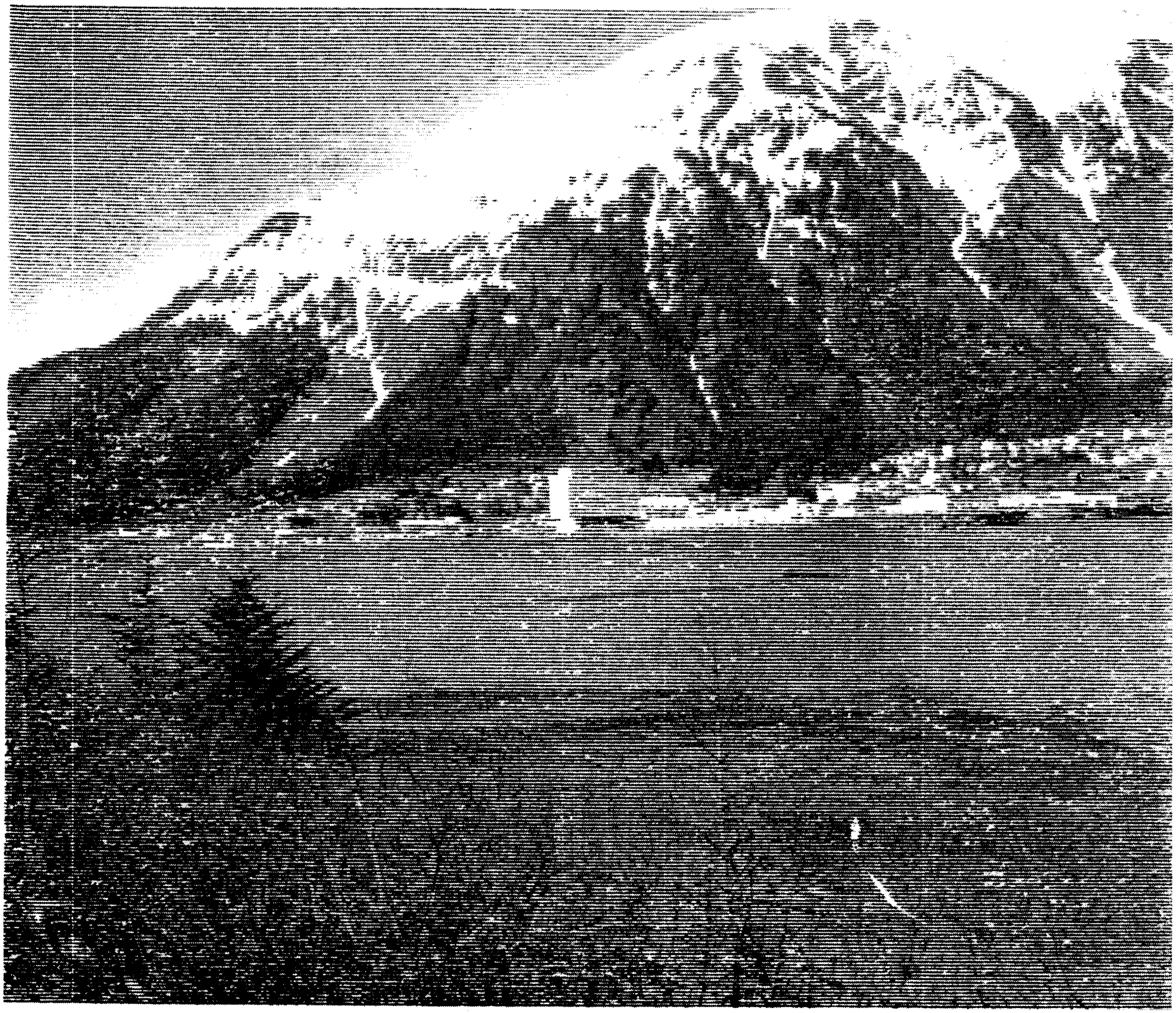
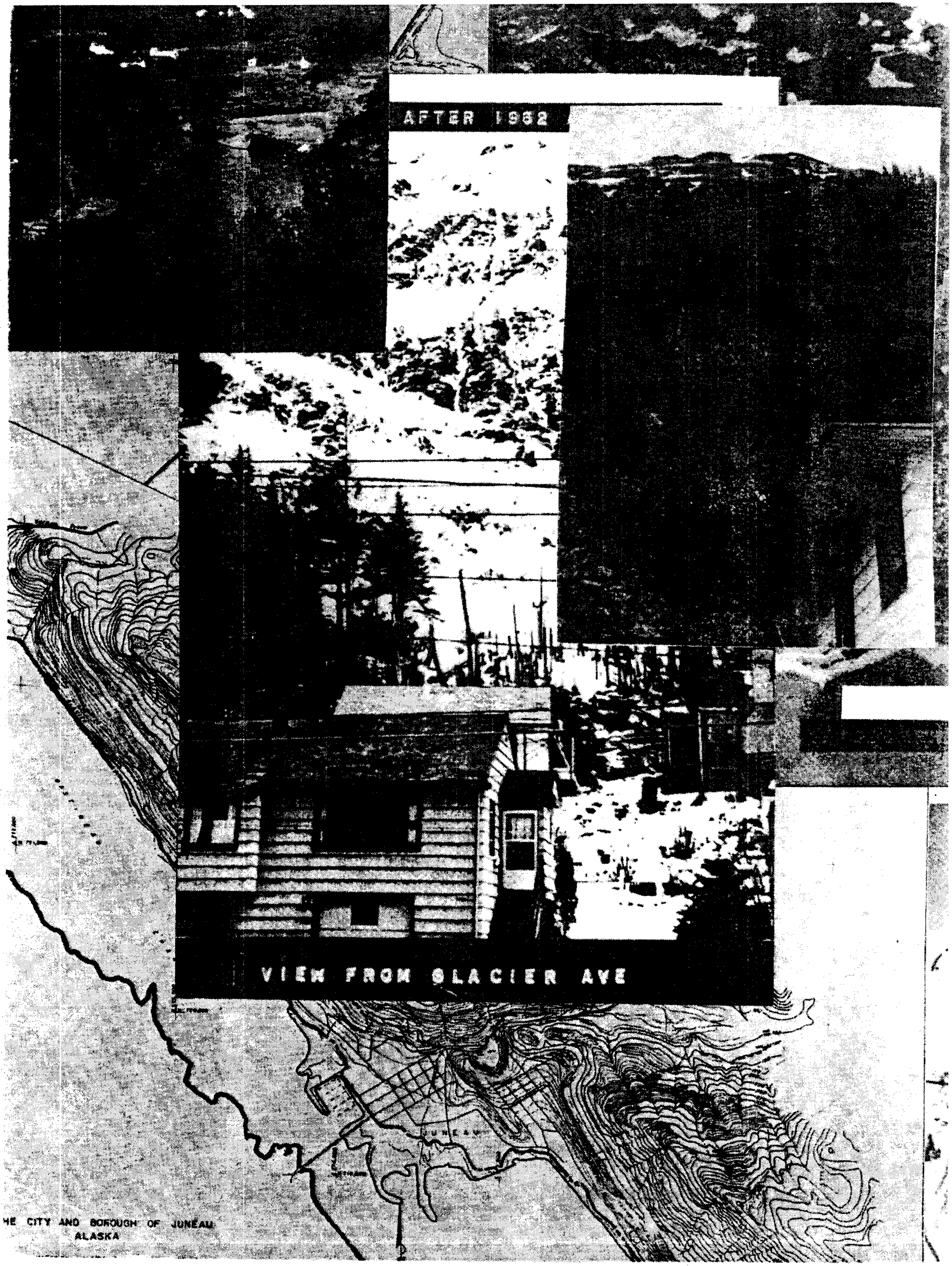


GEOPHYSICAL HAZARDS INVESTIGATION FOR THE CITY AND BOROUGH OF JUNEAU, ALASKA

A Summary Report 1972


AFTER 1962
VIEW FROM GLACIER AVE
HE CITY AND BOROUGH OF JUNEAU
ALASKA

GEOPHYSICAL HAZARDS INVESTIGATION

for the
City and Borough of Juneau

SUMMARY REPORT

October 1972

DMJM Daniel, Mann, Johnson, & Mendenhall
816 Pittock Block
Portland, Oregon 97205

The preparation of this report was financed in part through a comprehensive planning grant from the Department of Housing and Urban Development, under provisions of Section 701 of the Housing Act of 1954, as amended.

DMJM

DANIEL, MANN, JOHNSON, & MENDENHALL

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Mr. Arthur H. Hartenberger
Planning Director
City and Borough of Juneau
155 South Seward Street
Juneau, Alaska 99801

Dear Mr. Hartenberger:

It is with pleasure that we transmit herewith our final report on the Geophysical Hazards Investigation for the City and Borough of Juneau. This report consists of two parts:

1. The Summary Report of Findings
2. The Technical Supplement

We are also transmitting, under separate cover, the following reproducible maps which are designed for use in your planning program:

1. Composite Hazards Area Map Set
   Scale: 1" = 200' (set of 4)

2. Mass Wasting Hazard Classification
   Scale: 1:10,000

3. Snow Avalanche Hazard Classification
   Scale: 1:10,000

We believe that this investigation is one of the most comprehensive and detailed inventory of geophysical hazards affecting any urbanized area in the United States. This inventory, coupled with recommendations for the control of land use and development, represents a truly pioneering effort on the part of the City and Borough of Juneau.

We are proud to have been associated with this exciting and imaginative project. Much credit for its success goes to you, members of your staff, and others concerned with the future well-being of your community.

Very truly yours,

Arnold M. Cogan

Arnold M. Cogan
Associate Vice President

AMC/pl

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Borough Assembly	- Joseph A. McLean, Mayor
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We wish to thank the many people who assisted the Geophysical Hazards Investigation Team while they were in Juneau. Our appreciation also goes to the organizations who provided a forum so that the citizenry could be better informed of this project, and, to the citizens who came to become better informed about the purpose, content and meaning of this investigation. The cooperation we received while working in Juneau was excellent. The citizens can be justifiably proud of their city and of those individuals responsible for its administration.

