction of both elected officials and the citizenry in balancing the costs of control with the benefits of a carefully managed environment (PPACG, 1977).

Mass Transit. The Colorado Springs plan calls for the maintenance of existing bus service and its expansion as federal funds are available. When (and if) these funds are available, the expansion program should consist of express shuttle services during commuter hours connecting outlying fringe areas to major business districts. This program should incorporate an increased number of Park-N-Ride locations and exclusive bus ramps in order to provide quick commuter service. Such a program is already being implemented in Denver.

Traffic Patterns. The worst carbon monoxide concentrations are found where a large number of slow moving cars come together, such as in large parking lots or traffic jams (CAQDR, 1982). Part of the Colorado Springs plan calls for improving traffic flow, but only as federal funds are available. Meanwhile, the problem increases. Since this problem warrants immediate action, one method of decreasing traffic flow might be to apply some form of increased gas tax to local vehicles. Then, as federal funds become available, further traffic flow improvements could be initiated.

Episodic "Share-A-Ride Days". This program involves asking, on a rotating basis, car owners to leave their vehicles at home on winter days when high levels of carbon monoxide are predicted. To be effective, the APCD's technical staff would have to develop the expertise to accurately predict these high pollution days, while APCD's Rideshare unit would have to synthesize a network of employer and community based resources through which people could find alternative modes of travel. Public education and information programs would need to be developed since public support for a voluntary program of this magnitude would be critical for its success (APCD, 1982a).

Environmental Impact Statements for New Developments. The environmental impact on the local air quality of Colorado Springs caused by the continuing development of outlying fringe areas is unsure. Colorado Springs topography makes air pollution particularly hazardous to the lower downtown area. Since new development is occurring at higher elevations (James, 1983), it seems important that Colorado Springs become aware of the ramifications of each new development. Therefore, environmental impact statements should be mandatory for all new developments, and developments that would have a strong negative impact on air quality should not be permitted. Hopefully, such a program would create innovative development schemes that would utilize alternative energy sources.

Climate Design and Planning. Thorough design and planning for climatic conditions is sometimes precluded by the rush to begin construction or by the assumption of owners and architects that climate consideration is not worth the extra time and expense. The use of a climatological study in planning would help to identify beneficial changes in the microclimate of sites and undesirable climatic conditions that might result from land use and development. Thus, such a study can achieve economic, practical, and environmental benefits (McAnelly, 1974).

As 1987 approaches, the people of Colorado Springs must be willing to make sacrifices in their lifestyle and become more involved in air quality control programs in order to meet the national standards for air quality. They must change both how they commute and how their community is developed. Only by developing increased public concern for health and the environment can these sacrifices be achieved.

HAZARDOUS WASTES

Air and water pollution have been recognized for some time as hazards to health and the environment. The part played in the pollution of the environment by human produced hazardous wastes has only recently been recognized by federal, state, and local governments. In 1969, Pennsylvania passed a hazardous waste law which dealt exclusively with garbage and trash as the most severe hazardous waste products. The idea of including industrial wastes was not even contemplated (Epstein *et al*., 1982). Since that time, we have come to realize that both industrial and residential waste materials may be among the most potentially damaging hazards to our health and our environment.

The Federal Context

In 1974 both houses of Congress held hearings on the solid waste disposal problem. The problems of trash and garbage disposal were considered to be within state and local jurisdictions. Therefore, these hearings stressed the need for safe disposal of the hazardous materials in solid wastes and the need to find a way to close the loophole left by Congress in previous legislation on solid waste disposal. In a 1973 report to Congress, the Environmental Protection Agency (EPA) disclosed that the original air and water pollution control laws allowed the dumping of solid waste material on land and that subsequent laws had increased the amount of material allowed to be disposed of in this manner (EPA, 1983).

During this period the EPA tried to keep the problem before Congress, but other priorities, such as budgetary and economic considerations, had precedence. Several years prior to the implementation of the 1976 Resource Conservation and Recovery Act (RCRA), the EPA had documented several hundred cases of improper disposal causing health hazards (Cheremisinoff et al., 1979). The RCRA was a quick fix to a very complicated and widespread problem. Under the original RCRA, 41% of the nearly 700,000 identified hazardous waste generators were sufficiently small that they were exempt from the law. In addition, landfills which received wastes from only these small generators were also exempt. We now realize that these small producers and disposers are a major part of the waste disposal problem.

