Natural Hazard Research

HAZARD MITIGATION BEHAVIOR OF URBAN FLOOD PLAIN RESIDENTS

by

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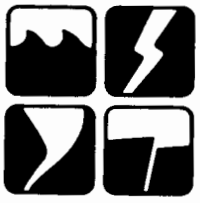

Working Paper #35

HAZARD MITIGATION BEHAVIOR OF URBAN FLOOD PLAIN RESIDENTS

This study reports findings of research which attempted to examine various characteristics of residents of flood hazard areas in an effort to determine which factors are likely to be most significant in explaining behavior to mitigate hazard impact potential. The study endeavors to illuminate a two-level process thought to be relevant to mitigation behavior. First, analyses were conducted to determine which characteristics play the most significant role in creating an overall awareness of the flood hazard. Second, analyses were carried out to identify which factors, including hazard awareness, are likely to produce mitigation action behavior.

Demographic, perceptual, experiential, and knowledge parameters for 249 respondents were examined through the use of structured telephone interviews. These were administered to residents of two similar flood plain areas in the Denver Metropolitan area. Respondents were chosen at random from mailing lists prepared by the Denver Urban Drainage and Flood Control District (UDFCD) for a flood hazard informational brochure which they were disseminating to occupants of flood plain areas within their jurisdiction.

Evaluating the effectiveness (defined as the promotion of protective action, or increasing hazard awareness) of this brochure was one major focus of the study. Consequently, respondents were selected from two separate flood areas. Residents of the first area had received the brochure, while residents of the other had not, but were scheduled to receive it during the project. Three groups of respondents were interviewed, one from the first area, and two from the second area. The

residents of the first area who had already received the brochure represented the first group. Residents of the second area who had not yet received the brochure comprised the second, and the third respondent group was made up of residents of the second area who were interviewed after receiving the brochure.

The analyses of the effectiveness of the brochure indicated that the information is heightening awareness of the flood hazard, and seems to be motivating mitigation behavior. However, the study also showed that a year after the brochures were disseminated, only one-third of the respondents remembered receiving them. Recommendations for heightening memorability and for other changes in the content and format are presented.

The analyses of hazard awareness indicate that five respondent characteristics seem most significantly associated with variation in awareness. These are: 1) prior hazard experience; 2) having suffered damage from flooding; 3) the respondent's age (with the younger respondents being more aware); 4) how long the respondent had lived at his/her present address (the longer, the more aware); and 5) the proximity of the residence to the creek (the closer, the more aware).

The analyses of mitigation behavior identified three major variables which are important for motivating mitigation action. These are: 1) a general concern about the possibility of flooding; 2) knowledge that the creek had flooded in the past; and 3) owning a home as opposed to renting. Other factors which came out of the analyses showed that generally, the respondents who have taken action are older, have lived at their present address longer, live closer to the creek, have higher hazard awareness, and have more previous hazard experience.

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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 will be used as working documents by the group of scholars directly involved in hazard research as well as inform a larger circle of interested persons. The series was started with funds granted by the U.S. National Science Foundation to the University of Colorado and Clark University but now is on a self-supporting basis. Authorship of papers is not necessarily confined to those working at these institutions.

Further information about the research program is available from the following:

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Requests for copies of these papers and correspondence relating directly thereto should be addressed to Boulder. In order to defray production costs, there is a charge of $2 per publication on a subscription basis or $3.50 per copy if ordered singly.

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Of course, errors of fact or judgment contained in the report, as well as any opinions expressed, are solely the responsibility of the author.

INTRODUCTION

Background to the Study

This study was begun in response to a request by the Urban Drainage and Flood Control District (UDFCD) of Denver, Colorado. The UDFCD was created in 1969 by an act of the Colorado State Legislature and is supported by property taxes from the counties which comprise its jurisdiction: all of Denver County and parts of Adams, Arapahoe, Boulder, Douglas, and Jefferson Counties.

Acting mainly as a coordinating agency of multi-jurisdictional urban drainage activities, the District's primary activities include preparation of drainage master plans, construction of facilities, and delineation of flood plains. In addition, the UDFCD provides communities with technical and administrative assistance on issues such as wise flood plain management and participation in the National Flood Insurance Program.

The District, in 1975, began a campaign to inform occupants of flood hazard zones about the nature of the flood problem, as well as measures which might be taken to mitigate the potential consequences of a 100-year or 1% flood (i.e., a flood which has a 1% probability of being equaled or exceeded in any given year). The campaign was undertaken both because of feelings of moral obligation, and because of the potential legal liability involved in having hazard information and not disseminating it.

In 1975, the UDFCD produced 2,000 brochures for residents of Lena Gulch, a relatively small drainage west of Denver, the urbanized part of which is principally in Wheat Ridge, Colorado. One side of the brochure displayed a map (1:24,000 scale) of the area with the 100-year flood plain (the area which would be inundated by the occurrence of a 1% flood) delineated. The other side of the brochure included definitions of the 100-year flood and the 100-year flood plain, and information about actions which flood plain residents could take to mitigate potential consequences of of a flood. (A photo-reduced example of the brochure is displayed in Appendix B.) The brochures were delivered to local officials, who were responsible for distribution to flood plain residents.

The following year (1976), a similar brochure was prepared for another drainage in the Denver Metropolitan area. This time the District distributed the brochures. This was accomplished by a carrier, who, equipped with a map of the 100-year flood plain, hung the brochures on the doors of most of the buildings in the flood plain. This method of distribution was subsequently abandoned as too costly.

In 1977, the campaign was stepped up and brochures were produced for four additional drainage areas. This time, the effort was conducted by mail which increased the coverage while minimizing the costs. While this approach entailed the arduous task of compiling addresses of flood plain structures in order to produce a comprehensive mailing list, it seemed to be the most effective distribution method.

It was after the distribution of brochures in 1977 that the UDFCD decided that an assessment of the effectiveness of the notification campaign was in order. Since their plans include the distribution of

some 14,000 additional brochures in 1978 (for fifteen drainage areas), and eventual distribution of brochures in approximately 30 drainage areas, an appraisal of the brochure's impact was justified and timely.

Purpose of the Study

The primary purpose of this study was to determine the extent (if any) to which the information brochure altered the awareness and/or behavior of recipients with respect to taking actions to reduce their risk from floods. Some of the possible behavioral measures include the purchase of flood insurance, flood-proofing the home or business, developing an emergency plan (e.g., an evacuation route), or heightening community awareness by talking to friends and neighbors or attending community meetings.

In addition, this situation was well-suited to an examination of the role which other factors may play in determining whether or not people take actions to mitigate potential hazardous consequences of a flood. Some of these factors are prior hazard experience (either floods or other natural disasters), perception of risk, knowledge of options, feelings of efficacy, and certain demographic characteristics.

It was hoped that the results would indicate which factors were significant in explaining why people do or do not feel concerned about the flood hazard, and why, acting on these feelings, they do or do not take protective actions. Further, it was thought that from these explanatory factors, it might be possible to develop recommendations for providing information to promote whatever behavior flood plain residents might regard as in their best interests.

RESEARCH METHODOLOGY

To attain the objectives of the research a number of fundamental methodological questions had to be addressed at the outset. The first major issue to be decided was which of the many drainage areas in the UDFCD's jurisdiction should be examined; secondly, which data were to be collected in those sites selected; thirdly, how would these data be collected; and finally, how would the information be analyzed. Each of these is discussed below.

Site Selection

It was decided immediately that no more than two sites would be examined both because of budgetary constraints and because two sites were considered adequate for the kind of comparative analyses being contemplated.

In order to evaluate the effectiveness of the information being disseminated by the Urban Drainage and Flood Control District, the sites were chosen so that residents of one had received the brochure while the other had not. Such a before and after comparison would ensure that the effects of the brochure would be easily discernible.

The two drainages selected after consultation with the UDFCD were Lena Gulch, located west of Denver, Colorado, and Ralston Creek, located northwest of Denver, the urbanized portion of which lies mostly in Arvada, Colorado. (See Figure 1 for locations.) The information brochures had been distributed in the Lena Gulch area twice in the past, the most