DANIEL, MANN, JOHNSON, & MENDENHALL

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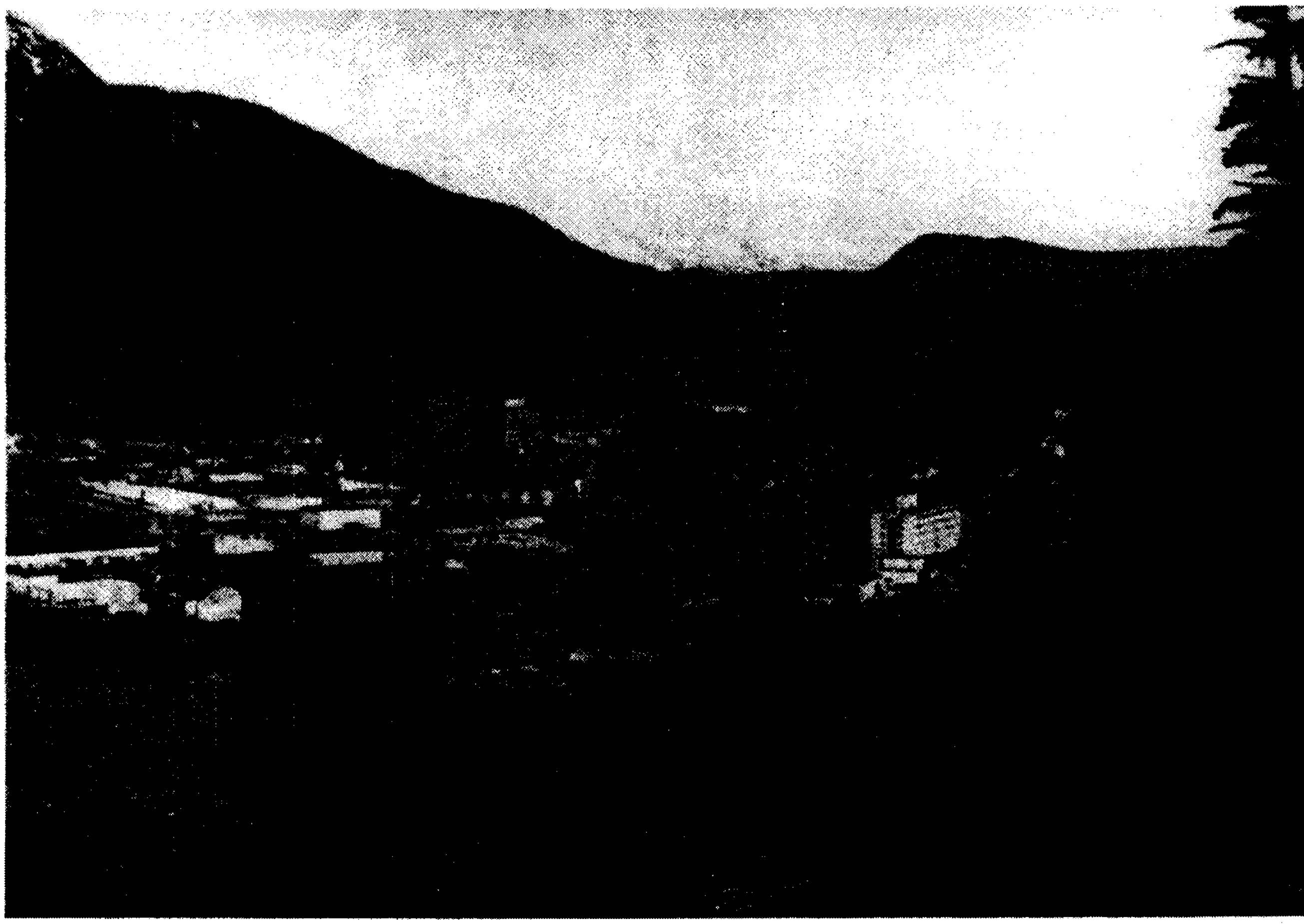


HIGHLIGHTS

HIGHLIGHTS

1. A large portion of the urbanized area of Juneau is subject to potentially destructive geophysical hazards. Sound and safe community development depends upon recognition of the constraints imposed by these hazards.

2. The differing nature and extent of aggregate and individual geophysical hazards must be recognized.

   a. Hazard from a severe earthquake is a generalized one. A revision in the adopted building code calling for more stringent application of building techniques designed to resist higher seismic loading than presently in force is required, as well as the designation of certain areas of Juneau for special consideration because of soil characteristics.

   b. The nature of the mass wasting hazard is such that a portion of the inherent danger to life and property could be minimized by requiring that certain design and construction techniques be employed. In general, mass wasting hazards do not necessarily prohibit the use of the land. However, a change in usage and upgraded construction and design criteria would be required.

   c. In the case of hazards resulting from snow avalanches, decisions which must be made are considerably more difficult. The potential extent of destructiveness of a snow avalanche is greater than that of a mass wasting event. Investigations have revealed that there is some possibility of installing defense structures. Supporting structures located in avalanche starting zones have generally proven too expensive. A more economical solution would be to build diversion, retarding or arresting structures in the runout zone immediately above developed areas. Such structures might mitigate the effects of a ground borne avalanche, but would not be effective against airborne avalanches.

3. The policy position of the Borough Planning Commission and the Borough Assembly must be that the preservation of life is paramount vis-a-vis geophysical hazards in all decisions related to land use development.

4. In view of the known and documented danger from mass wasting and snow avalanche hazards in the Juneau area, it is imperative that an immediate moratorium be placed on any zone change or building permit that would have the effect of increasing population density in areas designated High Hazard. See Figure 11.

   This moratorium should be temporary and in effect only until legislation and policies related to land use in hazardous areas have been considered by the Borough Assembly.

5. The Planning Commission and Borough Assembly should initiate policies which make the consideration of geophysical hazards a permanent part of the planning process related to regulations dealing with land use, zoning and community development.

6. Continued use of land subject to dangers from geophysical hazards should be strictly regulated by the adoption of overlay districts applicable only to such areas. No changes to uses should be allowed which will have the effect of increasing density in these areas. The maximum permitted density on land exposed to high degree of danger due to geophysical hazards should not exceed 10 persons per acre. The permitted density of land in areas of potential danger should not exceed 20 persons per acre.

7. In some instances regulations will be necessary which may reduce the development or resale potential of some property. A clear definition must be derived which will differentiate between real value and potential value as applied to developed and undeveloped property.

   a. The existence of geophysical hazards cannot be denied. Planning policies as related to such hazards cannot, therefore, be considered as being capricious and arbitrary decisions of those responsible for community planning.

   b. Owners of land subject to restrictions because of the existence of geophysical hazards need not be compensated for any loss in real or potential value, unless the Borough Assembly deems otherwise.

   c. The Borough Assembly should develop a flexible policy which will permit the control of land uses in hazardous areas. This policy should allow for a series of options, consonant with the degree of danger, to be exercised, ranging from allowing use of land on conditional basis to outright condemnation and purchase.

8. A program should be instituted whereby public land could be used as partial or total compensation for privately owned land that may be condemned because of its location in highly hazardous areas.

9. The present system of taxation will be inequitable to owners in high hazard areas if new legislation imposes constraints to development of their land. Taxes on land in highly hazardous areas should recognize the limited value of this land, and therefore, be adjusted to minimum levels. The Borough cannot advocate controls on land use because of hazardous conditions, while continuing to increase or maintain taxes at levels applicable to land not subject to the constraints imposed by geophysical hazards.

10. A base on land and improvements for all property located in hazardous areas should be immediately established which will fix values. While improvements which will not increase density or require rezoning cannot be prohibited on land affected by hazards, and for which the taxes may have been adjusted, compensation for such improvements which will tend to increase value beyond reasonable limits is not required if the land is to be publicly acquired in the future.

11. The geographic limits of the hazard areas should be incorporated into the Comprehensive Plan Map, zoning map and assessor's maps. A requirement should be made and enforced that a deed disclosure be made prior to transaction of property. The title and trust, lending and mortgage, and insuring agencies should be apprised of the existence, nature and extent of the geophysical hazards in the Juneau area.

12. Losses sustained as a result of a disaster due to an existing geophysical hazard are not isolated in effect. Individuals do not stand the losses alone. The community as a whole also suffers the loss and incurs the costs. This cost is incurred, directly or indirectly, as a result of litigation, disaster relief, damage to capital improvements, loss of revenues, etc. Therefore, the argument in justification for taking no action to limit land uses because only a limited number of individuals would sustain losses is a specious one.

HISTORY AND TASK DESCRIPTION

HISTORY AND TASK DESCRIPTION

At the inception of this project, the term "Geophysical Hazards" was adopted to describe, in general, the seismic, mass wasting and snow avalanche hazards existent in the Juneau area which were to be the subject of this investigation. Although the term itself is not scientifically accurate, its use has been nevertheless a convenient way to describe collectively such hazards. In this report seismic hazards refer to dangers existing due either to the proximity of fault lines and poor foundation conditions in Juneau, or to secondary triggering of mass wasting or snow avalanche effects. Mass wasting hazards refer to the danger existent in certain areas of Juneau because of their susceptibility to rock, mud or earth debris slides. Snow avalanche hazards are the danger caused by either airborne or ground borne snow slides in certain areas of the Borough.

In November 1968, Dr. Edward LaChapelle, in a report to the City and Borough of Juneau entitled "The Behrends Avenue Avalanche and Other Avalanche Hazards in the Greater Juneau Borough", recognized that a variety of geophysical hazards endanger many portions of the city. At that time, he recommended that the Borough government initiate immediately a survey of those geophysical hazards. Since that time, increasing numbers of people have become concerned about the location, extent and nature of such hazards. The initation of a detailed survey of the geophysical hazards affecting Juneau represents the final outgrowth of that concern. This report containing the findings of the detailed investigation that was conducted along with recommendations dealing with geophysical hazards is an extension of the advance planning program of the City and Borough of Juneau.

The purpose of this Geophysical Hazards Investigation has been twofold.

1. To investigate and report the extent and probability of geophysical hazards to urban development in the Juneau area resulting from any seismic, mass wasting or snow avalanche events that might occur.
2. To prepare recommended revisions to the Comprehensive Plan, Zoning Ordinance and Subdivision Ordinance and Building Code consistent with the findings of any hazards.

Specific urbanized areas within the City and Borough of Juneau were identified for detailed and intensive investigation, (see Figs. 3 and 9), because of the known and recorded existence of mass wasting and snow avalanche hazards. The remaining urbanized or urbanizing areas were subjected to a generalized investigation. The investigation related to seismic hazards was conducted for the whole City-Borough area, as well as those contiguous areas where faults exist which would affect Juneau.

Throughout the course of the field investigations, during the months of May and June 1972, a series of interviews with the local news media were arranged and public meetings held. The purpose of this was to inform the citizens of the City and Borough of Juneau of the purpose of this investigation, the work that was being done and of the findings of the Geophysical Hazards Investigation Team. A memorandum to the working file, listing the dates, occasions and participants, summarizing the citizens information program is included as an appendix to the Technical Supplement of this Summary Report.

This Summary Report and accompanying Technical Supplement set forth the findings and recommendations of the Geophysical Hazards Investigation.

GEOPHYSICAL SETTING

THE GEOPHYSICAL SETTING

The City and Borough of Juneau, Alaska is situated in the circum-Pacific Seismic Belt called the "Ring of Fire", on the border between the Boundary Range and the Alexander Archipelago Physiographic Divisions of Southeastern Alaska. To the east, the Boundary Ranges are characterized by deep, steep-walled, U-shaped valleys, many of which are filled with water, forming fjords. The mountains are massive, giving an impression of great bulk, and are bordered largely by cliffs that plunge several thousand feet to tidewater. Geologically, the Boundary Ranges are underlain by the massive granitic Coast Range batholith and a thick sequence of highly metamorphosed, youthfully weathered, sedimentary rock - mostly schist, phyllite and graywacke. To the west, across the Gastineau Channel, lies the Coastal Foothills Division. This division is characterized by blocks of high mountains and generally flat-floored valleys. It is underlain by mostly the same highly metamorphosed, youthfully weathered sedimentary rock, resulting from intrusion of the Coast Range batholith. The active Fairweather-Queen Charlotte Islands Fault lies near enough to affect the Juneau area.