In 1980, the 'Superfund' was created to try and clean up some of the most hazardous sites in the country. The initial estimate for cleaning up only the priority sites was $44.2 billion. After intense debate, a total of $1.6 billion was budgeted in December, 1980 for cleanup of the 115 most severe sites. In 1982, the number of sites identified for emergency 'Superfund' cleanup reached 418 with the EPA estimating that there might be a total of 7,200 sites requiring emergency action. By October 1984, the number of sites had grown to 786 with the total estimated at over 14,000 (Gazette Telegraph, 1984).

The Colorado Context

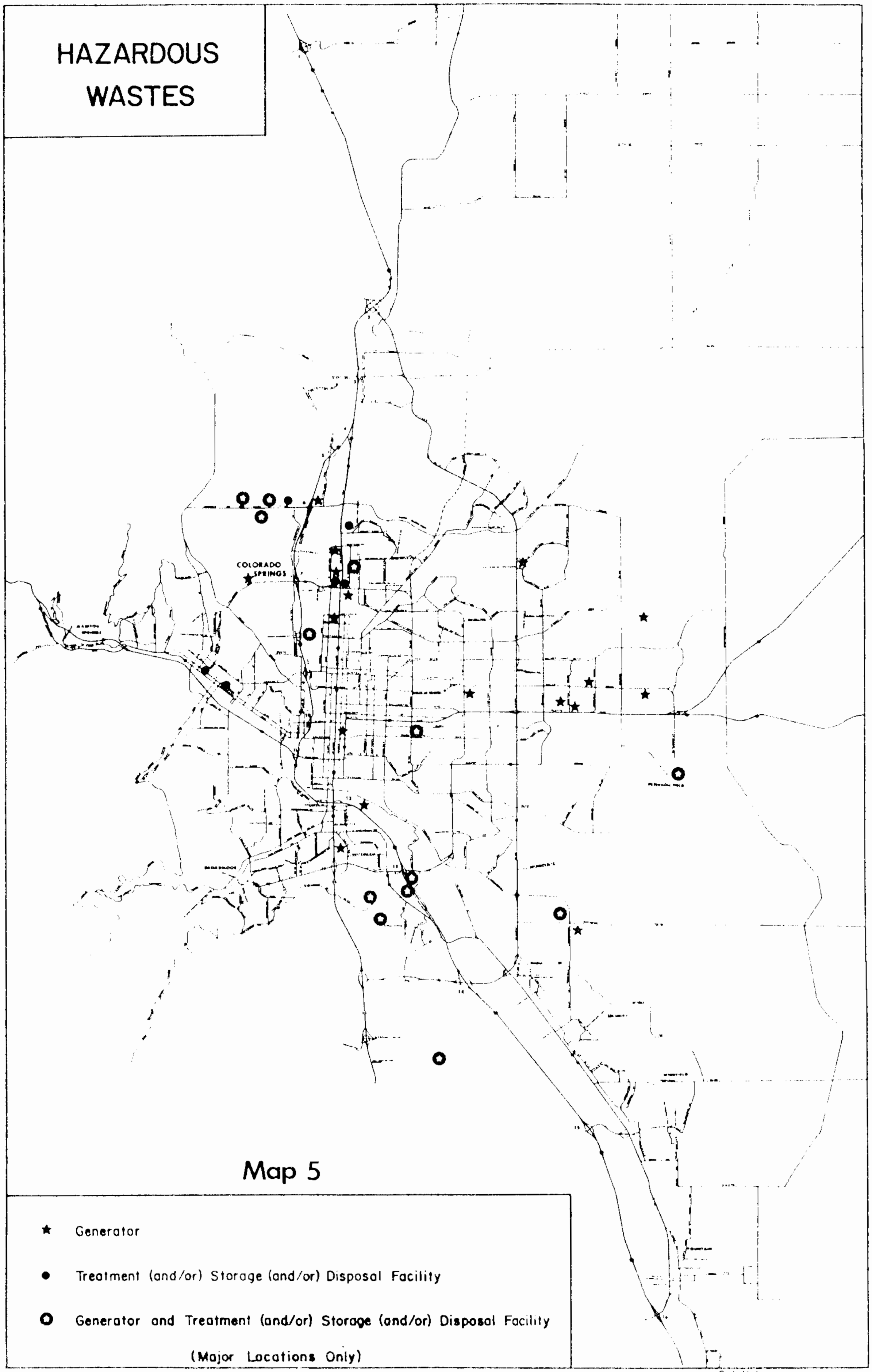
In 1979, despite regulations requiring some sort of action, only seven states had toxic substance legislation. By 1980, the EPA could identify only nine states that did not have such legislation; however, Colorado was one of those states (Epstein et al., 1982). Since then Colorado has submitted a plan to EPA and received approval in Novenber, 1984 (Brand, 1984). Yet even with these new state regulations, EPA Region VIII is still the primary agency for dealing with hazardous wastes in Colorado due to limitations in state funding.