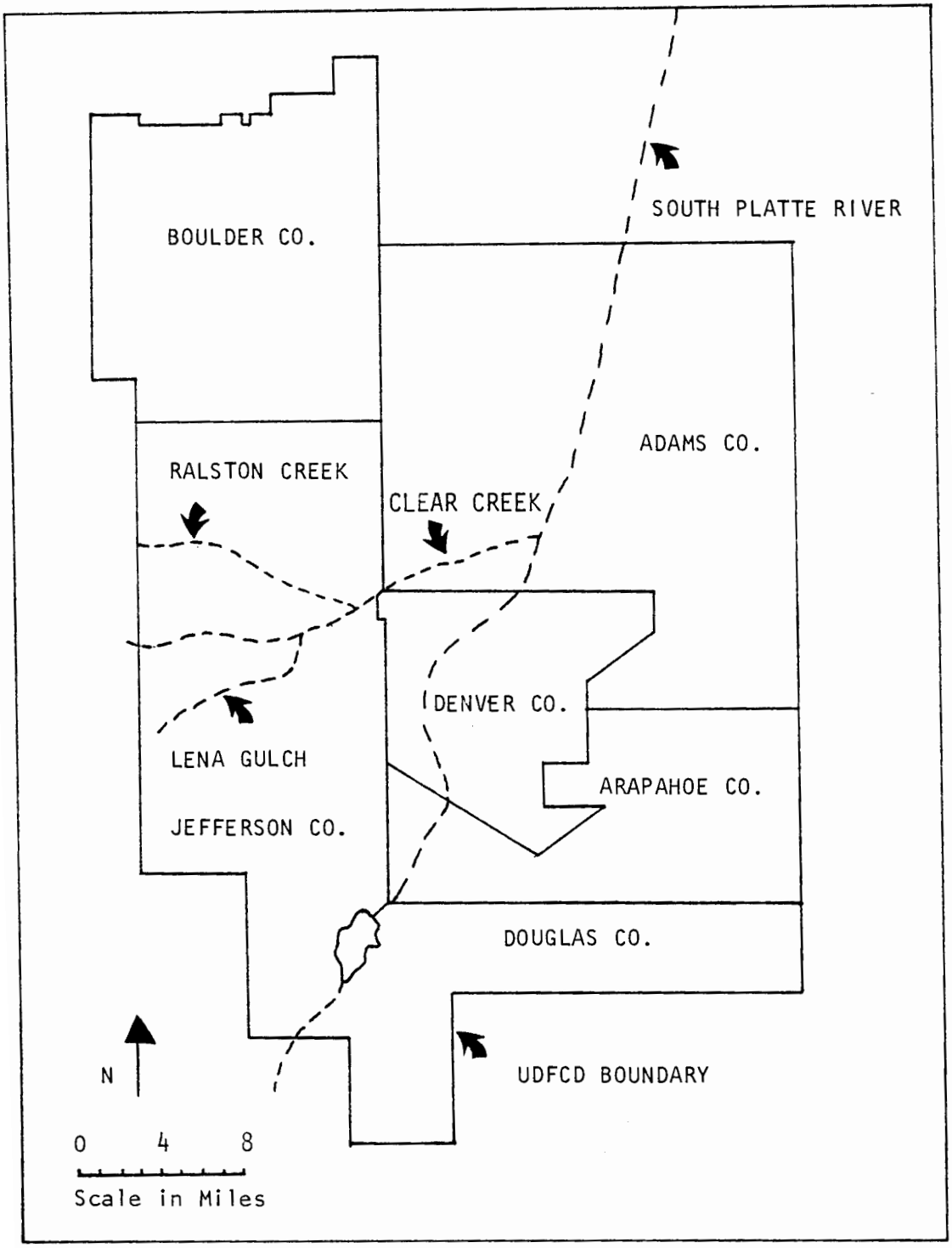

FIGURE 1

LENA GULCH AND RALSTON CREEK

recently being in February, 1977. Brochures had never been distributed in the Ralston Creek area, but were due to be distributed there during the study. This allowed a research design in which two separate populations were interviewed in the Ralston Creek area. The first group (hereafter referred to as Ralston Creek A) was interviewed prior to receiving a brochure, and the second population (hereafter referred to as Ralston Creek B) was interviewed following the distribution of brochures there. This design permitted a comparative analysis of the effects of the information within one geographic area, as well as between two different localities.

A field analysis revealed that the two sites were suitable for a comparative study. Although the size of the population-at-risk was somewhat larger in the Ralston Creek area, both were large enough to permit the selection of a random sample adequate for statistical analyses. A brief hydrologic description of each drainage follows.

Lena Gulch. Lena Gulch is controlled by four governmental units: the cities of Golden, Lakewood, and Wheat Ridge, and by Jefferson County. The gulch drains an area of approximately 13.8 square miles. Lena Gulch begins in the foothills west of Golden, and flows into Clear Creek. At this point, the peak discharge rate of the 100-year flood is estimated to be 2550 cubic feet per second (cfs), under present conditions. Under assumptions of future basin conditions, and predictions of future development, the peak flow of the 100-year flood is estimated to be 2850 cfs (Wright-McLaughlin, 1975, pp. 111-112). However, the existence of Maple Grove Reservoir may pose an additional flooding hazard under certain meteorological conditions.

Man's activities have probably increased the runoff peak flows in the basin from 40% to 100%, while simultaneously reducing the cross-sectional flow area by as much as 98% along some reaches of the stream (Wright-McLaughlin, 1975, pp. II-1). In some areas, major sections of the stream have been redirected. The present point of confluence of Lena Gulch and Clear Creek, for example, is approximately 2,000 feet downstream from its historical location.

Postulated average annual damages for the Lena Gulch drainage with present channel conditions and predictions of future developments are $749,000 (1976 vaules) (Wright-McLaughlin, 1975, pp. IV-9).

Although there has been no historical recording of flooding along Lena Gulch, a small flooding event took place in 1973. One gauging station, located approximately 6,000 feet upstream at the confluence with Clear Creek, recorded a discharge of 820 cfs for this event (DeGroot, 1978).

Ralston Creek. Ralston Creek, although it drains a much larger area (91.5 square miles), is quite similar to Lena Gulch in many respects. Like Lena Gulch, the headwaters for Ralston Creek are in the foothills. Flowing eastward, Ralston Creek enters the City of Arvada, Colorado, which is heavily urbanized along most of the stream. Some of the reaches of Ralston Creek have consequently been severely restricted by this development and encroachment into the flood plain. Land use along several reaches has, however, been consciously limited to activities which will not be negatively affected by a flood event (e.g., open space, bicycle paths, etc.).

Like Lena Gulch, Ralston Creek joins Clear Creek as its eastern terminus. At this point, the peak discharge rate of the 100-year flood is estimated to be 9,300 cfs, under present conditions. Under assumptions of future basin and drainage improvements, and predictions of future development, the peak flow of the 100-year event is estimated to be 8,800 cfs at the confluence of Ralston and Clear Creeks.

Average annual damages for the Ralston Creek drainage with present channel conditions and predictions of future development are estimated to be $3,799,500 (1976 values) (Wright-McLaughlin, 1977, p. IV-1).

As in Lena Gulch, no historic records of flooding have been maintained for Ralston Creek. However, in 1973 a 10-year flood did occur on Ralston Creek as the result of 3.13 inches of rainfall in a 24-hour period. (Root, 1978). The peak flow for a 10-year event has been estimated as 3800 cfs. (Wright-McLaughlin, 1977, p. III-2).

Data Collection

Since the type of information desired in the study was an assessment of general hazard awareness, and an inventory of the types and extent of mitigation efforts on the part of flood plain residents, it was thought from the outset that a survey would be the most appropriate and efficient method.

Three survey techniques were considered: 1) face-to-face interviews, 2) mailed questionnaires, and 3) telephone interviews. Each has advantages and disadvantages.* However, given the nature of the information

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*For comparison of these techniques, see Julian L. Simon, Basic Research Methods in Social Science. New York: Random House, 1969, p. 250.

desired, and a consideration of overall costs and benefits, the telephone survey technique was selected for this study.

A previous study (U.S. Department of Commerce, 1977) indicated that the response rate and the actual content of the responses could be significantly improved by sending out a brief cover letter to members of the sample population informing them in very general terms about the nature of the study, and that they would be contacted by telephone during a specified time period. Such a letter was employed in this study (see Appendix A). This increased the likelihood of finding the respondents at home, allowed them to begin thinking about the research topic, and reduced the introduction time necessary during the telephone call.

A random sample of respondents was selected from mailing lists compiled by the Urban Drainage and Flood Control District for Ralston Creek and Lena Gulch. After obtaining telephone numbers for the selected respondents, the preliminary cover letter (discussed above) was sent out and respondents were interviewed.

A moderate response rate (70%) to the telephone interview was obtained. Most respondents had received our cover letter, were expecting the call, and were willing to participate, and generally seemed interested in the study. The populations of respondents were: Lena Gulch N = 83; Ralston Creek A, N = 91; and Ralston Creek B, N = 75. All of these samples were of adequate size to permit the type of statistical analyses desired.

Interview Design and Rationale

The interview was designed to elicit information in five general areas: 1) flood hazard awareness; 2) prior hazard experience; 3) demographic factors; 4) mitigation action behavior; and 5) knowledge of the UDFCD brochure (asked only of respondents in Lena Gulch and Ralston Creek B). (See Appendix C for the complete interview, and a summary of responses.)

The areas and the specific questions designed to illuminate them were selected to explore a hypothetical two-level relationship between: 1) specific pre-determining variables (i.e., prior hazard experience, hazard information, and demographic factors) and hazard awareness; and 2) between hazard awareness, prior experience, hazard information, demographic factors and hazard mitigation behavior. This hypothetical relationship is shown schematically in Figure 2.

These relationships have been often postulated in natural hazards literature. However, the nature of the relationships seems unclear at present. For example, although information and experience are believed to be associated with taking action, the nature of these associations has been questioned by Kates(1962, p. 140):

> A major limitation to human ability to use improved information is the basic reliance on experience. Men on flood plains appear to be very much prisoners of their experience, and the effect of such experience is not consistently in the direction of taking individual action to reduce flood damage.... Floods need to be experienced, not only in magnitude, but in frequency as well. Without repeated experience, the process whereby managers evolve emergency measures of coping with floods does not take place.
>
> Conversely...with limited experience, other managers appear to decide that they have received the flood that nature has had in store for them and that they will not have another flood for some time.

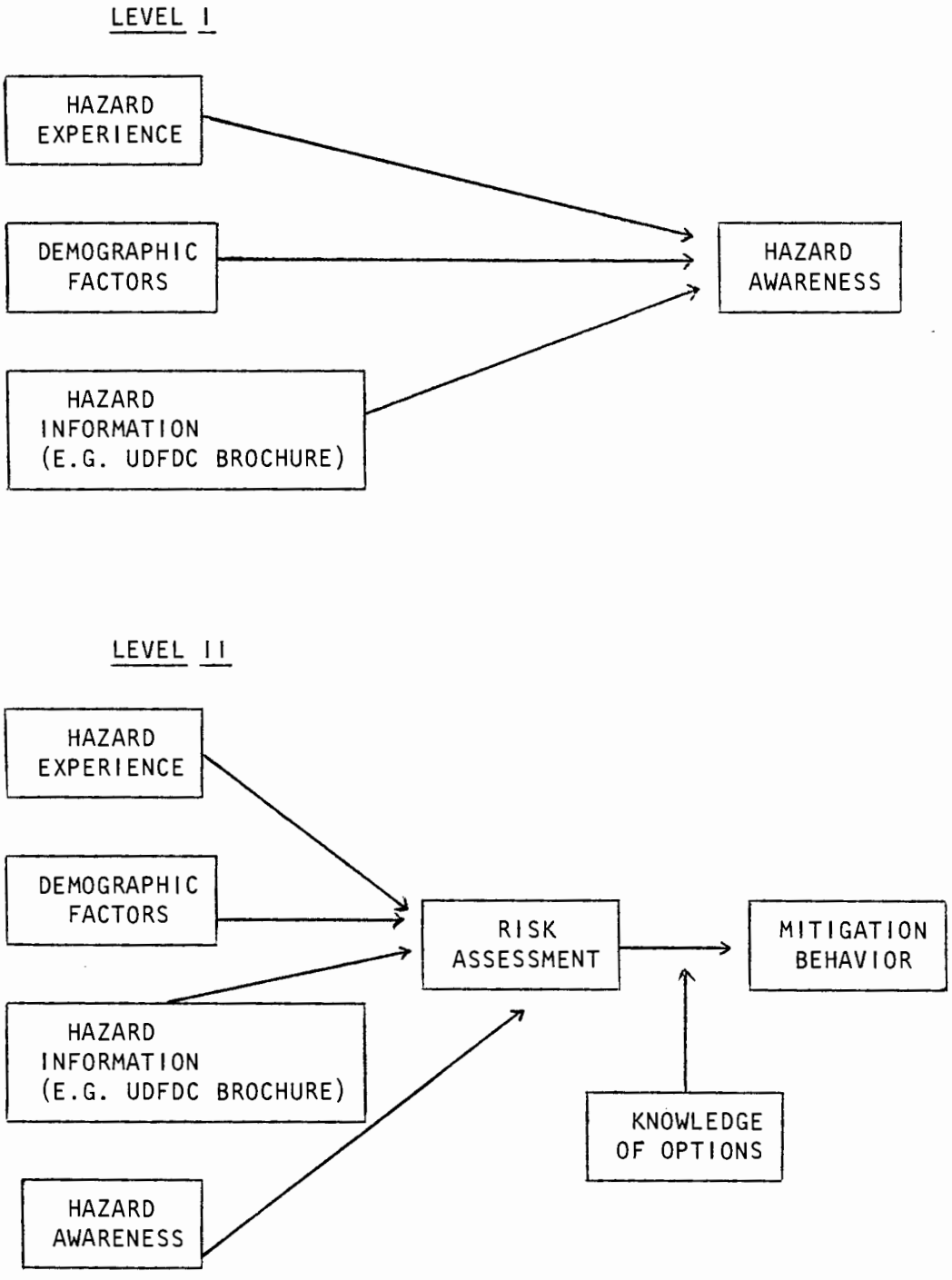

FIGURE 2

RELATIONSHIP OF VARIABLES

It is clear from the foregoing that experience and information are related in some way to taking protective action. However, it is also clear that the relationship is a complex one, with experience and information being manipulated to form some assessment of the risk involved. The factors so easily subsumed under the rubric of "risk assessment" in the figure actually encompass a plethora of complicated and possibly overriding explanatory variables for why a person does or does not take protective action. Burton and Kates (1964) state:

> To expect radical changes in the pattern of human adjustment to flooding simply by providing detailed and precise flood hazard information is unduly optimistic. Good predictions of the future choices of resource managers are likely to be based on an understanding of their hazard perception and the ways in which it differs from that of the technologists.

Working in another area of environmental behavior, Arbuthnot (1977) arrived at a similar conclusion:

> The success of public policy decisions, educational programs and other efforts dependent upon specific individual action in the realm of environmental issues may well hinge upon our understanding of the relationships among personality characteristics, attitudes, and environmental values, knowledge, and behaviors.

An attempt was made in the survey to unravel a part of this problem. A number of questions were specifically designed to ascertain, albeit in a rough way, the manner in which a respondent was assessing his or her potential risk from a flood event. An effort was made, for example, to distinguish whether or not a respondent who expressed no concern about flooding was unconcerned because the probability of a flood occurring was assessed as low, or because the consequences if a flood did occur were assessed as low, or both. In addition, if respondents stated that they had not taken a particular action, they were asked to give the reasons for not doing so. It is important, in this regard, to distinguish

between a respondent who took no action because it was felt to be unnecessary, and a respondent whose inaction was a result of not knowing any available options.

In summary, the survey was designed to test a hypothetical relationship, in the sense of pointing up probable patterns. The questions were selected to give broad coverage to those factors previously identified in the literature as having probable significance for affecting behavior. While the study did not attempt to define causal relationships between single variables, it did try to elicit information which would provide a profile of that respondent likely to have higher hazard awareness. Secondly, it did attempt to determine which factors, in conjunction with higher awareness, are likely to characterize those respondents with a higher probability of taking some sort of action. And finally, the research attempted to examine the role played by the UDFCD brochure. The success of these attempts is discussed in the next chapters.

DATA ANALYSIS

In examining the possible relationship between the variables, hazard mitigation behavior was considered the dependent variable for the study, while hazard risk assessment was considered a mediating variable through which the demographic factors, prior hazard experience, hazard awareness, and hazard information may have influenced mitigation behavior.

This chapter will cover five major areas: 1) a brief summary of the demographic features examined; 2) a discussion of the other variables for each population; 3) the type and extent of interaction between the variables for each population; 4) a systematic comparison of the relevant

findings from the analyses of the three populations; and 5) a discussion of the role played by the Urban Drainage and Flood Control District brochure.

Demographic Characteristics

The survey examined eight selected demographic features thought to be relevant to hazard mitigation behavior. These were: 1) length of residency at present address; 2) respondents' age; 3) number of adults (18+ years) in household; 4) number of children per household; 5) type of residence; 6) owning or renting; 7) market value of single-family residences; and 8) the value of contents.

The responses indicated that the residents of the Ralston Creek area have lived at their present address longer, are slightly older, have more persons per household, have more people living in single-family residences, have a larger percentage of persons owning their home, and have more property and content value, than the respondents from the Lena Gulch area.

The relationship of these demographic features to hazard awareness and mitigation behavior is discussed in a subsequent section.

Additional Variables for Populations

Prior hazard experience. In the literature of natural hazard management, prior hazard experience has often been mentioned as an important, although not completely clear, influence on hazard awareness and mitigation action. White (1945, p. 51), for example, states:

> The flood hazard is underestimated by most flood-plain dwellers because of the infrequency of major floods, the frailties of human memory, and the reluctance of some people, for economic reasons or from sheer obstinacy, to admit that past floods may be repeated or exceeded....As a general rule, the flood hazard tends to wax and wane in the public mind in direct relation to the occurrence of high water.

Others have also explored this relationship and, at present, the results seem somewhat conflicting. Baumann and Sims (1974), for example, investigating response to the threat of hurricane conclude:

> It is clear that neither awareness of the existence of the hurricane hazard, nor indeed past experience with it, are sufficient to produce effective precautionary actions.

Obviously some discrepancies exist and in order to further test such a relationship, a number of questions about hazard experience were included in the interview. These are discussed below, and the results are summarized in Table 1.*

Experiencing a flood--Respondents were asked if they had ever personally experienced a flood, and if so, when was the most recent they had experienced. The intent was to test two hypotheses: 1) that having experienced a flood made a person more aware of the hazard, and more likely to take protective action; but 2) that this effect was related directly to the recentness of the experience. In this regard White (1945, p. 51) found:

> So long as there are no other floods, the memory of the last one grows progressively dimmer. Its scars disappear, public interest in preparedness or protection weakens, and at length its ravages are forgotten.

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*The complete data from these analyses are available, in aggregated form, upon request from the Institute of Behavioral Science, University of Colorado.

TABLE 1

HAZARD EXPERIENCE

Comparison of Responses from Lena Gulch and Ralston Creek

Experience	Lena Gulch	Ralston Creek A	Ralston Creek B
Experienced a flood (% responding yes)	66.2	43.8	42.7
Recentness of flood (mean years ago)	4	5.5	7.8
Experienced flood damage (% responding yes)	20.7	14.9	10.7
Experienced other hazards (% responding yes)	34.9	36.3	37.3
Knew someone who experienced flood (% responding yes)	56.6	58.2	46.7
Knew someone who experienced other disaster (% responding yes)	31.3	41.1	28.0
Friends discussed flooding (% responding yes)	55.4	39.6	53.3
Heard about floods on TV/Radio (% responding yes)	21.9	14.3	20.2
Read about flooding in newspapers	40.2	19.8	44.0
General hazard experience (mean score on experience index)	3.31	2.64	2.83

Suffering damage in a flood--It was considered important to not only know if a respondent had experienced a flood event, but whether or not they had suffered any damage and if so, how much. Kates (1962, p. 133) found:

> There is evidence that monetary damages do affect the adoption of flood loss reduction alternatives.

Experiencing other natural disasters--This was included because it was thought that some of the experience gained through experiencing one type of disaster might be transferable to the flood situation.

Knowing someone who had experienced a flood or other natural disasters--Again, it was thought that experience might be gained vicariously by knowing someone who had experienced a flood or other natural disaster.

Hearing about the possibility of flooding--Three additional questions were asked of respondents to further define the content of their second-hand hazard experience. These were: 1) have friends or neighbors ever talked about the possibility of flooding in your area; 2) have you heard anything about flooding in your area on TV or radio; and 3) have you ever read anything in the newspapers about the possibility of flooding in your area.

Hazard experience index--An index of prior hazard experience was created for each respondent from the information obtained above. For each affirmative response, the subject was given a score of one. These were summed and each respondent was then placed on a 0-8 scale of hazard experience according to their responses. Hazard experience, through this somewhat rough index, could then be handled as interval data which

allows a number of statistical procedures to be employed which are not applicable to data in nominal (yes/no) form. Respondents in Lena Gulch averaged significantly higher on this experience scale than did those in either Ralston Creek population. Using this rough measure of the variables included one may say that, on average, the respondents from Lena Gulch have had more hazard experience than have the respondents in either Ralston Creek group.

The major problems in employing such an index are that it may exclude some factors relevant to hazard experience, and does not allow a separation of the contributing factors. It also assumes that these factors are indeed additive in the sense of providing a composite of experience.

Hazard awareness--Another factor which is hypothesized as being associated with hazard mitigation action is hazard awareness.* The fundamental logic behind this relationship is that in order for people to take action to mitigate the potential adverse effects of an event, they must have some knowledge of both the probability and possibility of the event, and its potential consequences. Accordingly a number of questions have been included to illuminate the respondents' awareness of the flood hazard.

In one important respect hazard awareness was examined somewhat differently in the study than were the demographic variables or the

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*Many authors have explored this relationship including: Kates, (1962), op. cit.; I. Burton, R. W. Kates, and G. F. White. The Environment as Hazard. New York, Oxford University Press, 1978; and H. J. McPherson and T. F. Saarinen, "Flood Plain Dwellers Perception of the Flood Hazard in Tucson, Arizona." The Annals of Regional Science, Vol. II (July 1, 1977), pp. 25-40.

hazard experience variables. In one set of analyses, hazard awareness was the dependent variable, and the other factors were examined in an effort to identify the best predictors of awareness. In a second set of analyses hazard awareness was examined as one of a number of independent variables to determine its relationship to hazard risk assessment and ultimately to mitigation behavior.

The hazard awareness questions, and a brief discussion of the rationale for their inclusion are presented below. The findings are summarized in Table 2.

Definition of 100-year flood plain--It was thought that one measure of hazard awareness would be whether or not the respondent knew the correct definition of the term "100-year flood plain." This would also be a rough indicator of the effectiveness of the UDFCD brochure since it provides a definition of this term.

Definition of 1% flood plain--This was included for essentially the same reasons as above, although this term is not included in the brochure. It has come into use mainly to avoid the confusion produced by the term 100-year flood (plain), which often results in the misperception that such a flood can only occur once in 100 years. In actuality the phrase describes an event the magnitude of which has a 1% chance of being equaled or exceeded in any given year.