Since the Pleistocene glaciers which covered the Juneau region began to recede, the earth's crust, which was depressed under the great weight of ice, has been rebounding - rising upward. Both the depressing process and the on-going rebounding have created a complex system of small regular cracks in the rock material. The existance of these joints plays an important role in the geomorphic development of the Juneau region.

Climate also plays an important role. Juneau's climate is governed by both cold polar air masses and warm, moist maritime air masses. These combine with orographic phenomenon to produce a high average annual precipitation that is distributed fairly evenly throughout the year. Deep snow accumulations build at higher elevations, and high run-off from lower elevations is normal. During the winter months many freeze-thaw cycles occur. The complex system of joints in the bedrock permits ample infiltration of moisture which, during the frequent freeze-thaw cycles, wedges blocks and plates of bedrock material apart. These accumulate on the slopes as debris.

The short period since the beginning of the soil forming processes, the dominance of mechanical weathering and the steepness of the slopes has resulted in the formation of only a thin mantle of coarse-grained soil. On the predominantly steep slopes, this soil is rapidly removed by landsliding and soil creep, thus retarding or precluding the natural development of soil-holding vegetation. The accumulated debris and lack of supporting vegetation are then affected by gravity and precipitation causing active mass wasting.

A similar combination of climate, geology and soil factors create a wintertime condition which directly affects the Juneau area. Precipitation in the form of snow accumulates on the steep slopes of the mountains behind the city. The poor soils inhibit the growth of vegetation, frost wedging of ice in bedrock joints contributes an unstable surface and rapidly changing extremes of temperature decrease the little on-slope storage capacity for snow accumulation. Frequent snow avalanches, ranging from very small and inconspicuous to large and destructive, are normal.

Seismic events, mass wasting and snow avalanches, all dynamic earth-shaping forces, expose portions of the urban and urbanizing areas of the City-Borough to extreme geophysical hazards.

FINDINGS

FINDINGS

A. Some Comments on the Philosophy of Probabilities

In order to anticipate any potential loss to the community which would be incurred if a destructive event were to take place, some estimates of mathematical probability can be established. Historical data is researched, statistical analyses assembled, and then, the past patterns are projected into the future. This method is particularly valid in cases where future events are dependent upon the events which have preceded. However, natural phenomenon such as earthquakes and mass wasting or avalanches are random, independent events, and are not readily subject to mathematical projection.

The case of flipping a coin is used for illustration. At every flip, the probability of heads coming up is 50%. Each flip is an independent event. Regardless of any pattern of past flips, the probability of heads coming up at any future flip remains 50%.

This example does not suggest that in the case of natural phenomena, historical evidence is to be discounted. Natural processes are immensely more complex than the example of the coin, and historical patterns can provide one basis for judgmental evaluations.

Great care must also be exercised in the use and interpretation of the statistical terms which apply to natural phenomenon. Such terms as recurrence interval or return interval are potentially misleading. These are defined as the average interval of time within which an event (such as a storm) of a given magnitude will be equalled. This is dependent upon the underlying premise that the storms occurring in a period of time constitute a sample of an indefinitely large population in time. For instance, if in a period of ten years of record the largest storm recorded was of a certain size, it is probable that the next ten years will also contain a storm of equal magnitude. In this sense, recurrence interval,or return interval, is also a statement of probability. An event having a recurrence interval of ten years is one that has a 10% probability of occurring in any given year. Which year cannot be determined.

Concerning the 1962 Behrends Avenue avalanche,

> "Hart has pointed out in this report that the average return interval (emphasis added) is 13 years. If the average life of a house located within the present influence zone is taken as 40 years, then the encounter probability between house and avalanche is 96%. This means almost certain damage or destruction of a house sometime during its normal expected life. The probability is not 100% because the return interval is an average of presumably random events, for which there is a finite probability that more than 40 years will elapse between two successive events. From the practical standpoint of evaluating the significance of this to a homeowner on Behrends Avenue, it should be remembered that which 40 years this might be is completely undetermined."
> (LaChapelle, 1968)

It must be emphasized that in the case of the natural phenomena under investigation, though mathematical probability of any occurrence in the statistical sense can be established, proba-ility does not constitute a forecast. It falls to knowledge and interpretation of the history and the technical ingredients of each phenomenon for a qualitative judgment of probability.

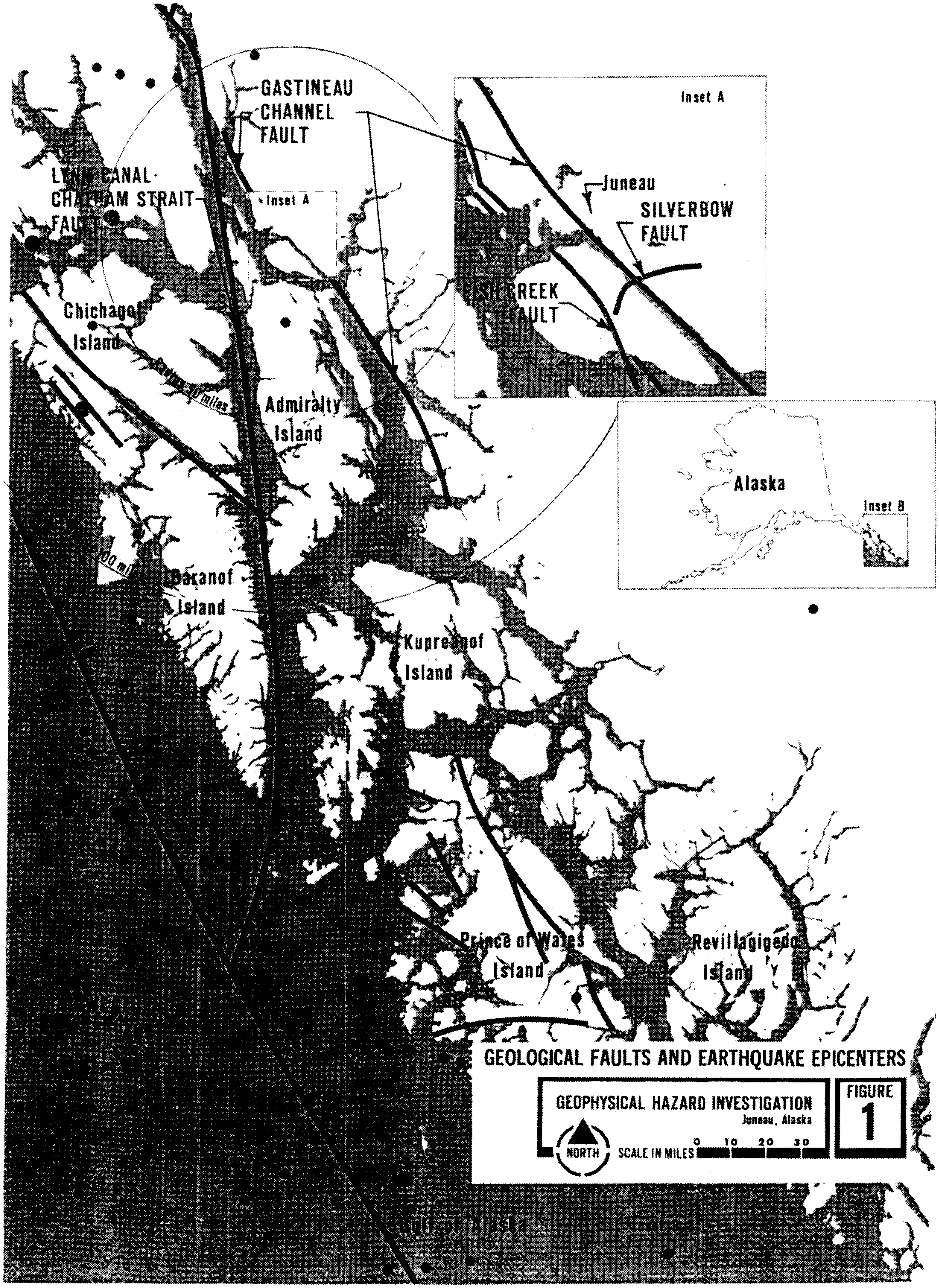
In those instances where a hazard is known to exist, prudence demands an assumption that an event will take place, and appropri-ate action necessary to minimize losses to life and property should be initiated.

B. Results of the Seismic Hazard Investigation

1. Earthquakes

There are five known major fault zones within 100 miles of Juneau, see Fig. 1. Of these, the Gastineau Channel-Berners Bay Fault, the Silverbow Fault, the Fish Creek Fault and the Lynn Canal-Chatham Strait Fault exhibit no evidence of movement during the Pleistocene or Recent time. The Fairweather-Queen Charlotte Island Fault has been the scene of numerous major quakes in historic times. From 1899 to the present, sixteen earthquakes with magnitudes ranging from 6.0 to 8.6 on the Richter scale have been recorded. It is reasonable to predict that earthquakes strong enough to affect Juneau will occur along this fault.

Although the four inactive faults have shown no historical movement, it should not be assumed that they are tectonically inactive. A long period of seismic quietude may be an indication that strain is being accumulated which could be released as an earthquake. The relative probability of occurrence of earthquakes or earth movements in the Juneau area within 100 years (based in part on the historical record, and in part on subjective reasoning); is assessed as follows:



GEOLOGICAL FAULTS AND EARTHQUAKE EPICENTERS

GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 1

Event[1]	Probability[2]
Earthquake of magnitude 6 or greater with epicenter at Juneau	1
Earthquake of magnitude 6 or greater with epicenter within 50 miles of Juneau	3
Earthquake of magnitude 6 or greater with epicenter within 100 miles of Juneau	5
Movement along faults in Juneau area	1

2. Geologic Setting

Every geologic unit responds differently to the shaking and vibrations of earthquakes. Structures located on soft ground have suffered five to ten times greater damage than structures on hard-rock formations. Water filled alluvium or saturated filled ground tend to magnify the amplitude of earthquake shockwaves. Conversely, bedrock or other extremely competent materials tend to dampen shockwave amplitude.

Thick beds of loose, water-saturated, cohensionless alluvium frequently react to earthquake shaking by granular response. That is, compaction or densification results in differential settling of the land surface. Bedrock and other extremely competent materials commonly exhibit an elastic reaction. However, brittle response of bedrock material can be expected in precipitous areas with attendant rockfalls, rock avalanches and earthslides

[1] Adapted from Miller, 1972
[2] Probability ranges from 1 (almost impossible) to 5 (almost certain) (Miller,1972)

on steep slopes.

A detailed investigation of the surficial geology of the Juneau urban area was recently completed by the United States Geological Survey.[3] This open file report fully describes the origin, location and characteristics of each unit of surficial geology. Accompanying maps locate each unit and interpret its anticipated behavior in the event of a seismic occurrence.

The Geophysical Hazards Investigation Team has reviewed these findings and concurs without exception. Fig. 2, adapted from Miller, 1972, delineates those areas where, based on the anticipated behavior under seismic stress, poor, marginal and acceptable geologic foundation materials can be expected.