The Colorado Springs Context

In June, 1984, El Paso County enacted very strong regulations concerning hazardous waste disposal. Section 25A of the county regulations prohibits burial or any other form of hazardous waste disposal within the zoned portion of the county. These regulations allow transfer, temporary storage, and treatment only. In addition, a processing facility cannot be built in the county unless the site contains at least 200 acres. The cost of such a facility would be in the neighborhood of $10 million after land acquisition, thus precluding construction of such a facility in the near future (Sierra Club, 1984).

The Local Problem. There are innumerable producers and users of hazardous materials in the Colorado Springs area. They range from a Hewlett-Packard facility which produces tons of material which is monitored throughout its effective lifetime, to a single, small dry cleaner that may produce a half-barrel of material a month, to metal plating shops which produce relatively dangerous materials with little or no monitoring of their waste disposal (Map 5).

Industry Wastes - Currently, Hewlett-Packard (as an example of the large industrial producer) has at least two ways of safely disposing of hazardous materials. Most of the solvents used in its electronics manufacturing processes are shipped to the Oil Solvent Recovery Company northeast of Denver where much of the material is recycled or processed for future use in some other industry. Those materials which are chemically or economically unfeasible to recycle are shipped to Rollins Environmental Services in Texas for very high temperature incineration. All of the wastes are monitored from initial production to final disposal by a professional waste management person. Few problems are posed for the community save those caused by transportation of the material out of the area.


HAZARDOUS WASTES
COLORADO SPRINGS
Generator
Treatment (and/or) Storage (and/or) Disposal Facility
Generator and Treatment (and/or) Storage (and/or) Disposal Facility
(Major Locations Only)
C J Huber

Map 5

This well-managed process used by large industries is very different from that followed by small users and producers of toxic substances. At present, small producers are not even covered by the laws and regulations governing hazardous waste production and disposal. In August 1985, however, this will all change. At that time, anyone producing more than 100 kilograms per year will be subject to rules similar to those now followed by the large producers. This means that producers must be able to dispose of very small quantities of material. At present there is no infrastructure available to consolidate these small amounts of waste or to centrally dispose of them in a way that is economically viable. Colorado Springs probably does not need its own waste disposal site but does need a way to coordinate shipments of wastes to other adequate sites.

Individual Wastes - Besides industrial toxic waste production, another major concern is the use and disposal of materials used by individuals and households. There are mechanisms in place for industry to use and handle toxic materials, but there is no such system available for users of very small amounts of such materials. Many products which should be considered hazardous waste exist for the home; one good example is house and garden pesticides.

The EPA does not regulate the disposal of house and garden pesticides, since small amounts are usually disposed of singly. However, a problem exists because many people dispose of pesticides at virtually the same time during the year. It is estimated that 50,000,000 pounds of pesticides are used by individuals in urban areas of the United States every year (McEwen and Stephenson, 1979), and most of these are used and disposed of in the spring and early summer in those same urban areas (Rumker et al., 1972). Therefore, the problem of pesticides permeating the environment is both spatially and temporally focused in the areas of highest population density (Montz, 1983).