Perceived location of residence--This was felt to be an important preliminary indicator of risk perception. Respondents were unlikely to be concerned about flooding, or to take action if they perceived themselves to be outside the flood hazard zone. As an indicator of awareness,

TABLE 2

HAZARD AWARENESS

Comparison of Responses from Lena Gulch and Ralston Creek

Awareness Indicator	Lena Gulch	Ralston Creek A	Ralston Creek B
Definition of 100-year flood plain (% responding correctly)	13.3	13.3	25.3
Definition of 1% flood plain (% responding correctly)	9.6	11.2	8.0
Perceived location of residence (% responding correctly)	44.6	37.4	54.6
Concerned about flooding (% responding yes)	49.4	37.4	32.0
Estimation of flood probability (% responding correctly)	36.1	27.8	28.4
Gambler's fallacy (% responding "equally likely")	50.0	56.7	63.6
Locus of control (% responding people can take steps)	60.2	54.4	67.1
Knew creek had flooded (% responding yes)	79.3	56.7	41.3
General hazard awareness (mean score on awareness index)	3.41	2.92	3.08

each respondent's answer was matched against an objective determination of the residence's location with respect to the flood plain. (For this purpose, each address was checked on 100-year flood plain maps provided by UDFCD, and was coded as being either in the flood plain or on its fringe. Of the Lena Gulch respondents, 48 [57.8%] were actually in the flood plain and 35 [42.1%] were on the fringe. For Ralston Creek A, 64 [70.3%] were in the flood plain, and 27 [29.7%] were on the fringe. For Ralston Creek B, 45 [60.0%] were in the flood plain, and 30 [40.0%] were on the fringe.) A new variable was thus created for each respondent by matching their response to this question with the code punched for objective location.

Concerned about flooding--It was thought that in order for a respondent to take protective action against possible flood damages, some concern about the probability of flooding must exist. Also, the converse was felt to be important information, i.e., if a respondent was not concerned about flooding, there would be less likelihood of that respondent taking any mitigating actions. Further, the reasons for concern, or its absence, were elicited. (These are summarized in Table 3.)

Estimation of flooding possibility--Another important indicator of risk perception is how a respondent estimates the probability of a flood event occurring in a given time period. Here, respondents were given a set of possibilities ranging from 0 chances of flood occurrence within the coming year to 10 chances in 100 of a flood occurrence within the same time frame.

TABLE 3

REASONS FOR CONCERN OR LACK OF CONCERN ABOUT FLOODING

A Comparison of Responses* for Lena Gulch and Ralston Creek

Reasons for Concern	Lena Gulch (% responding yes)	Ralston Creek A (% responding yes)	Ralston Creek B (% responding yes)
Past experience	58.5	32.3	45.8
Residence location	19.5	14.7	12.5
Flooding is possible	9.8	35.2	20.8
Possible consequences	9.8	0	0
Other (e.g. heard about Big Thompson flood)	17.1	24.2	25.0
Reasons Unconcerned			
Not near enough to creek	23.8	20.7	48.1
Flood not frequent enough	16.7	25.8	13.7
Residence is elevated	45.2	31.0	12.6
Control works are in effect	4.8	5.1	5.9
Renting	7.1	1.7	0
Other (e.g. owns insurance)	33.3	48.3	52.9

*Multiple responses were possible.

Gambler's fallacy--A common misconception of probabilities is something which Slovic, et al., (1974) have referred to as the "Gambler's Fallacy", and finds expression in such sayings as: "bad things always come in threes", and "a 100-year flood occurred here 3 years ago, so we won't have another one for 97 years". Persons operating under such assumptions are likely to act differently in mitigating hazards than persons employing a different logic. For example, someone ascribing to the first saying may overreact, while someone operating on the basis of the second may be inclined to do nothing. To elicit this information, respondents were asked whether the occurrence of a major flood in an area meant that the occurrence of another major flood, in that same area, was less likely, equally likely, or more likely; the correct response, of course, was "equally likely".

Locus of control--Locus of control has been hypothesized by Rotter (1966) as an important predictor of mitigation action. In the context of the present study, it describes whether or not a person feels efficacy for dealing with a hazard situation. For example, one may be aware of the flood hazard and be concerned about it but feel that there is really very little that can be done to mitigate its potential effects. Consequently, no actions are attempted which might lessen the impact of a disaster. On the other hand, one might feel that steps can be taken to minimize the adverse consequences, and may then act upon such a belief. The two attitudes may produce very different mitigation behavior, and therefore were examined in the study. Although difficulties have been encountered in asking such a question directly, such an approach seemed sufficient for the purposes of the present study.

Knowledge of local flooding--As a final measure of awareness, respondents were asked whether they knew if the creek in their area (Lena Gulch or Ralston Creek) had ever flooded. This was another effort to ascertain the manner in which respondents were assessing risk. As stated above, both areas experienced minor flooding in 1973, well within the direct experience of most respondents.

Hazard awareness index--An index of hazard awareness, similar to that of prior hazard experience, was created for each respondent. Each respondent was given a score of one for each of the following: a correct definition of the 100-year flood plain, a correct definition of the 1% flood plain, a code of "1" on the created variable matching perceived with objective location, if they were concerned about the possibility of flooding, if they assessed the chances of flooding in their area as 1 in 100 for the next year, if they responded that the chances were equally likely for a second flood occurrence, if they felt steps could be taken, and if they knew that the creek had flooded in the past. Summing the scores places each respondent on another 0-8 scale, this time for hazard awareness. The difficulties discussed in connection with the experience index also apply in this case. Again, this afforded the opportunity of handling hazard awareness as interval rather than nominal data, providing much greater flexibility in the analyses. Respondents in Lena Gulch averaged higher on the awareness scale than did respondents in either Ralston Creek population. This may be interpreted to mean that Lena Gulch respondents are more aware of the flood hazard than are Ralston Creek respondents. If one carries this through the hypothesis stated earlier, one would then be led to say that since the respondents in Lena

Gulch have higher awareness (and more hazard experience, as learned from the earlier analysis), they would be more likely to take mitigation actions. This relationship was also analyzed, and is discussed below.

Hazard mitigation behavior--In order to analyze which factors were likely to produce mitigation behavior, it was necessary to obtain information from the respondents about whether or not they had taken any mitigating actions, if so, what, and if not, why not. Questions were asked about four types of mitigation behavior. The results are presented in Table 4, and the specific actions taken are summarized in Table 5. First, respondents were asked whether or not they had developed any sort of emergency plan, e.g., an evacuation route, for use in case of a flood event. Second, they were asked whether or not they had purchased flood insurance. Both Arvada and Wheat Ridge are participating in the regular phase of the National Flood Insurance Program, which means that flood insurance is available to members of these communities at highly subsidized rates. Respondents were asked whether or not flood insurance was available in their area, and if so, whether or not they had purchased it. If they responded that it was not available, or that they did not know if it was available, they were then asked if they would purchase it if it were available. Third, respondents were asked if they had undertaken any measures to flood proof their residence (e.g. elevate the structure, install sumps or pumps, strengthen walls, or the like). Fourth, respondents were asked whether or not they had ever taken any public actions to deal with flooding, such as talking to friends or neighbors or attending community meetings. They were also asked if they would be willing to take such public actions in the future.

TABLE 4

HAZARD MITIGATION BEHAVIOR

A Comparison of Responses from Lena Gulch and Ralston Creek

Mitigation Behavior Indicator	Lena Gulch	Ralston Creek A	Ralston Creek B
Have you established an emergency plan (% responding yes)	40.9	34.1	49.3
Is flood insurance available (% responding yes)	72.3	61.5	74.7
Have you purchased flood insurance (% responding yes)	26.5	20.1	25.7
Would you purchase if available (% responding yes)	30.1	25.7	30.8
Have you flood-proofed your residence (% responding yes)	19.3	9.9	18.7
Have you taken public action to deal with floods (% responding yes)	37.3	18.7	24.0
Would you take action in the future (% responding yes)	80.7	55.8	59.2
Taken any action (% who had)	72.3	56.0	64.3
# of actions taken (mean score on index of actions)	1.20	0.80	0.95

TABLE 5

MITIGATION ACTIONS TAKEN

A Comparison of Lena Gulch and Ralston Creek*

	Lena Gulch (% responding yes)	Ralston Creek A (% responding yes)	Ralston Creek B (% responding yes)
Emergency Plan Actions	N=34	N-31	N=37
Evacuation route	100.0	83.9	94.6
Move contents	11.7	25.8	0
Operate electricity, water, etc.	5.8	3.2	0
Prepare sandbags	0	3.2	2.7
Provide food and water	0	3.2	0
Other	5.8	16.1	5.4
Flood-proofing Actions	N=16	N=9	N=14
Installed water tight windows and doors	12.5	22	7.1
Sealed walls and foundations	25.0	22	14.3
Strengthened walls	6.2	22	0
Installed drain sumps or pumps	31.2	22	0
Elevated structure on columns	18.8	0	7.1
Other	12.5	33.0	78.6
Public Actions	N=31	N=17	N=18
Talk to neighbors	38.7	64.7	50.0
Attend meetings	70.9	29.4	38.9
Support land acquisition	19.3	17.6	11.1

*Multiple responses were possible.

In addition to these mitigation variables, two other action variables were created for each respondent. The first was a dichotomous variable, and was created for each respondent to ascertain whether he or she had taken any action at all to mitigate the flood hazard. The variable was created by coding the respondent "1" if any of the above actions had been taken, and "0" if none had been taken. In Lena Gulch, 72.3% had taken action, while only 56.0% of the Ralston Creek A respondents had taken any flood mitigation actions. This figure for Ralston Creek B was 69.3%.

The second of these variables was created by summing all of the actions taken by a respondent, scoring one for each action taken (see Table 5) and then placing the respondent on a 0-15 scale of possible actions. Mitigation action could then be handled as interval data and subjected to various analyses. Again the Lena Gulch respondents displayed a higher number of actions (mean = 1.2) than did those from Ralston Creek A (mean = 0.8), or Ralston Creek B (mean = 0.9).

In addition to ascertaining which actions had been taken, it was important to understand the reasons actions had not been taken. For example, there is a fundamental difference between a respondent who does not purchase flood insurance because he or she does not know that it is available and one who does not purchase it because it is thought to be too expensive or unnecessary. The reasons given for not taking particular actions are summarized in Table 6.