Particular attention is directed to the classification system:

a) Areas of poorest foundation conditions. A severe local response to an earthquake probably will cause one or more of the following to occur: differential downslope movement, compaction and differential settlement, ejection of water and (or) sediment, and local sliding toward unsupported faces of deltas.

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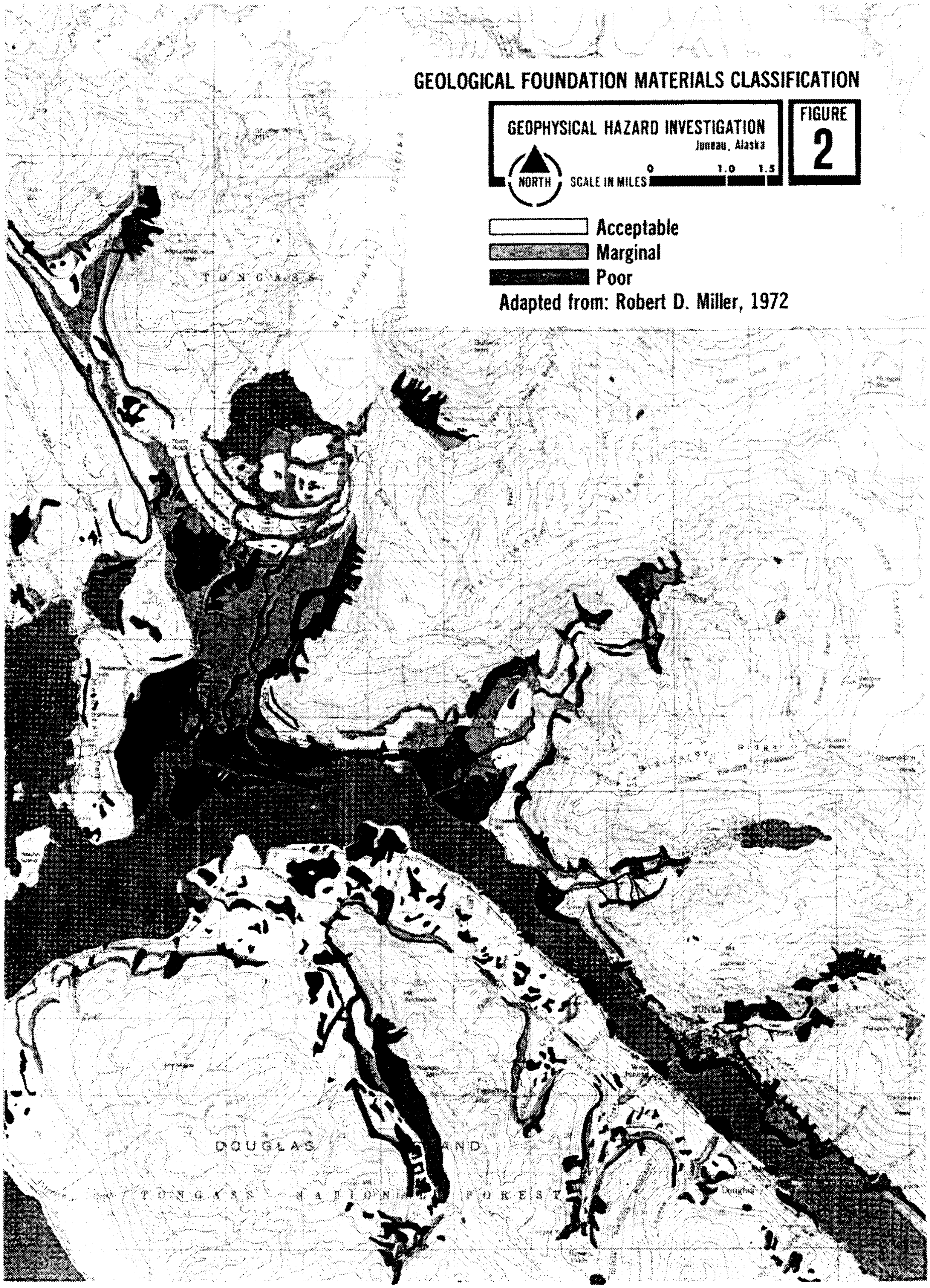
[3] Miller, R.D.
Surficial Geology of the Juneau Urban Area and Vicinity, Alaska, with Emphasis on Earthquake and Other Geologic Hazards; United States Department of the Interior Geological Survey, open file report, 1972.

b) Areas of marginal foundation conditions. A severe local response to an earthquake probably will cause one or more of the following to occur: differential compaction, ground fracturing, ejection of water and /or sediment. Reaction to seismic shaking depends on earthquake magnitude, epicentral distance, seismic wave length and amplitude, and duration of shaking. Depth to water table and density and thickness of geological units also bear on the ground reaction. Prediction of which of the areas in the classification may not be damaged by an earthquake cannot be made.

c) Areas of most acceptable foundation condition. Best foundation material (bedrock); or, very good foundation material (generally dense or well compacted); or, satisfactory foundation material, though local conditions will govern reaction to earthquakes which might cause some compaction, some fracturing, and some isolated water and/or sediment ejection.

Particular note should be made of the urban and urbanizing areas which are underlain by unconsolidated material, and are classified as having poorest foundation conditions. Reference to Fig. 2 shows that large areas of the Mendenhall Valley, the vicinity of the Juneau International Airport, the Lemon Creek and Salmon River Deltas and the man-made filled areas of the Juneau waterfront are potentially


GEOLOGICAL FOUNDATION MATERIALS CLASSIFICATION
GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska
FIGURE
2
NORTH
SCALE IN MILES
0
1.0
1.5
Acceptable
Marginal
Poor
Adapted from: Robert D. Miller, 1972
TONGASS
DOUGLAS
TONGASS NATIONAL FOREST

unstable in the event of a seismic occurrence.

It must be stressed that foundation conditions are a highly site-specific phenomenon and do not necessarily entail a hazard condition. While an area may be classed as having poor conditions from a small scale perspective, structural criteria or land use decisions, particularly in the case of public occupancy and high-density structures, must be made on the basis of detailed on-site engineering geology reports.

3. Effects of Triggering

In addition to the danger presented directly by earth movement, a seismic event poses a much greater threat in terms of the mass wasting, or avalanches which could be triggered. The following table estimates the probability of occurrence, within the next 100 years, of selected seismic initiated, geomorphic events.

Geomorphic Event[1]	Probability[2]
Massive landslides in glaciomarine deposits similar to landslides that occurred in the Bootlegger Cove Clay in the Anchorage area during the March 1964 earthquake	1
Delta-front slides into water as result of earthquake, causing waves with rapid run-ups in excess of 5 feet	3
Tsunamis in Gastineau Channel with rapid runups in excess of 5 feet	2
Debris flows along existing or new channels on mountain slope above the Gastineau Avenue-Franklin Street area	5

[1]Adapted from Miller, 1972
[2]Probability ranges from 1 (almost impossible) to 5 (almost certain) (Miller, 197

Geomorphic Event (Cont.)	Probability
Massive rockslide-avalanches along mountain fronts	4
Isolated rockfalls along existing talus cones, and as unexpected occurrences elsewhere	5
Damage from severe shaking caused by earthquake of magnitude 6 or greater with epicenter within 100 miles of Juneau	3
Compaction and settlement of water-saturated deposits from shaking of ground in response to earthquake of magnitude 6 or greater with epicenter within 100 miles of Juneau	3

We are also concerned about the possiblity of seismic-triggered landslides descending into Salmon Creek Reservoir. A major slide would probably result in extreme hydrostatic pressure on the circa 1915 dam. Any possibility of failure of the dam would endanger the developed and developable portions of the Salmon Creek Valley. This possibility must be carefully evaluated prior to determination of future land uses or developments in the vicinity of the dam or in areas which would be subject to inundation as a result of dam failure.

C. Results of the Mass Wasting Hazard Investigation

1. Geographic Limits

The mass wasting hazard investigation was conducted at two levels of detail:

a) A generalized investigation including the City-Borough portion of Douglas Island and a seven mile wide corridor on the east side of the Gastineau Channel from Thane to the Mendenhall Valley.

b) A detailed investigation limited to the sub-areas shown on Fig. 3.

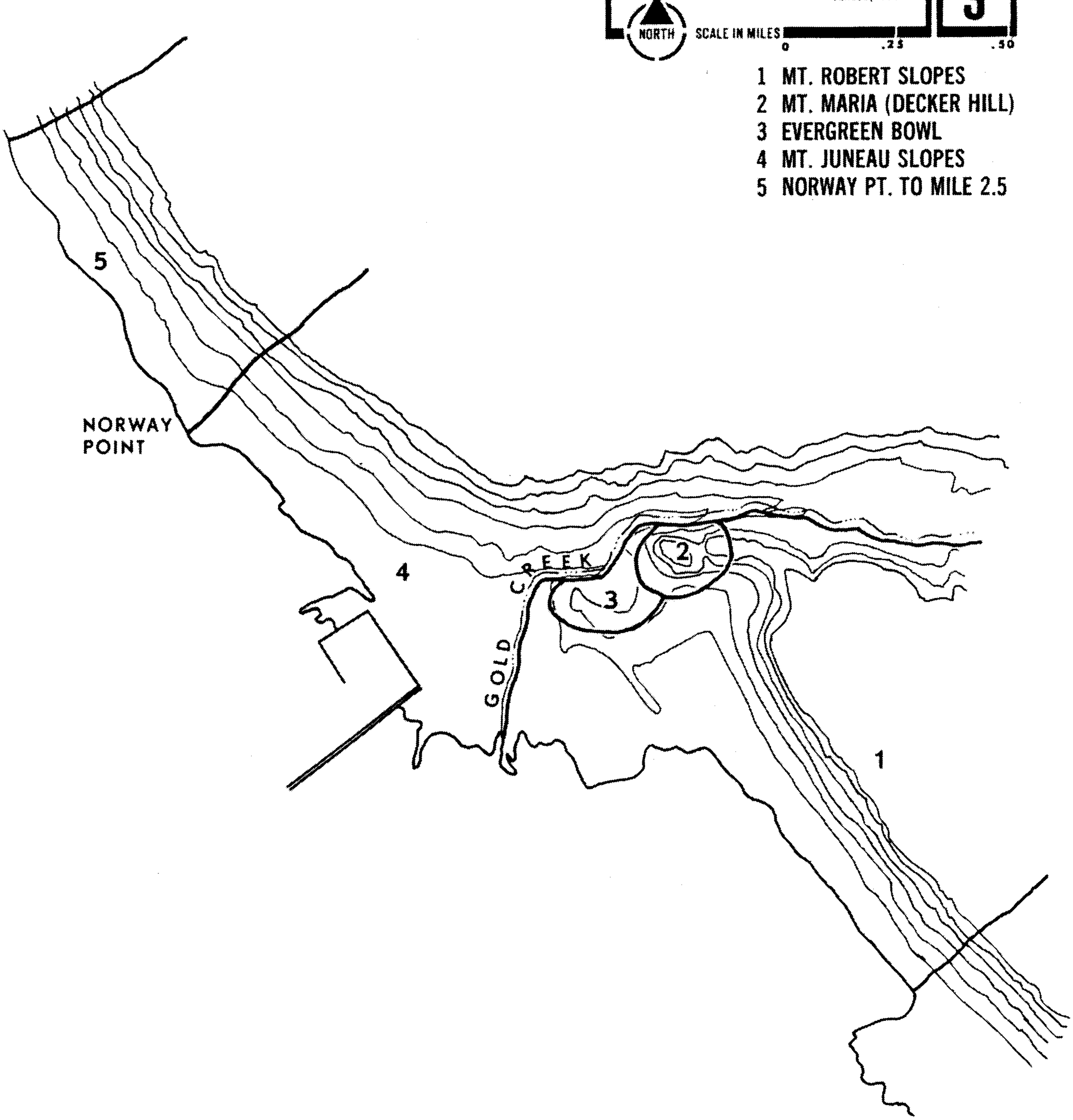
2. Hazard Classification System

A separate classification system was needed for each of the two levels of investigation. The propensity for mass wasting to occur at any given location is dependent upon the ratio between the effective angle of internal friction characteristic of the natural soil and the slope on which that soil is located. The angle of internal friction for soils in the Juneau area ranges from 28^{o} to 37^{o}. Consequently, at the generalized investigation level, if the slope of the land exceeds 37^{o}, the area is classified as highly unstable. Slopes with gradients between 28^{o} and 37^{o} are classified as potentially unstable. Figs. 4 and 5 show those areas covered by the generalized investigation, based on the angle of internal friction and mapped slope angle, which are classified as highly unstable and potentially unstable.