CONCLUSIONS

> ... it can be said that for the majority of its citizens Los Angeles remains an epitome of the sunshine state of California--a place of both challenge and opportunity. There are those who believe that it mirrors the face of Western civilization where twentieth-century man has achieved the most advanced urban society on earth and has tamed his environment on the way to these achievements. There are others who see such a society merely as brittle veneer in an environment where hazards have proliferated in response to man's interference with the natural order of things (Whittow, 1979).

We in Colorado Springs might appropriately substitute 'Colorado' for 'California' and 'Colorado Springs' for 'Los Angeles' in the above quotation. There are many in the community who are optimistic and believe in the advanced urban society. There are others who see only disasters waiting to happen. Somewhere, in between these extremes, lies our real condition. We hope that this document might stimulate more understanding of the particular environment around Colorado Springs, that it might encourage others similarly to evaluate their own localities, and that all such studies might engender an attitude of respect and concern for what we do in and to our environment.

We want readers to consider this paper a user's manual. We hope that anyone involved in the growth of the Colorado Springs region including developers, potential homeowners, city and county officials, students, and prospective residents use this work as a primer for decision making, and that similar persons outside our area use it as a guide to develop their own studies. Obviously, this document will be more pertinent to some than to others. It does provide, however, information on a wide range of hazards.

In a very real sense, as mentioned in the introduction to this work, when a prospective property buyer is considering a piece of land, that buyer should heed the phrase *caveat emptor* . No one has as much to lose as she or he. This paper can provide some insight and give some warning concerning the hazards affecting various sites in the Colorado Springs area. However, the final decision is the buyer's. When making these decisions, the hazardousness of a property may be at the bottom of a long list of priorities, but we encourage purchasers to look carefully at the local environment, since a hazard event of one type or another can cost large amounts of money and potentially cause serious injury to the buyer or her/his family.

We also realize that there is no such thing as a risk-free environment. Critics of this report may suggest that there is a greater risk in crossing Nevada Avenue than there is in living in areas of expansive soils or potential flooding. This is not a valid comparison. If people can make a decision to protect their property investment and lower the risk to their family, why not do it? We are not calling for panic due to environmental risks; we are advocating rational action as opposed to uninformed inaction.

The preceding chapters give you a general view of the locations and potential severity of hazards in Colorado Springs. They do not provide all of the information one may need or desire. The maps are small scale, and exact locations are difficult to pinpoint at their level of resolution. If a person--particularly a newcomer to a region--has a concern about a specific site or questions about the general problems of a given area, he or she should not hesitate to ask questions of a realtor, developer, landlord, or a city or county planner. People have a right to know what hazards impinge on their home site and what mitigation options are available (e.g., National Flood Insurance). This paper is intended only as one step in making available some of the information that citiziens need to determine accepatable risk and to make their own informed decisions.

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APPENDIX

Addresses of Useful Agencies.

City of Colorado Springs
30 S. Nevada
Colorado Springs, Colorado 80903
- Planning Department
- Public Works Department
- Engineering Division

Colorado Department of Natural Resources
1313 Sherman
Denver, Colorado 80203
- Mined Land Reclamation Division
- Water Conservation Board

El Paso County Disaster Services
230 E. Kiowa
Colorado Springs, Colorado 80903

El Paso County Health Department
Air Pollution Division
501 N. Foote
Colorado Springs, Colorado 80909

El Paso County Land Use Department
27 E. Vermijo
Colorado Springs, Colorado 80903

Federal Emergency Management Agency
Natural and Technological Hazards Division
Denver Federal Center
Building 710
Denver, Colorado 80225

National Forest Service
Pikes Peak National Forest
320 W. Fillmore
Colorado Springs, Colorado 80907

National Weather Service
Colorado Springs Municipal Airport
Colorado Springs, Colorado 80916

Natural Hazards Research and Applications Information Center
I.B.S. #6
Box 482
University of Colorado
Boulder, Colorado 80309

Penrose Public Library
Local History Section
20 N. Cascade
Colorado Springs, Colorado 80903

Pikes Area Council of Governments
27 E. Vermijo
Colorado Springs, Colorado 80903

Regional Building Department
101 W. Costilla
Colorado Springs, Colorado 80903

U.S. Soil Conservation Service
1826 E. Platte
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