Summary--The original hypothesis (i.e., the more hazard experience, the higher the hazard awareness; and the higher the hazard awareness,

TABLE 6

REASONS FOR NOT TAKING ACTION

A Comparison of Lena Gulch and Ralston Creek*

	Lena Gulch (% responding yes)	Ralston Creek A (% responding yes)	Ralston Creek B (% responding yes)
Reasons for no emergency plans	N=49	N=60	N=38
Not necessary	42.8	61.0	55.3
Have not thought about it	32.6	28.8	26.3
No knowledge of options	12.2	11.9	2.6
Other	14.3	10.3	18.4
Reasons for not purchasing insurance	N=61	N=70	N=37
Too expensive	43.2	24.3	27.0
Do not need	29.6	45.7	43.2
Renting	6.8	2.8	0
Other	20.5	22.9	29.7
Reasons for not flood-proofing	N=67	N=82	N=61
Too expensive	2.9	4.9	1.6
Not necessary	43.3	57.3	57.4
No knowledge of options	19.4	24.4	13.1
Renting	5.9	1.2	0
Other	31.3	23.4	24.5
Reasons for no public action	N=52	N=74	N=57
Not necessary	34.6	47.9	43.9
Don't have time	17.3	13.5	0
No knowledge of options	5.7	5.4	1.8
No interest	0	4.1	8.8
Other	44.2	33.8	47.4

*Multiple responses were possible.

the more mitigation actions are taken) is supported by these preliminary analyses. More rigorous testing of these relationships, and a clearer identification of the independent variables are presented in the next section.

Interaction of Variables

Four major sets of analyses were performed. One set was designed to examine for each population the relationships between the dependent variable, hazard awareness, and the independent variables, demographic characteristics, hazard information, and hazard experience. A second group of analyses was performed for each population to discern the relationships between the dependent variable, mitigation action behavior, and the independent variables, demographic characteristics, hazard experience, hazard information, and hazard awareness. The third set of analyses was carried out to identify significant relationships among the three populations in a comparative way. The fourth set of analyses, which is discussed in the final section of this chapter, was undertaken to explain the role played by the UDFCD information brochure in heightening awareness and increasing mitigation actions in the Lena Gulch and Ralston Creek B populations.*

Hazard awareness--When responses were analyzed to determine the factors most important for explaining differences in levels of awareness, one variable was identified as being significantly related in all

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*The complete data from these analyses are available, in aggregated form, upon request from the Institute of Behavioral Science, University of Colorado.

three populations. This was prior hazard experience, as measured on the created experience scale. It was shown to have a positive relationship with awareness (i.e. the more experience, the higher awareness). This supports the original hypothesis of the study.

Other factors which were significantly related to increased hazard awareness in one population or another included having suffered damage from flooding, the respondent's age (the younger, the more aware), the perpendicular distance from the creek (the closer, the more aware), how long the respondent had lived at his/her present address (the longer, the more aware), and the property and content value (the higher, the more aware).

However, very little can be said, with confidence, about any of these factors acting independently, but only that as a group, they seem to account for a large part of the variance in hazard awareness. The reason for this caveat is that there is considerable correlation between many of these factors (e.g. in Lena Gulch, the correlation between age and tenure is .590).

Mitigation action behavior--As described above, mitigation action was separated into two distinct dependent variables for examination. One of these was the binary variable of whether a respondent had taken any mitigation actions at all (yes/no). The other was the variable which described how many separate mitigation actions the respondent had taken (0-15 scale). The analyses for each are discussed, in turn, beginning with the dichotomous action variable.

In the series of analyses which examined whether or not a respondent had taken any mitigation action whatsoever, the intent was to discern

which factors were likely to be most important in influencing that decision.

Lena Gulch--Seven variables seem to be most significantly related to taking or not taking action for this population. These are being concerned about the possibility of flooding, knowing that Lena Gulch had flooded in the past, having experienced a flood previously, living in a single-family residence, owning rather than renting, knowing someone who had experienced other natural disasters, and remembering receiving the Urban Drainage and Flood Control District brochure.

A further examination of the make-up of Lena Gulch respondents who took action revealed that they are older, have been at their present address longer, live closer to the creek, have higher hazard awareness, and have more hazard experience. The best predictors of whether or not a person in Lena Gulch would take action include, in their order of importance, the length of residency, the recency of an experienced flood, the amount of prior hazard experience, the distance from the creek, and the property value of the residence.

Ralston Creek A--In this population, five variables seem to be most significantly related to having taken action. These are being concerned about the possibility of flooding, knowing Ralston Creek had flooded in the past, knowing someone who had experienced a flood, owning rather than renting, and the value of contents.

The characteristics of those most likely to take action in this sample were almost identical to those in the Lena Gulch group. Here, the best predictors, in the order of their importance, of whether a respondent would fall into the action or no action category were the

amount of prior hazard experience, the length of residency, the degree of hazard awareness, the number of adults in the household, and the recentness of an experienced flood.

Ralston Creek B--In this sample, three factors seem to be significantly related to taking action. These include being concerned about the possibility of flooding, the distance from the residence to the creek, and remembering receiving the UDFCD brochure.

Again those most likely to take action were older, had been at their present address longer, had higher property and content value, had higher hazard awareness, and more hazard experience. For this sample, the best predictors of whether a respondent would take action or not were the degree of hazard awareness, the content value, the distance from the creek, the amount of hazard experience, and the property value.

Number of actions taken--An analysis was performed for each population to determine the most significant factors for predicting what type of respondent is likely to take the most actions. In each analysis the created action scale was the dependent variable. For Lena Gulch, five independent variables were identified which accounted for 54% of the variance in the number of actions taken by respondents. These five, in the order of their explanatory power are: 1) experiencing damage from a flood; 2) hazard awareness; 3) respondent's age; 4) property value; and 5) prior hazard experience. All are positively related with taking more actions. In other words, the more of each, the more actions.

For Ralston Creek A, analysis was not possible because there was very little variance in the dependent variable (number of actions taken).

However, for Ralston Creek B, there was enough variance in the dependent variable to allow analysis. Here, 40% of the variance was accounted for by seven variables. These variables, in the order of their explanatory importance are: 1) hazard awareness; 2) content value; 3) prior hazard experience; 4) flood recentness (the more recent, the more actions); 5) distance to the creek (the closer, the more actions); 6) the length of residency; and 7) the number of children in the household. All of these except as noted, are positively related with taking more actions.

The foregoing analyses identified a number of interesting factors about hazard experience, hazard awareness, and hazard mitigation behavior. These will be interpreted and summarized in the final chapter.

Comparison of Populations

Two analyses were carried out to identify important differences, if any, among the three populations of respondents. The first identified the following as significant differences. The Ralston Creek B sample had lived at their present address longer than either of the other samples, were older, and had more property and content value. On the other hand, the Lena Gulch sample had higher hazard awareness, more hazard experience, had a larger percentage of respondents taking action, and had taken more mitigation actions than the other populations.

The second analysis produced the following significant results:

1. There was considerably higher concern about the possibility of flooding in Lena Gulch than in either Ralston Creek group. However, there was higher concern expressed in the Ralston Creek A group than in Ralston Creek B. The reason for this latter finding is not clear. One explanation may be that increased knowledge, of certain types, may instill a sense of security, and therefore, a lowered degree concern.
2. A much larger percentage of respondents had heard friends or neighbors talking about the possibility of floods in the Lena Gulch and Ralston Creek B populations than in the Ralston Creek A population.
3. A much larger percentage of the Lena Gulch and Ralston Creek B respondents had read about the possibility of flooding in the newspapers than had those in Ralston Creek A.
4. A larger percentage of the respondents of Lena Gulch and Ralston Creek B had taken public actions to deal with flood associated problems.
5. A much higher percentage of Lena Gulch respondents stated they would be willing to take public actions in the future, than the respondents in either Ralston Creek group.
6. A much larger percentage of the Lena Gulch respondents had personally experienced a flood.
7. A much higher percentage of respondents owned their residences in the Ralston Creek populations than in the Lena Gulch group.
8. A much higher percentage of the Lena Gulch and Ralston Creek B populations had taken some mitigation action to deal with flood problems than had the Ralston Creek A respondents.

Summary--The findings just presented indicate a number of important differences among the populations. These findings are in keeping with the hypothesis set out earlier. From the analyses conducted, it appears that the Lena Gulch population has had a greater amount of prior hazard experience, has higher hazard awareness, has a larger percentage of persons who have taken mitigation actions, and, on average, has respondents who have taken a greater number of mitigation actions. Several findings may also hint at the influence of the brochure put out by the UDFCD. These are discussed in the final section of the report.

The UDFCD Brochure

Since respondents were only asked nominal questions about the brochure, the most meaningful analysis which could be performed to assess its impact was a chi-square test. Accordingly, such an analysis was performed which correlated remembering receiving the brochure/not remembering the brochure with 10 other variables. The following results were obtained for the Lena Gulch populations.

1. Of the 9 respondents who knew the correct definition of the 100-year flood plain, 88.9% of them remembered receiving the UDFCD brochure. (Significant at the 92% confidence level.)
2. Of 30 respondents who were concerned about the possibility of flooding, 70% of them remembered receiving the brochure. Of 31 respondents who remembered receiving the brochure, 67.7% were concerned about flooding. Of 52 respondents who did not remember receiving the brochure, only 17.3% were concerned about flooding. (Significant at the 95% confidence level.)

3. Of 20 respondents correctly assessing the probability of flooding in their area as 1% in the next year, 12 (60%) remembered receiving the UDFCD brochure. Out of 31 respondents who remembered the brochure, 38.7% of them correctly assessed the chances of flooding, while of the 52 who did not remember receiving the brochure, only 15.4% assessed the probability correctly. Also in the former group, only 25.8% assessed the flood probability as 0, while in the latter group, this assessment (0 probability) was made by 47.8%. (Significant at the 98% confidence level.)
4. Of the 26 respondents who had developed an emergency plan, 73.1% of them remembered receiving the UDFCD brochure. Out of 31 respondents who remembered receiving the brochure, 61.3% had developed an emergency plan. Of the 52 respondents who did not remember receiving a brochure, only 13.5% had developed an emergency plan. (Significant at the 97% confidence level.)

The following variables were also tested in this chi-square but found to have no significant relation to the UDFCD brochure: definition of the 1% flood plain, purchasing flood insurance, floodproofing, or taking public action.

For the Ralston Creek B population the following significant relationships were identified:

1. Of 46 respondents who had taken some form of hazard mitigating action, 80.4% remembered receiving the UDFCD brochure. Of the 47 respondents who remembered receiving the brochure, 78.7% had taken mitigation actions. (Significant at the 95% confidence level.)

2. Of 18 respondents who knew the correct definition of the term 100-year flood plain, 88.8% remembered receiving the UDFCD brochure. (Significant at the 97% confidence level.)
3. Of 36 respondents who correctly answered the question regarding the Gambler's Fallacy, 67.4% remembered receiving the brochure. Of the respondents who remembered receiving the UDFCD brochure, 62.5% correctly answered the Gambler's Fallacy question. (Significant at the 95% confidence level.)