MASS WASTING HAZARD INVESTIGATION SUB-AREAS

GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 3



1 MT. ROBERT SLOPES
2 MT. MARIA (DECKER HILL)
3 EVERGREEN BOWL
4 MT. JUNEAU SLOPES
5 NORWAY PT. TO MILE 2.5

In addition to the basic mechanical properties of the soils, the detailed investigation included three additional criteria:

a) History of mass wasting occurrences

b) Presence of gullies or V-notch channels
   - having substantial accumulations of debris
   - relatively free from debris

c) Probable extent of area affected by landslide.[1]

Areas classified as high hazard demonstrate a history of landslides, and have channels or gullies containing substantial amounts of accumulated debris. This accumulation of debris, while temporarily stabilized, will eventually come down into the area below. No prediction can be made of when a slide will occur.

Areas classified as potential hazard also exhibit a history of landslides, but the channels or gullies present are relatively free from debris.

3. Significant Findings of Mass Wasting Hazard Investigation

The following findings constitute the most significant classification of hazard areas. Refer to Figs. 6 and 7 and the Mass Wasting Investigation Technical Report for complete information.

a) Mt. Roberts Slopes:

21 channels have been mapped on the Mt. Roberts slope above the city, (nos. 13 to 29). Fifteen are

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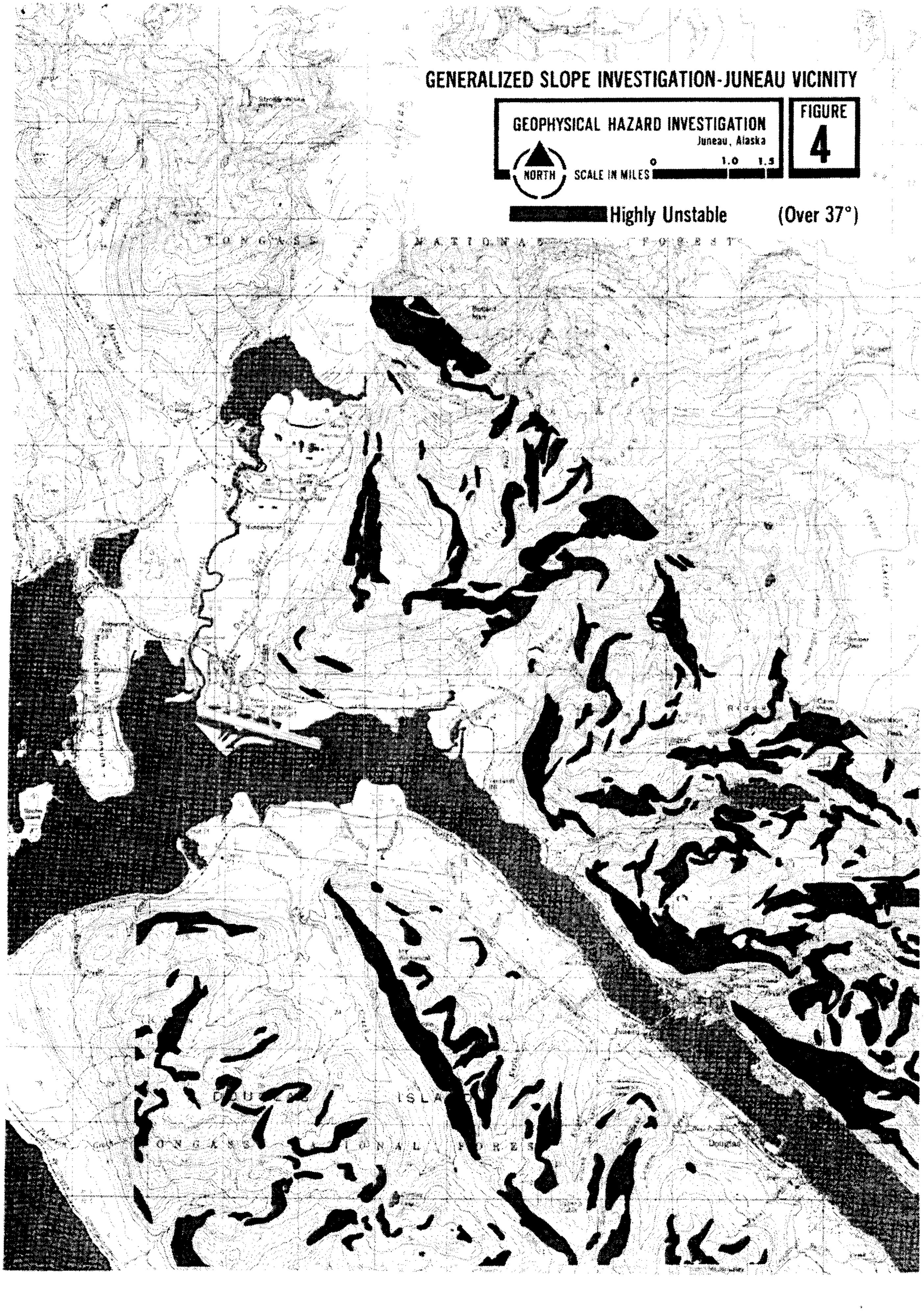
[1] The term landslide as used in the remainder of this Summary Report embraces all mass wasting events exclusive of "creep". Implicit in the term landslide as used herein are the following: rockfalls, rockslides, rock avalanches, debris slides, debris avalanches and debris flows.

GENERALIZED SLOPE INVESTIGATION-JUNEAU VICINITY



identified as having a high hazard principally because of the large accumulations of temporarily stabilized loose debris material. The remaining are classified as potentially hazardous. Considering the extremely steep slopes, unstable bedrock and soil conditions, numerous high hazard gullies extending directly into the urban area and the known history of landsliding, most of the Mt. Roberts slope above South Franklin Street and Gastineau Avenue is to be considered as highly hazardous in terms of danger of property damage and loss of life.

b) Mt. Maria (Decker Hill):

The area directly below the open rock cliff above Basin Road is a high hazard zone. The area below the rock cliff above 6th and Nelson Streets is a high hazard area. The trestle portion of Basin Road is also a high hazard area.

c) Evergreen Bowl:

The slopes surrounding Evergreen Bowl are potential hazard areas to property at the top of the slope and adjacent to Basin Road, Gold Belt Avenue and 7th Street. A high hazard area from falling rock also exists above Calhoun Street between Dixon Street and 6th Street.

GENERALIZED SLOPE INVESTIGATION-JUNEAU DOUGLAS AREA

d) Mt. Juneau Slopes:

The slopes from Norway Point to the Behrends Avenue snow avalanche path, though free from channels or gullies, are classified as high hazard due to the overall unstable conditions. Three distinct channels (Nos. 3 to 5), exist within the Behrends Avenue avalanche track. These are classed as high hazard, with No. 3 extending to Behrends Avenue. Above Evergreen Avenue three channels (Nos. 6, 7 and 8) present a significant danger to urban areas. These are classed as high hazard. Channels 9, 10, 11 and 12 were identified on the slopes above Gold Creek and designated as high hazard areas.

e) Norway Point to Mile 2.5:

The channel (No. 2b) above Norway Point is very active and is classed as a high hazard area, with the remainder of Norway Point classified as potentially hazardous area. Channel No. 2a just west of Norway Point is also a high hazard area. The area between Channel No. 1a and 1c is classed as potential hazard. The channel above the Johnson Children's Home (No. 1c) is classified as high hazard. Between miles 2.0 and 2.5 on the Glacier Highway, Channel No. 1b is classified high hazard.

4. <u>Probability of Occurrence</u>

A review of the history of recorded landslide occurrences in the Juneau urban area reveals some valuable information: (see Fig. 8)

MASS WASTING HAZARD AREAS

GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 6

NORTH

SCALE IN MILES 0 .25 .50

Potential Hazard
High Hazard

- 18 years have passed since the last landslide.
- 17 destructive or potentially destructive landslides occurred during the period 1918 through 1954.
- All recorded landslides occurred between September 25 and January 2.
- 16 of the 17 landslides occurred during eleven major storms, each having between two to four inches of rain in a 24-hour period. (The seventeenth occurred during an abnormally warm period with heavy rain and snow melt.)
- Eleven of the 17 landslides occurred on the Mt. Roberts slopes above South Franklin Street.
- Of the total eleven landslides which occurred during the 26 years of the A-J mill operation (1918-1944), seven landslides occurred above South Franklin Street. It is interesting to note that while it is reported that the A-J Mining Company did its blasting on Sundays, no landslides occurred on a Sunday.
- Between 1944 when the A-J ceased operation, and 1954, five landslides occurred - four above South Franklin Street.

A comparison between the United States Weather Bureau calculations of the probabilities of a storm of greater than two inches rainfall in a 24-hour period during the period September through January and the actual percentage of landslides during that period is as follows:

MASS WASTING CHANNELS AND ROCK SLIDE AREAS

GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 7

NORTH SCALE IN MILES 0 .25 .50

Rock Slide Hazard Areas

	Probability of More Than 2" in 24-Hours	Actual % Distribution of Slides by Month
-	September - 18% probability	23.6%
-	October - 25% probability	35.4%
-	November - 15% probability	29.9%
-	December - 9% probability	5.8%
-	January - 4% probability	5.8%

This high degree of correlation is very important, indicating that the occurrence of landsliding is dependent upon high precipitation to act as a triggering mechanism.

A landslide cannot occur, regardless of the most favorable weather conditions, unless earth material is available to slide. For the past 18 years material has been accumulating in the channels and gullies classified as high hazard. This accumulation represents the potential for highly destructive landsliding. Combined with the very high probability of rainfall sufficient to trigger a slide, this accumulation of material constitutes an imminent and unpredictable danger.