The following variables were also tested in this analysis but found to have no significant relationship to the UDFCD brochure: definition of the 1% flood plain, concern about flooding, correctly assessing future flood probabilities, purchasing flood insurance, flood-proofing, developing an emergency plan, taking public actions, and the locus of control issue.

The role of the UDFCD brochure will be discussed further in the final chapter.

SUMMARY AND CONCLUSIONS

The analyses performed have produced a number of significant findings relative to the two dependent variables: hazard awareness and hazard mitigation behavior. Further, several important things have been learned about the effect of a particular type of information, the brochure produced by the Urban Drainage and Flood Control District. This chapter will summarize and interpret the findings, present recommendations for modifying or focusing the brochure, and for future research.

Summary of Findings

Hazard Awareness--An index of hazard awareness was created for each respondent, and analyses were conducted to identify those factors which best accounted for differences in respondent awareness. The single factor identified as an important predictor of hazard awareness in all three populations was prior hazard experience, as measured by the hazard experience index. In each case, this factor was among the top three explanatory variables of awareness. This supports the first part of the original hypothesis of this study, that increased hazard experience may lead to increased hazard awareness. However, no threshold level was discovered, i.e., it was not possible to identify how much experience is necessary to heighten awareness.

Another explanatory variable which was significant for the Lena Gulch and Ralston Creek A populations was the length of time the respondent had lived at his/her present residence. This is related directly to awareness, so that the longer the person had lived in the area, the more aware he or she was of the flood hazard. It was stated above that this variable was interpreted to be an indicator of hazard experience, and indeed the analysis indicates a high degree of correlation.

Two other factors which were significant for the Lena Gulch and Ralston Creek B populations were the respondent's age and the perpendicular distance from the residence to the creek. Each was negatively related to awareness. In the case of distance to the creek, it makes intuitive sense that the closer one is, the more aware one is likely to be. However, in the case of age, this inverse relationship (i.e. the younger the more aware) is counter to some aspects of the study's logic.

For example, one would hypothesize that length of residence and other hazard experience would increase with age. Since on the basis of analyses conducted in this study these are directly related to awareness while age is not, obviously some other factor is at work, or the result is an artifact of the data.

Hazard mitigation behavior--Again variables were created for each respondent to allow a greater variety of analyses. One variable was a simple dichotomy--had a respondent taken action or not. The second was a scale of the number of individual mitigation actions a respondent had taken.

Action dichotomy--One set of analyses was performed for each population to discover any significant interaction between hypothesized predictors and action. Out of a number of variables which were shown to be relevant, one was identified which was significant for all three populations. This was a concern about the possibility of flooding. The respondents who expressed concern were substantially more likely to take action. It is interesting to note that the majority of those concerned gave past experience as the major reason for this concern.

A second factor which was significant for the Lena Gulch and Ralston Creek A groups was knowing that the creek had flooded in the past. Again, those who knew were far more likely to take action than those who did not know. This variable may also be tied to hazard experience and hazard awareness.

In the Lena Gulch and Ralston Creek A groups homeowners were found to be more likely to take action than renters. Some of these data may be somewhat artificial due to the extreme preponderance of owners in the

samples. In fact, there were no renters at all in the Ralston Creek B population.

In the case of the Lena Gulch and Ralston Creek B groups, a fourth important predictor of action was whether or not the respondent remembered receiving the UDFCD brochure. Substantially more people who remembered receiving the brochure took action than those who did not remember receiving it.

Other factors which were significant for predicting action in one or more groups were having experienced a flood, knowing someone who had experienced a flood or another natural disaster, and living in a single family residence.

When second of analyses was performed to characterize and contrast the respondents who took action with those who did not, remarkably similar profiles were obtained for the three samples. In each case the respondents who had taken action were older, had lived at their present address longer, were closer to the creek, had higher hazard awareness, and had more previous hazard experience. These data lend a great deal of support to the original hypothesis.

Finally those factors were discerned which are the most successful predictors of whether or not a person will take action. Here the three samples agreed two out of five times, each listing prior hazard experience, and length of residency among the five most successful predictors. These findings corroborate other evidence presented for predicting action behavior.

Action scale--Only two analyses were successfully performed for this variable. Two variables, hazard awareness and prior hazard experience,

were important in both populations for predicting the number of actions a respondent is likely to take. Other factors which were important in one group or the other were experiencing damage from flooding, property value, content value, and the recentness of an experienced flood.

Information brochure--An analysis of the effects of the brochure produced by UDFCD revealed a number of interesting findings. Among the explicit findings, the following are of particular interest: 1) in both populations, the largest percentage of respondents who knew the definition of the 100-year flood plain remembered receiving the brochure; 2) a substantially larger percentage of those respondents in Lena Gulch who expressed concern about the possibility of flooding remembered that they had received the brochure; 3) a large percentage of the Lena Gulch respondents who correctly assessed the probability of flooding had received the brochure; 4) conversely, a much smaller percentage of these respondents incorrectly assessed the flooding possibility as zero; 5) a much larger percentage of the Ralston Creek B respondents who correctly assessed the Gambler's Fallacy situation remembered receiving the brochure; and 6) a much larger group from both populations who took mitigation actions remembered receiving the brochure.

In addition to these findings, a number of other factors may be attributed through inference to the influence of the brochure. For example, while analyses showed a significantly higher awareness for the Lena Gulch respondents than the Ralston Creek A respondents, the difference in awareness between Lena Gulch and Ralston Creek B was not significant. Also, although the difference in the number of actions taken was significantly higher in Lena Gulch than in Ralston Creek A, this difference was not

significant between Lena Gulch and Ralston Creek B. Two additional findings of interest, which may be attributable to the influence of the UDFCD brochure, are 1) significantly more respondents have heard friends or neighbors discussing the possibility of flooding in Ralston Creek B than in Ralston Creek A; and 2) significantly more respondents have read about the possibility of flooding in the newspapers in Ralston Creek B than in Ralston Creek A. Other factors being equal, one might postulate that these increases may be due to a sensitizing effect of the UDFCD brochure. In other words, once awareness of flooding had been heightened by the brochure, the residents may have begun to pay greater heed to other sources of flood information. Such an effect would be worth investigating in greater detail, as it may have important implications for this and other public awareness programs.

Interpretation and Recommendations

The UDFCD information brochure--On the basis of these limited analyses it is possible to say in a preliminary way that the brochure is effective both in heightening awareness and in motivating action behavior. It also seems to play a significant role in promoting increased concern about the possibility of flooding, an additional factor found to be important for taking protective actions. However, it is of particular interest to note that approximately one year after the dissemination of the brochures only 37% of the respondents remembered receiving the information. However, in the case of the Ralston Creek B population, which was interviewed from four to six weeks after the brochure was

disseminated, the rate for remembering the brochure increased to 62%. Further research seems needed to evaluate why certain people remember receiving such information while others do not. It could be that a process of self-selection is taking place. That is, the people who remember receiving the information may be those who are already interested in, or concerned about flooding. Consequently, a change in the format of the brochure may be required to heighten its memorability.

Specific recommendations for modifying the content of the brochure include the following: 1) making the map more understandable and useful; 2) specifying clearly on the brochure that it is being distributed only to those persons who are actually in the floodplain; 3) providing a history of flooding in the particular drainage and a description of maximum levels reached; 4) providing flood insurance rates, and stating that flood insurance is available to renters to cover content losses; 5) discussing, in more detail, the fact that the occurrence of one flood does not alter the probability of occurrence of another flood in the same area; 6) clarifying the definition of 100-year flood and 100-year flood plain; and 7) providing a more comprehensive list of actions that individuals may take to mitigate the hazardous consequences of a flood.

Additionally, the present study has been able to tentatively identify those respondents who are less likely to take protective actions. These findings have direct implications for the dissemination of hazard information such as the UDFCD brochure. For example, the findings would suggest that a particularly concentrated effort be made to notify newer residents, those living farther from the creek, renters, and people with less prior hazard experience. Finally, given the percentages of respondents who

remembered receiving the brochure, it seems quite important, as the UDFCD has already recognized, to disseminate the information on a sustained basis.

Hazard awareness and mitigation behavior--The question of the relationship between prior hazard experience and hazard awareness has produced conflicting results in the past. This study has shown a positive association between the two, i.e. more experience produces heightened awareness.

Past research on the possible associations between hazard awareness, prior hazard experience, and mitigation behavior has yielded contradictory findings. This study has shown positive relationships between experience, awareness, and taking protective measures to mitigate the adverse consequences of flooding. Of course, such findings cannot be taken as conclusive, and a number of salient questions are raised by these results.

For example, if hazard experience is an important predictor of awareness, how much and what type experience is necessary to produce awareness? Can information provide an effective surrogate for personal experience, and if so, what is the most productive way of presenting such information to the public? Must one suffer damage from flooding before one takes protective measures, and if so, how much? Is all experience likely to generate mitigation behavior, or does experiencing a number of small events lead to the conclusion that nothing larger can happen? A number of these questions relate to thresholds of acceptable risk. All need to be answered if the existing relationships are to be illuminated in a meaningful way.

Conclusion

This study set out to test a number of relationships which have previously been explored in the literature of natural hazards management. Although the present research has not resolved the earlier issues in a definitive way, the findings do lend support to the association between hazard experience and hazard awareness, and, in turn, between these and taking protective action. The study has identified a number of issues which will require further exploration to determine the precise nature and extent of these relationships.

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APPENDIX A

PRE-INTERVIEW NOTIFICATION LETTER

UNIVERSITY OF COLORADO AT BOULDER
Boulder, Colorado 80309

INSTITUTE OF BEHAVIORAL SCIENCE

March 7, 1978

Dear j:

The Denver Urban Drainage and Flood Control District is currently in the process of evaluating the effectiveness of a recent information campaign.

As a part of this effort, we at the Institute of Behavioral Science of the University of Colorado will be conducting a series of short (approximately 15 minute) telephone interviews. The purpose of the interviews will be to find out how effective the information campaign has been.

We would greatly appreciate your cooperation when we call during the week of March 13.

Sincerely,

Marvin Waterstone

MW/jm

FLOOD HAZARD INFORMATION BROCHURE

DEFINITIONS

1. One-Hundred Year Flood - A flood that will be equaled or exceeded on the average of once every one hundred years. It has about a 1% chance of occurring in any year or about a 30% chance of occurring over the life of a 30-year mortgage.

2. One-Hundred Year Flood Plain - That area next to a stream or gulch which would be flooded by a one-hundred year flood.

3. [illegible] - That area next to a stream or gulch which will be or [illegible] flooded. The natural [illegible] usually greater than [illegible] flood plain.

The Urban Drainage & Flood Control District
2480 West 26th Avenue, Suite 156-B
Denver, Colorado 80211

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LENA GULCH

1978

Flood Hazard INFORMATION

LENA GULCH FLOOD PLAIN

In 1973, the Urban Drainage and Flood Control District joined with Wheat Ridge, Lakewood, Jefferson County, and Golden to complete a flood control plan for Lena Gulch. The consulting firm of Wright-McLaughlin Engineers was retained to complete the study.

As a part of the flood control study, the engineers defined the 100-year flood plain. The flood plain is shown in a report entitled, "Lena Gulch Master Drainage Plan," dated June, 1975.

PURPOSE OF THIS NOTIFICATION

This brochure has been delivered to occupants living in or near the 100-year flood plain as defined on the brochure's map and has been made available to the general public. The purpose of this notification is to inform the public of the flood hazards associated with Lena Gulch from Clear Creek to the confluence of Jackson and Apex Gulches. The map on the back of this page shows the approximate 100-year flood plain limits at a scale of 1" = 2000'. More detailed maps, at a scale of 1" = 200' are contained in "Lena Gulch Master Drainage Plan." Copies of the more detailed maps are on file at the offices of the Urban Drainage and Flood Control District (455-6277), Lakewood City Engineer (234-8858), Lakewood Superintendent of Code Administration (234-8860), Wheat Ridge Planning Office, Department of Community Development (422-8028), Golden Community Development Department (279-3331), and Jefferson County Engineer (279-5575).

The 100-year flood plain has been defined by Colorado (HB 1041) and Federal Law (Public Law 93-234) as the flood hazard area which should be identified, designated, and regulated by local governments. LARGER FLOODS CAN AND DO OCCUR.

Flood plain limits can change due to road and bridge construction, flood plain development, flood control improvements, or natural processes. The flood plain shown on the map was defined using the best engineering techniques available for channel and flood plain conditions existing at the time of the study and future basin urbanization. The flood plain was [illegible] by the Colorado Water [illegible] on July [illegible], 1975.

NOTICE TO OCCUPANTS OF THE LENA GULCH FLOOD PLAIN DOWNSTREAM FROM MAPLE GROVE RESERVOIR

Maple Grove Reservoir is owned by the Consolidated Mutual Water Company. Although it was constructed as a water supply facility, Maple Grove Reservoir does provide some flood control for the more frequent flood events. However, it should not be relied upon to provide protection from large floods.

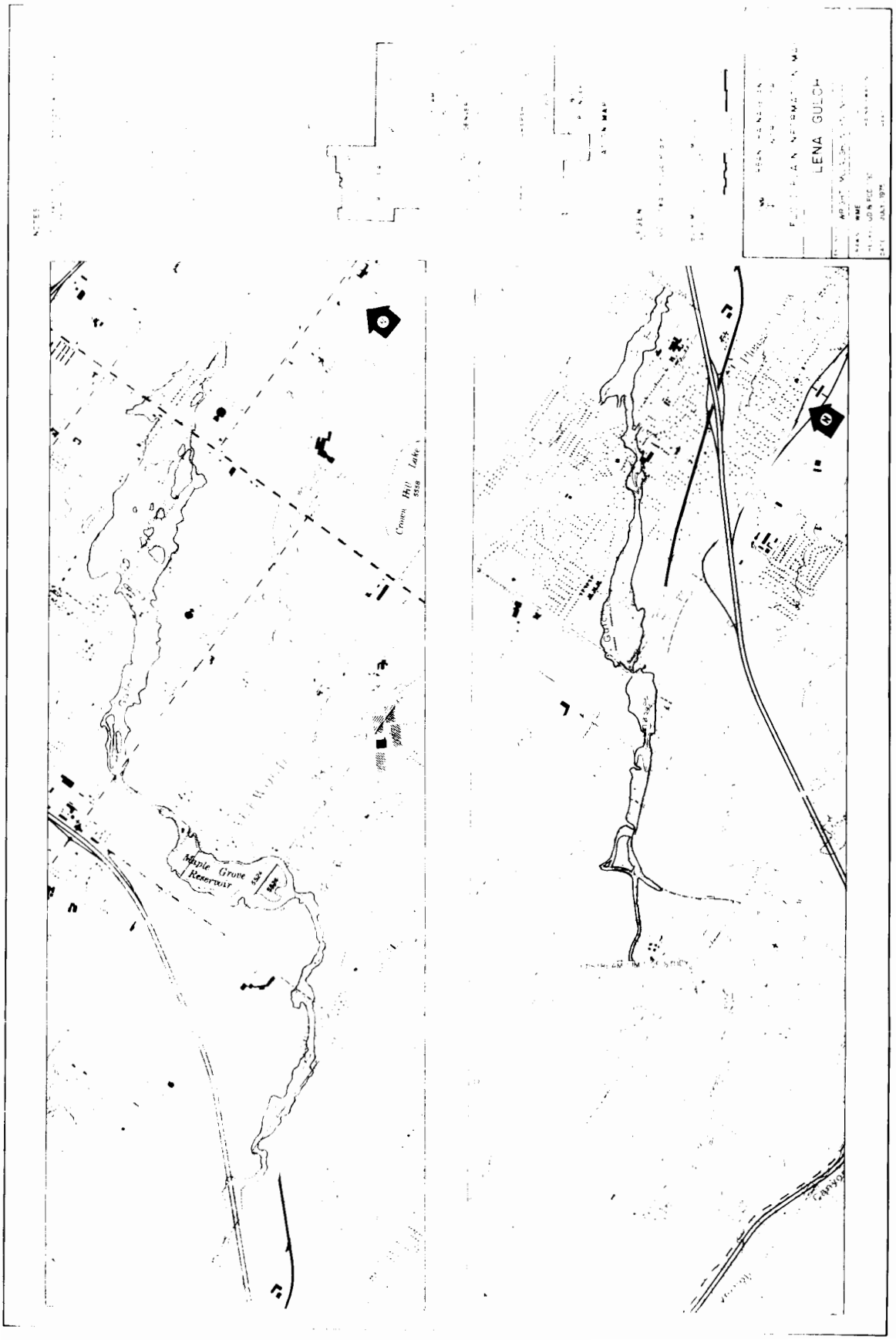
[illegible] the reservoir [illegible] were [illegible] purpose [illegible] the dam [illegible] floods [illegible] through [illegible]

[illegible]

WHAT CAN [illegible]

[illegible] own property [illegible] shown on the [illegible] you can [illegible] the flood hazard [illegible] you can take [illegible]

1. [illegible]
2. Plan escape route [illegible] ground.
3. Buy flood insurance [illegible] insurance agent [illegible] you.
4. During times of heavy [illegible] watch the level of water [illegible]


LENA GULCH
Crown Hill
5558
Maple Grove
Reservoir

APPENDIX C

QUESTIONNAIRE SUMMARY

Content Area		Question Number
1.	Flood Hazard Awareness	II.A., II.B., II.C., II.D., II.E., II.F.
2.	Prior Hazard Experience	II.G., II.H., II.I., IV.A., IV.B., IV.C., IV.D., IV.E.
3.	Demographic Factors	I.D., V.A., V.B., V.C., V.F., V.G., V.H.
4.	Mitigation Action Behavior	III.A., III.B., III.C., III.D., III.E.
5.	Receipt of Brochure	VI.A.

		Lena Gulch (N=83)	Ralston Creek A (N=91)	Ralston Creek B (N=75)
I.	Personal Data			
	A. Name of respondent _____			
	B. Address _____			
	C. Received letter			
	Yes	58-69.9%	64-70.3%	57-80.3%
	No	25-30.1%	27-29.6%	14-19.7%
	D. How long have you been at your present address?			
	1. Under 1 year	9-10.8%	10-10.9%	0-0.0%
	2. 1-3 years	22-26.5%	18-19.8%	18-24.0%
	3. 4-6 years	13-15.7%	18-19.8%	11-14.7%
	4. 7-10 years	14-16.9%	15-16.5%	15-20.0%
	5. Over 10 years	25-30.1%	30-32.9%	31-41.0%
II.	Awareness of Flood Hazard			
	A. What does the term "100 year floodplain" mean to you?			
	Incorrect	45-54.2%	42-46.7%	30-40%
	Correct	11-13.2%	12-13.3%	19-25.3%
	Don't know or no response	27-32.5%	36-40.0%	26-34.7%
	B. What does the term "1% floodplain" mean to you?			
	Incorrect	13-15.7%	14-15.7%	4-5.3%
	Correct	8-9.6%	10-11.2%	6-8.0%
	Don't know or no response	62-74.6%	65-73.0%	65-86.7%

	Lena Gulch	Ralston Creek A	Ralston Creek B
C. Where is your residence in relation to a "100 year floodplain?"			
1. In	60-72.3%	43-47.3%	33-44.6%
2. Out	6-7.2%	8-8.8%	3-4.1%
3. Fringe	4-4.8%	13-14.2%	27-36.5%
4. Don't know	13-15.6%	27-29.6%	11-14.9%
D. Are you concerned about the possibility of your residence being flooded? Yes	41-49.4%	57-62.6%	24-32.0%
No	42-50.6%	34-37.4%	51-68.0%
1. Why are you concerned? (Note probe)			
a. Past experience	24-58.5%	11-32.3%	11-45.8%
b. Residence location	8-14.5%	5-14.7%	3-12.5%
c. Flooding is possible	4-9.8%	12-35.2%	5-20.8%
d. Other reasons	7-17.1%	8-24.2%	6-25.0%
2. Why not? (Note probe)			
a. Not near enough to creek	10-23.8%	12-20.7%	12-43.1%
b. Flood not frequent enough	7-16.7%	15-25.8%	7-13.7%
c. Elevation	19-45.2%	18-31.0%	9-17.6%
d. Control works	2-4.8%	3-5.1%	3-5.9%
e. Renting	3-7.1%	1-1.7%	0-0.0%
f. Other	14-33.3%	28-48.3%	27-52.9%
3. Is a, b, or c an important factor in your not being concerned?			
a. Yes _____			
b. No _____			
c. Which _____			
E. What do you feel are the chances of your residence being flooded this year? Do you feel they are:			
1. 0	33-39.7%	51-56.6%	43-58.1%
2. 1 in 100	30-36.1%	25-27.7%	21-28.4%
3. 5 in 100	9-10.8%	7-7.7%	8-10.8%
4. 10 in 100	5-9.6%	4-4.4%	0-0.0%
5. Over 10 in 100	3-3.7%	3-3.3%	2-2.7%
F. Does the occurrence of a major flood in a given area mean that the occurrence of another major flood in the same area is:			
1. Less likely	10-12.2%	15-16.6%	8-12.1%
2. Equally likely	41-50.0%	51-56.6%	42-63.6%
3. More likely Why?	31-37.8%	24-26.7%	16-24%
G. Have friends or neighbors ever talked to you about the possibility of flooding in your area?			
1. Yes	46-55.4%	36-39.6%	40-53.3%
(What have they said?)			
2. No	37-44.5%	55-60.4%	35-46.7%
H. Have you ever heard anything on TV or the radio regarding the possibility of flooding in your area?			
1. Yes	18-21.9%	13-14.3%	15-20.3%
2. No	64-78.0%	78-85.7%	59-79.7%