HISTORIC LANDSLIDE DEPOSITS

GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 8

NORTH — SCALE IN MILES: 0, .25, .50

(P) Prehistoric (Before 1880)
(11) Historic (After 1880)

ESTIMATED AGE OF DEPOSIT

1-1912	7-1918	13-1932
2-1932	8-1935	14-1936
3-1892	9-1918	15-1952
4- --	10-1936	16-1952
5-1922	11-1949	17-1935
6- --	12-1920	

D. Results of the Snow Avalanche Hazard Investigation

1. Geographic Limits

The Avalanche Hazard Investigation was conducted at two levels of detail. A detailed investigation was made of the four sub-areas shown on Fig. 9. A generalized investigation was also performed in those areas outside the detailed investigation area where avalanche hazards might affect urban development, specifically along the four major arterial roads: Glacier Highway, Thane Road, Douglas Road North and Douglas Road South. No investigation was made in the valleys not accessible by road, including the valleys on Douglas Island, Salmon Creek Valley, Lemon Creek Valley and in Last Chance Basin above the bridge.

2. Hazard Classification System

The Swiss Federal Institute for Snow and Avalanche Research has developed a standard procedure for classifying avalanche hazard zones. See Fig. 10 and Table 1. Table 1 sets forth the criteria for each zone.

SNOW AVALANCHE HAZARD INVESTIGATION SUB-AREAS

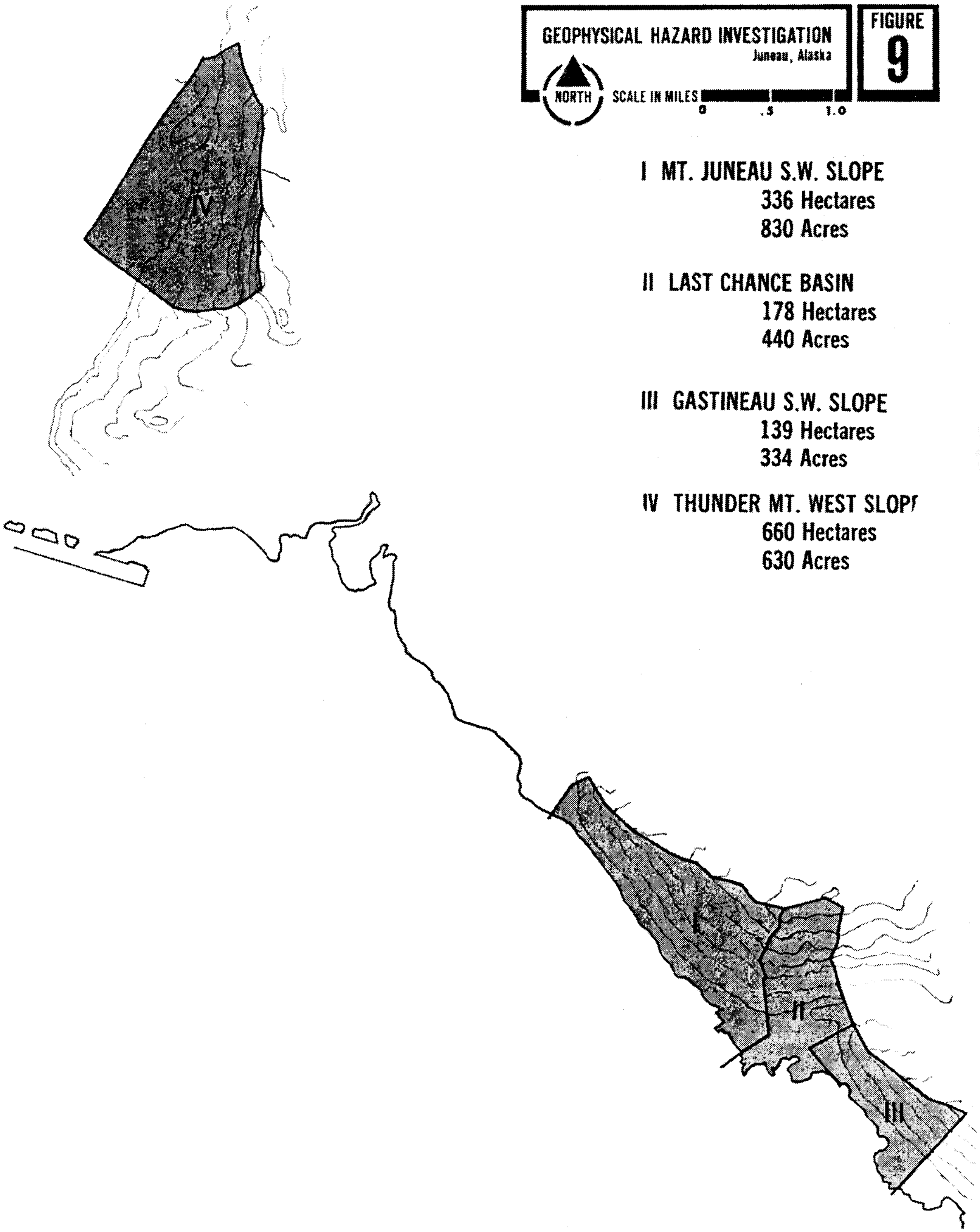
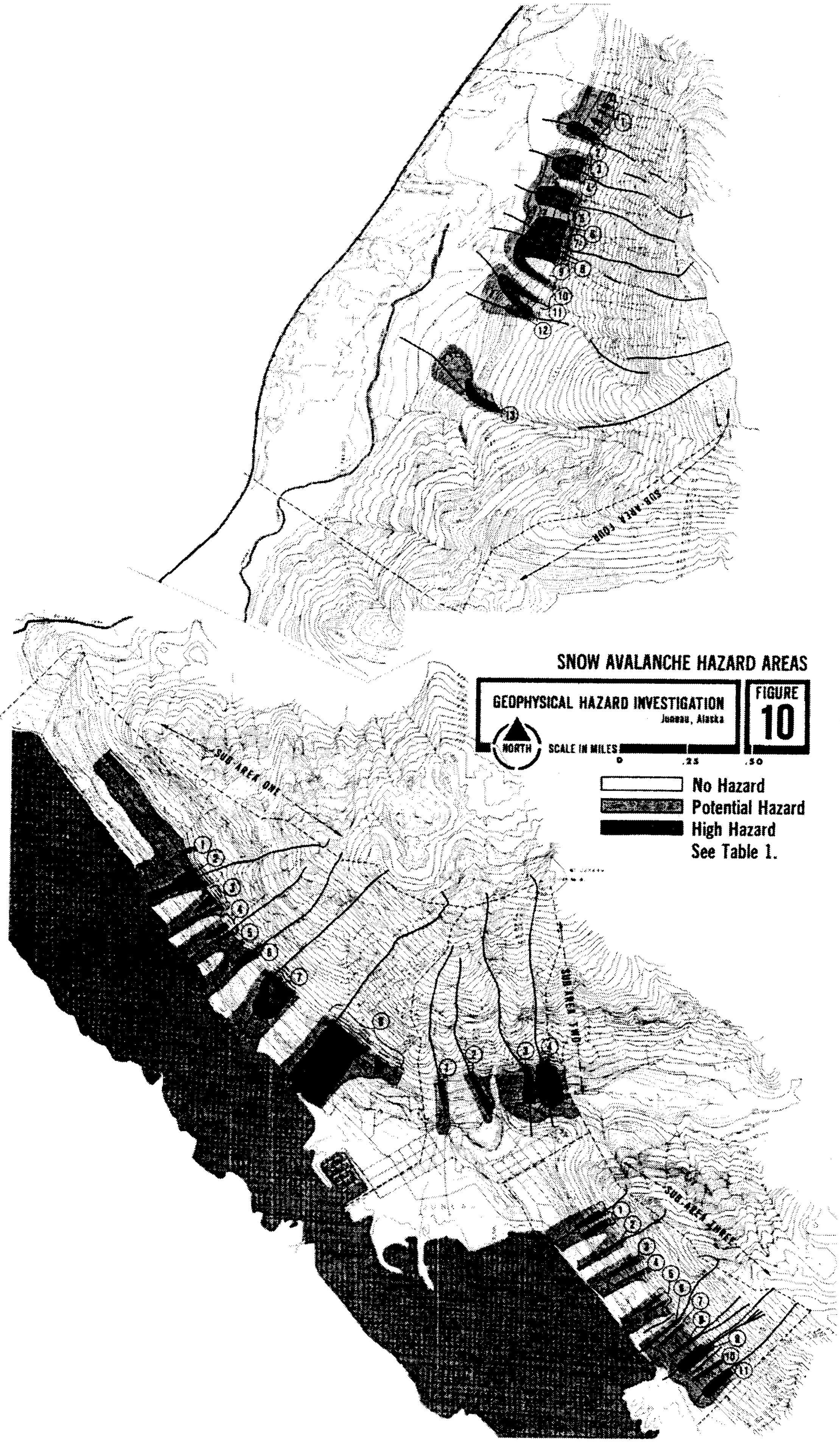


TABLE 1

TABULATION OF SNOW AVALANCHE ZONE CRITERIA

Zone	Zone Characterized As:	Return Period	Damage will Result to Structures not Capable of Withstanding the Wind/ Snow Pressures Listed Below	Probability of Occurrence*
No Hazard	Free of Avalanche Hazard	None	20 lb/ft^2 wind pressure (= Approx. 70 mph wind)	
Potential Hazard	Avalanches Occur Seldom But May be Powerful	More than 90 yrs.	More than 600 lb/ft^2 snow pressure (= More than 350 mph wind)	less than 1% per year
		or More than 30 yrs.	200 600 lb/ft^2 snow pressure (= Approx. 220-350 mph wind)	less than 3% per year
		or Less than 30 yrs.	20-200 lb/ft^2 snow pressure (= Approx. 70-220 mph wind)	more than 3% per year
High Hazard	Frequent and Powerful Avalanches	Less than 30 yrs.	200-600 lb/ft^2 snow pressure (= Approx. 220-350 mph wind)	more than 3% per year
		or Less than 90 yrs.	More than 600 lb/ft^2 snow pressure (= More than 350 mph wind)	more than 1% per year

* See Section A. Comments on Probability


SNOW AVALANCHE HAZARD AREAS
GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska
FIGURE
10
NORTH
SCALE IN MILES
0
.25
.50
No Hazard
Potential Hazard
High Hazard
See Table 1.
SUB-AREA ONE
SUB-AREA TWO
SUB-AREA THREE
SUB-AREA FOUR

3. Significant Findings of the Snow Avalanche Hazard Investigation (Refer to Fig. 10)

a) Sub-Area I - Mt. Juneau S. W. Slope:

This sub-area presents the most critical avalanche hazard to urban and urbanizing land. Six potential hazard zones cross the Glacier Highway between the Juneau-Douglas High School and mile 2.5. A number of high hazard zones exist in this area, two of which, the Behrends Avenue zone and the White Subdivision zone extend to the Gastineau Channel. The remaining high hazard zones do not extend below the 25 meter (82 feet) elevation line, and therefore, do not impose a great threat to present urban land.

b) Sub-Area II - Last Chance Basin:

There are four potential hazard zones in this sub-area. Two are deep into Last Chance Basin and do not at present affect any urban land. Avalanche zone #4 which is the site of the 1972 avalanche which severed the city water flume is most important. Here the high hazard zone extends across Gold Creek and up to Basin Road.