	Lena Gulch	Ralston Creek A	Ralston Creek B
I. Have you ever read anything in the newspapers regarding the possibility of flooding in your area?			
1. Yes	33-40.2%	18-19.8%	33-44.0%
2. No	49-59.7%	73-80.2%	42-56.0%
III. Mitigation Actions			
A. Is flood insurance available in your community?			
1. Yes	60-72.3%	56-66.5%	56-74.7%
No	5-6.0%	4-4.4%	4-5.3%
Don't know	18-21.7%	31-34.1%	15-20.0%
2. Have you purchased flood insurance?			
a. Yes	16-26.5%	12-20.9%	18-25.7%
(When was it purchased?)			
b. No	44-73.4%	44-79.1%	
(Why not?)			
1. Too expensive	19-43.2%	12-27.3%	10-27.0%
2. Don't need	13-29.5%	18-40.9%	16-43.2%
2a. Renting	3-6.8%		
3. Other	9-20.5%	10-22.7%	11-29.7%
3. Would you purchase flood insurance if it were available?			
a. Yes	9-39.1%	9-25.7%	4-30.8%
b. No	14-60.8%	26-74.2%	9-69.2%
(Why not?)			
1. Too expensive	4-28.6%	5-20.83%	0-0.0%
2. Don't need	6-42.8%	14-58.3%	6-66.7%
2a. Renting	2-14.3%	2-8.3%	3-33.3%
3. Other	2-14.3%	6-26.0%	
B. Have you taken any measure to flood-proof your residence?			
1. Yes	16-19.3%	9-10.0%	14-18.7%
a. installed water-tight windows and door closures	2-12.5%	2-22.0%	1-7.1%
b. sealed walls and foundations against seepage	4-25.0%	2-22.0%	2-14.3%
c. strengthened walls to resist water pressure	1-6.2%	2-22.0%	0-0.0%
d. install drain sumps or pumps	5-31.2%	2-22.0%	0-0.0%
e. elevate structure on open columns	3-18.8%	0-0.0%	1-7.1%
f. other	2-12.5%	3-33.0%	11-78.6%
2. No Why not? (Note probe)	67-80.7%	82-90.0%	61-81.3%
a. too expensive	2-2.9%	4-4.9%	1-1.6%
b. not necessary	29-43.3%	47-57.3%	35-57.4%
c. no knowledge of options	13-19.4%	20-24.4%	8-13.1%
d. other	21-31.3%	19-23.4%	18-29.5%
e. renting	4-5.9%	1-1.2%	

			Lena Gulch	Ralston Creek A	Ralston Creek B
C.	Have you established a plan of action in case of flood?				
	1.	Yes	34-40.9%	31-34.0%	37-49.3%
		What does the plan include?			
		a. evacuation route	34-100.0%	26-83.9%	35-94.6%
		b. moving damageable contents to higher level	4-11.7%	8-25.8%	0
		c. emergency means for operating electricity, water, and sanitary services	2-5.8%	1-3.2%	0
		d. preparation of sandbags	0	1-3.2%	1-2.7%
		e. provision of emergency food and water	0	1-3.2%	0
		f. other	2-5.8%	5-16.1%	2-5.4%
	2.	No Why not? (Note probe)	49-59.0%	60-65.9%	38-50.7%
		a. not necessary	21-42.8%	36-61.0%	21-55.7%
		b. haven't thought about it	16-32.6%	17-28.8%	10-26.3%
		c. no knowledge of options	6-12.2%	7-11.9%	1-2.6%
		d. other	7-14.3%	6-10.3%	7-18.4%
D.	1.	In dealing with flood-associated problems, have you ever taken any public actions?			
		Yes	31-37.3%	17-18.7%	18-24.0%
		No	52-62.6%	79-81.3%	57-76.0%
		a. talking to neighbors	12-38.7%	11-64.7%	9-50.0%
		b. attending community meetings	22-70.9%	5-29.4%	7-38.9%
		c. supporting public acquisition of floodplain land	6-19.3%	3-17.6%	2-11.1%
	2.	If not, why not? (skip if any checks on 1.)			
		a. not necessary	18-34.6%	35-47.9%	25-43.9%
		b. don't have time	9-17.3%	10-13.5%	0
		c. no knowledge of options	3-5.7%	4-5.4%	1-1.8%
		d. no interest	0	3-4.1%	5-8.8%
		e. other	23-44.2%	24-33.8%	27-47.4%
	3.	Would you be willing to take such public actions in the future?			
		a. Yes In what ways?	67-80.7%	48-55.8%	42-59.2%
		i. Talk to neighbors	11-16.4%	10-22.7%	1-2.4%
		ii. attend meetings	26-38.8%	16-36.4%	7-16.7%
		iii. almost anything	5-7.5%	3-6.8%	1-2.4%
		iv. other	35-53.0%	24-60.0%	24-80.9%

	Lena Gulch	Ralston Creek A	Ralston Creek B
b. No			
Why not?	16-19.2%	38-44.2%	29-40.8%
i. not necessary	6-37.5%	9-23.7%	9-30.0%
ii. no time	4-25.0%	3-7.9%	3-10.3%
iii. renting	2-12.5%	2-5.3%	1-3.4%
iv. other	5-31.2%	21-61.8%	16-55.2%
E. Do you feel that people can take steps to prevent or minimize damage due to flooding, or do you feel that if a flood is going to come, there is very little one can really do about it?			
1. people can take steps	50-60.2%	49-54.4%	47-67.1%
2. very little one can do	33-39.7%	41-45.5%	23-32.9%
IV. Hazard Experience			
A. To your knowledge has (name of creek) ever flooded?			
Yes	65-79.2%	51-56.6%	31-41.3%
No	17-20.7%	39-43.3%	44-58.7%
B. Have you personally experienced a flood?			
1. Yes	55-66.2%	50-56.2%	32-42.7%
No	28-33.7%	50-56.2%	43-57.3%
a. When _____			
b. Was that the most recent flood you've experienced?			
i. Yes _____			
ii. No _____ When most recent? _____			
c. where _____			
2. Have you suffered damage in a flood?			
a. Yes			
How much?	17-20.7%	11-14.9%	8-10.7%
b. No	65-79.2%	63-85.1%	67-89.3%
C. Do you know someone who has experienced a damaging flood?			
1. Yes	47-56.6%	53-58.2%	35-46.7%
a. who _____			
b. when _____			
c. where _____			
2. No	36-43.3%	38-41.8%	40-53.3%
D. Have you personally experienced any other type of natural disaster, e.g., an earthquake, a fire, hurricane or tornado?			
1. Yes	29-34.9%	33-36.3%	28-37.3%
a. what type _____			
b. when _____			
c. where _____			
2. No	54-65.0%	58-63.7%	47-62.7%
E. Do you know someone who has experienced any other type of damaging natural disaster?			
1. Yes	26-31.1%	37-41.1%	21-28.0%
a. who _____			
b. what type _____			
c. when _____			
d. where _____			
2. No	57-68.6%	53-58.9%	54-72.0%

	Lena Gulch	Ralston Creek A	Ralston Creek B
V. Demographic Data			
A. Age of respondent			
1. 18-25	6-7.2%	10-10.9%	3-4.1%
2. 26-35	26-31.3%	23-25.3%	14-18.9%
3. 36-45	16-19.3%	19-20.8%	19-25.7%
4. 46 or over	35-42.1%	39-42.9%	38-51.4%
B. Number of persons in household:			
Adults (18+)	2.02	2.177	2.3
Children	.99	1.266	1.3
C. House	64-77.1%	82-90.1%	73-98.6%
Mobile Home	0-0.0%	1-1.1%	0-0.0%
Apartment	19-22.8%	8-8.8%	1-1.4%
D. Is your apartment building insured against flooding?			
1. Yes	2-10.5%	0-0.0%	0-0.0%
2. No	2-10.5%	0-0.0%	0-0.0%
3. Don't know	15-79.0%	8-100%	75-100%
E. Is your apartment building floodproofed?			
1. Yes	0-0.0%	0-0.0%	0-0.0%
2. No	7-36.8%	2-25.0%	0-0.0%
3. Don't know	12-63.2%	6-75%	75-100%
F. Own	59-71.0%	77-86.5%	73-98.6%
Rent	24-28.9%	12-13.4%	1-1.4%
G. Market value of property			
1. $15-30K	6-10.9%	5-6.5%	1-1.4%
2. 31-45K	17-30.9%	23-29.8%	13-18.6%
3. 46-60K	21-38.1%	36-46.8%	33-47.1%
4. over $60K	11-20.0%	13-16.8%	23-32.7%
5. no response	28	14	5
H. Value of contents			
1. $ 5-10K	32-47.0%	18-31.0%	14-20.6%
2. 10-25K	30-44.1%	32-55.2%	36-52.9%
3. 26-40K	5-7.3%	7-12.2%	12-17.6%
4. over $40K	1-1.5%	1-1.7%	6-8.8%
5. No response	15	31	7
VI. Receipt of Notification			
A. Did you receive a flood information brochure from the Denver Urban Drainage and Flood Control District in 1977?			
1. Yes	31-37.3%		47-62.7%
2. No	23-27.7%		17-22.7%
3. Don't remember	29-34.9%		11-2.2%
B. Was the brochure useful?			
1. Yes _____ In what ways?			
a. heightened awareness of flood hazard			_____
b. pointed out action possibilities			_____
c. other			_____
2. No _____ Why not?			
a. could not locate my residence			_____
b. could not understand			_____
c. other			_____
C. How could the brochure be improved?			

	Lena Gulch	Ralston Creek A	Ralston Creek B
VII. Objective Location of Residence			
A. Perpendicular distance to creek			
1. 0-50 feet	12-14.4%	8-8.8%	4-5.3%
2. 50-100 feet	6-7.2%	16-17.5%	9-12.0%
3. 100-200 feet	9-10.8%	24-26.4%	17-22.7%
4. 200-500 feet	18-21.7%	30-32.9%	24-32.0%
5. over 500 feet	38-45.8%	13-14.3%	21-25.0%
B. Actual residence location			
1. in floodplain	48-57.8%	64-70.3%	45-60.0%
2. fringe	35-42.1%	27-29.7%	30-40.0%