Avalanche zone #1, the high hazard zone, terminating in the slope above presently urban land, is a danger as the potential hazard zone extends into the area of upper Calhoun Avenue where it crosses Gold Creek.

c) Sub-Area III - Gastineau-S. W. Slope of Mt. Roberts: Eleven distinct avalanche tracks are identified along the Thane Road between the A-J Mine Office and the A-J rock dump. While the high hazard of these eleven tracks terminate on the slope above Thane Road, the potential hazard zones extend to Gastineau Channel. At present no significant structures are affected by these tracks. Travel along Thane Road during avalanche periods is considered to be dangerous.

d) Sub-Area IV - Thunder Mountain - West Slope: Thirteen avalanche tracks are identified in this sub-area. In all but two cases the high hazard zones terminate above the 25 meter (82 feet) elevation and the potential hazard zones do not extend into presently urbanized land.

4. Probability of Occurrence

Unlike the Mass Wasting Hazard Investigation where the potential for landsliding includes a cumulative element, potential for snow avalanching, on an annual basis is non-cumulative. The setting for avalanching - steep slopes, poor or no snow retaining ground cover, are ever-present, but snow accumulation is dependent upon the weather phenomena occurring in each separate winter.

Calculations of avalanche probability require a history of weather and snow accumulation data collected over an extended period of time at potential avalanche sites, as well as over a wide geographic area. In Juneau such a program has never been in effect which would have provided the requisite weather and snow data, thus precluding any precise computation of probability based on weather records.

It must be nevertheless emphasized that the most decisive weather condition for causing an avalanche to occur is the amount and intensity of each single snowfall. The available precipitation data of Juneau was gathered and analyzed for this investigation. From this analysis an estimate of snow accumulation was made. However, for the reasons stated above, the probability of avalanche occurrence was not made. Consequently, the susceptibility of certain areas to avalanche hazards, i.e. no hazard, potential hazard and high hazard, was made on criteria based exclusively on terrain configuration and vegetation cover. To determine the probability of an avalanche occurring it would be necessary to compare snowfall data to known avalanche occurrences. Unfortunately, very little correlative information of such nature is in existence, thus making the determination of probability extremely difficult.

E. Composite Mass Wasting and Snow Avalanche Hazard Rating System

The purpose of this Composite Hazard Rating System is twofold.

- to identify areas wherein the aggregate, life and property are exposed to high, moderate and low hazards
- to provide a basis for prioritizing corrective and preventative measures.

Only mass wasting sub-areas 1 - 5, and snow avalanche hazard sub-areas 1 - 3, are included in the compilation of a Composite Hazard Rating System because these affect the urbanized areas of Juneau most directly. Seismic hazard, except for the potential for triggering either mass wasting or avalanches is not included. Triggering responses are implicit in the areas classified as having a snow avalanche or mass wasting hazard.

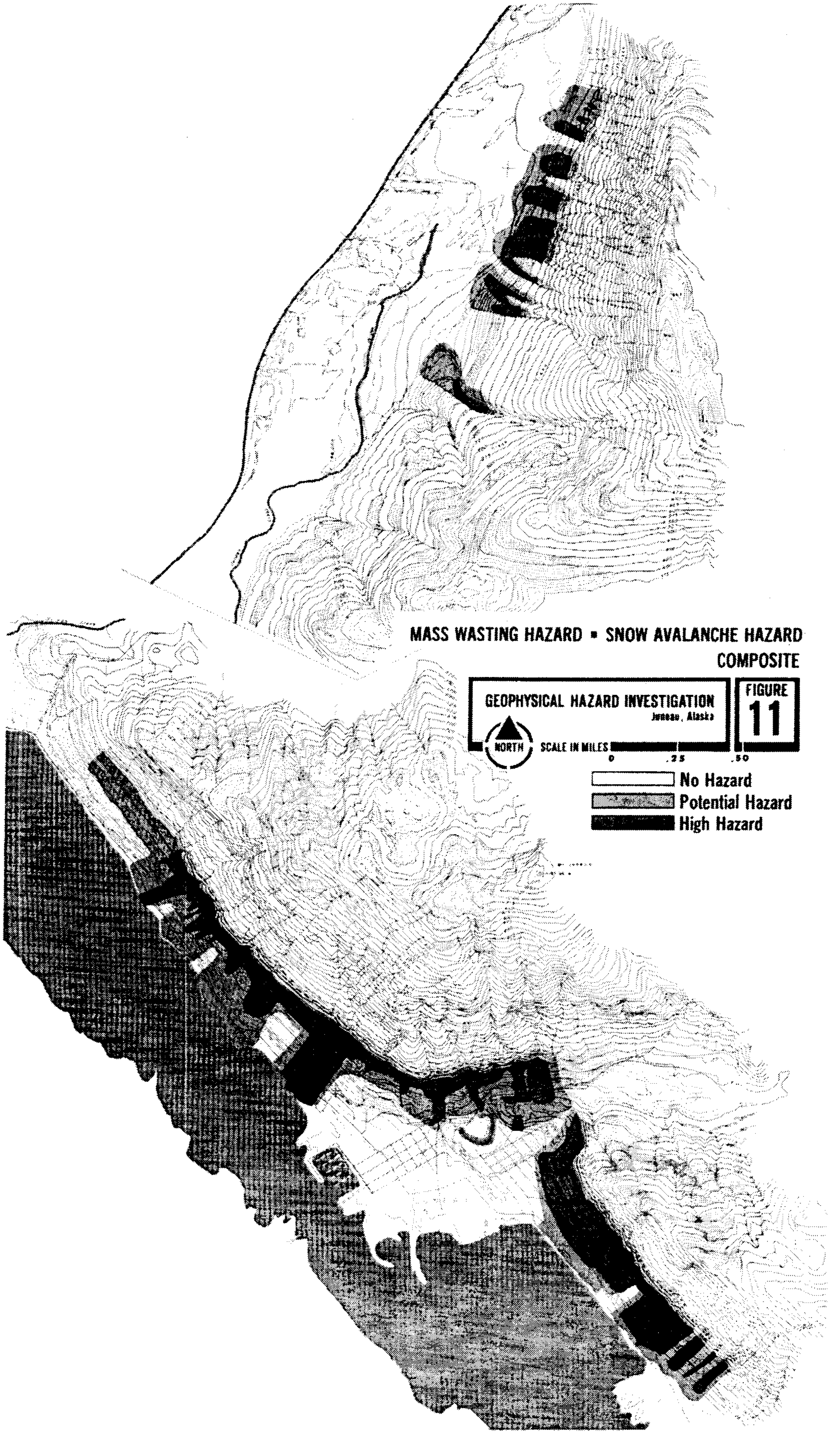
Each category of hazard - mass wasting and snow avalanche - identifies three degrees of hazard. Aggregating the two systems, nine combinations of hazards are possible. Practically speaking, nine classifications is an unworkable number. However, it is logical to group several of these combinations under common headings. If a geographic area is known to be vulnerable to both a high snow avalanche hazard and a potential mass wasting hazard, then the known higher level of hazard should govern, and the resulting composite hazard class is High Hazard. Similarly, two high hazard ratings constitute a Very High Hazard. Adopting this philosophy, classifications result as shown in Table 2.

TABLE 2

COMPOSITE HAZARD CLASSIFICATION

MASS WASTING HAZARD CLASSIFICATIONS \ SNOW AVALANCHE HAZARD CLASSIFICATIONS	High Hazard	Potential Hazard	No Hazard
High Hazard	Very High Hazard	High Hazard	High Hazard
Potential Hazard	High Hazard	Potential Hazard	Potential Hazard
No Hazard	High Hazard	Potential Hazard	No Hazard

Maps of the individual hazard investigations were overlayed and the above criteria applied. Developed or feasibly developable land was found not to exist on the slopes above the 300 foot elevation in the areas investigated, (see Figs. 3 and 9). Consequently, areas above were excluded from consideration in developing the composite hazard classification. It must be noted that two areas were found which fell into the Very High Hazard class. These are located on the slopes above 300 feet elevation in the Behrends Avenue Avalanche Track and above the White Subdivision, and do not include any presently developed or developable land. Consequently, there is no area classed in the Very High Hazard category shown on the Composite Snow Avalanche and Mass Wasting Hazard Map, Fig. 11.


MASS WASTING HAZARD ■ SNOW AVALANCHE HAZARD
COMPOSITE
GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska
FIGURE
11
NORTH
SCALE IN MILES
0
.25
.50
No Hazard
Potential Hazard
High Hazard

ECONOMIC EVALUATION

ECONOMIC EVALUATION

To provide the City and Borough staff and members of the Planning Commission and Borough Assembly with additional data which would assist them in making decisions, an economic evaluation of the land affected by geophysical hazards was made. The economic data can be used as a tool which would make it possible to evaluate the economic consequences of policies affecting present and future land use in these areas.

The land affected by geophysical hazards was divided into six areas. This division was made on the basis of similarity of land uses, thereby an evaluation of basically homogeneous areas could be made. See Fig. 12. With the assistance of the Planning Staff the developed and developable land area in zones of high and potential hazard was then calculated. Values for the land, except that which is in public ownership, and any improvements were obtained from the Assessor's records. The valuations are based upon 100% of 1972 fair market value. By aggregating the valuations and then dividing these by the land area average values for land, improvements and total value per acre were obtained. The breakdowns for each of the six areas are shown on Table 3.

TABLE 3

ECONOMIC EVALUATION - REVISED TO 1972

Land Area and Assessed Value Tabulation

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Square Feet						
High Hazard Zone		2,482,778	642,968	100,595	738,199	1,174,355
Potential Hazard Zone	904,613	479,869	1,365,464	506,156	406,429	3,180,391
TOTAL	904,613	2,961,127	2,008,431	606,751	1,144,662	4,354,746
Acres						
High Hazard Zone		57.00	14.76	2.31	16.95	26.96
Potential Hazard Zone	20.77	11.02	31.35	11.62	9.33	73.01
TOTAL	20.77	67.98	46.11	13.93	26.28	99.97
Land Value ($)						
High Hazard Zone		1,268,463	60,217	30,520	321,425	84,285
Potential Hazard Zone	681,928	2,065,748	294,402	363,800	214,116	241,073
TOTAL	681,928	3,334,211	353,719	394,320	535,541	325,258
Building Value ($)						
High Hazard Zone		2,578,576		65,800	1,144,850	81,341
Potential Hazard Zone	382,732	6,258,755	580,300	868,388	598,574	594,230
TOTAL	382,732	8,837,331	580,300	934,188	1,743,424	675,571
Land Value/Acre ($/Ac)						
High Hazard Zone		22,254	4,080	13,212	18,963	3,126
Potential Hazard Zone	32,832	187,454	9,391	31,308	22,949	3,302
TOTAL	32,832	49,047	7,671	28,307	20,378	3,254
Building Value/Acre ($/Ac)						
High Hazard Zone		45,238		28,485	67,543	3,017
Potential Hazard Zone	18,427	467,945	18,510	74,732	64,156	8,139
TOTAL	18,427	129,999	12,585	67,063	66,340	6,758
Total (Land & Building) Value/Acre ($/Ac)						
High Hazard Zone		67,492	4,080	41,697	86,506	6,143
Potential Hazard Zone	51,259	755,399	27,901	106,040	87,105	11,441
TOTAL	51,259	179,046	20,256	95,370	86,718	10,012

Source: City and Borough of Juneau

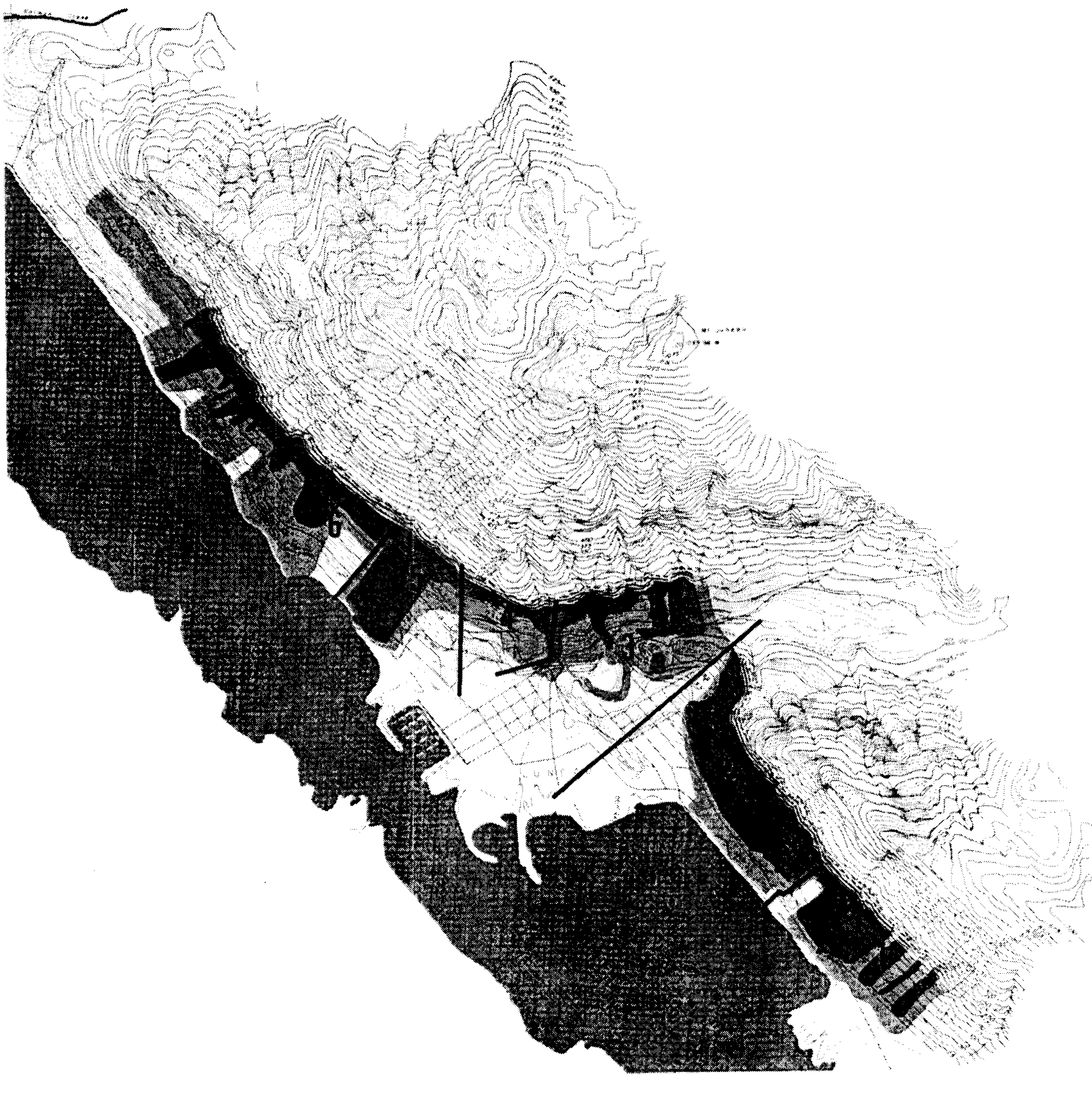
ECONOMIC EVALUATION AREAS

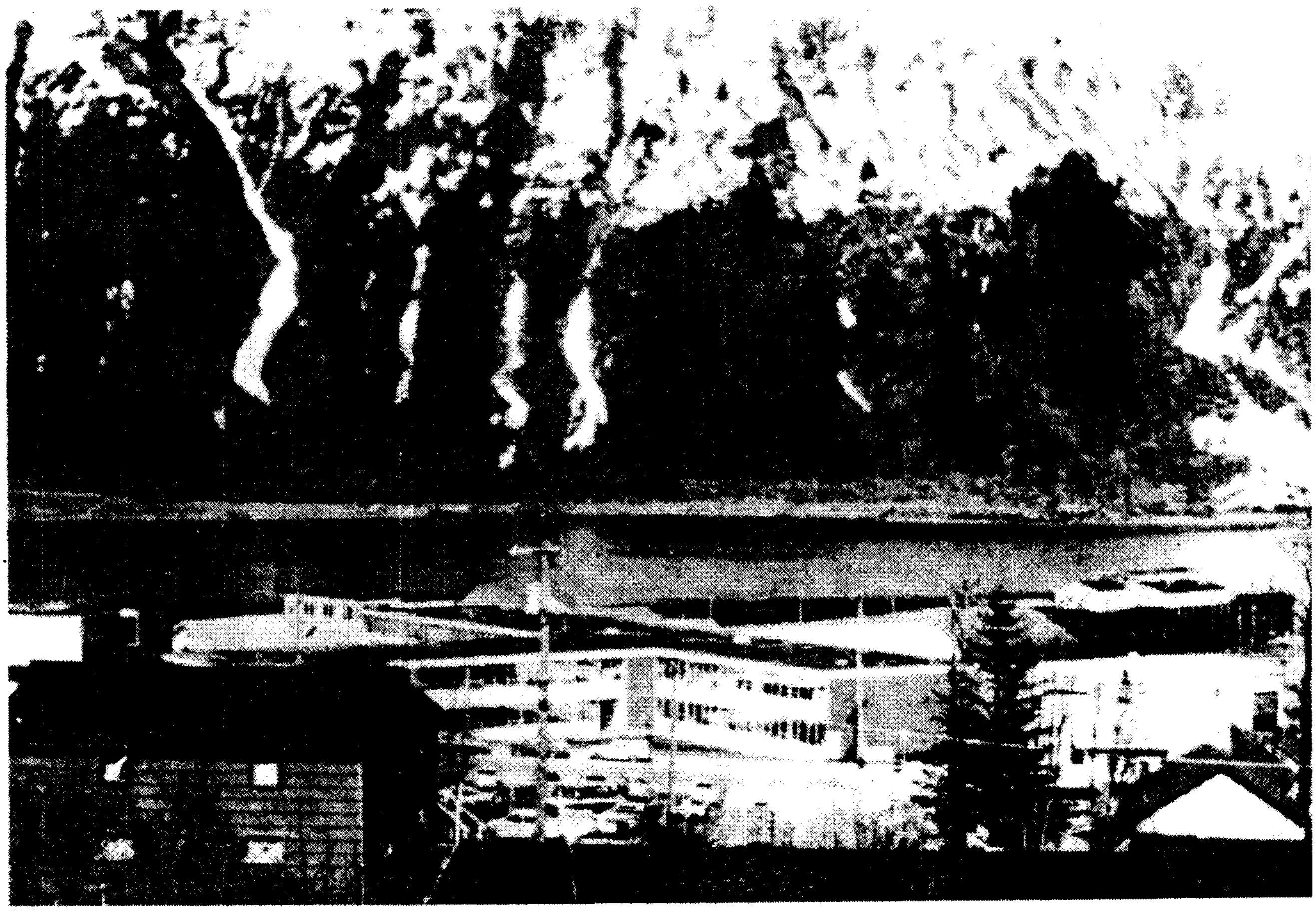
GEOPHYSICAL HAZARD INVESTIGATION
Juneau, Alaska

FIGURE 12

NORTH

SCALE IN MILES 0 .25 .50





FRAMEWORK FOR RECOMMENDATIONS

FRAMEWORK FOR RECOMMENDATIONS

This section describes the growth of the city of Juneau and influences of geophysical hazards on community development. It places findings of the Geophysical Hazards Investigation into a planning and land use control framework; and recommends alternative actions to the Borough Assembly as it deals with the problems of land use and community development in hazardous areas.

A. Juneau History

Discovery of gold in 1880 and resultant mining activities created the city of Juneau. Topography restricted early physical growth to the narrow, relatively flat area along the waters edge, backed by the steep slopes of Mt. Juneau and Mt. Roberts. Street and building locations were determined primarily by convenience to the mining sites, availability of materials and transportation. Poor roads limited access to areas outside the immediate environs of the city. Until recent years, much of the growth of the city has continued within the original city limits.

A significant change occurred in 1900. As a result of the move of the state capital site from Sitka, Juneau was established as a permanent city. Greater capital investment was required to provide the buildings and ancillary spaces required for governmental functions. The permanent residential population increased, less accessible land was developed and the community expanded further.

B. Community Development and Geophysical Hazards

Historically, the existence of any geophysical hazard has been a minor factor in determining the development and growth of a city. Disastrous events are not completely predictable, and long periods of time may elapse between disasters of major proportions. Consequently, people tend to either ignore or forget the existence of such hazards.

Community development generally occurs on sites which can serve the functional needs of a society. Cities are generally established because of proximity to good harbors, trade routes, market areas, natural resource deposits, etc. Development patterns are established early. As the community grows to maturity, it becomes increasingly difficult to modify the course of development once established. The city of San Francisco is an example. Developed as a trade center serving both the interior of the United States and the Orient, the city was virtually destroyed by the 1906 earthquake and fire. Despite the ever-present danger of another catastrophic earthquake, the city was rebuilt and continues to flourish on the same site.

Extensive development also has occurred along the San Andreas Fault in California. Development continues despite all scientific evidence which indicates that a severe earthquake of catastrophic proportions will in all probability occur sometime in the future, causing extensive losses of life and property.

Three elements affect community planning.

1. Cultural

   Cultural influences on community planning are difficult to define because they exist in the value system which establishes goals. Nevertheless, they exert a significant force in the shaping of a community. Communities whose cultural values are similar will generally have similar patterns of growth.

2. Physical

   The physical element imposes controls and limits to community development in very obvious ways. Topography, soil conditions, flood plains, water tables, all impose certain kinds of constraints and conditions upon land use patterns and development.

3. Public Welfare

   Land use planning and development regulations derive their authority from community held concepts about public welfare. The belief is that the regulation of uses of land to achieve community goals and that the control of development to maintain certain standards will insure the health, safety and well being of citizens as well as promoting a well balanced and attractive community for the benefit of all. The issue, which is applicable to Juneau, is to deal with the existing geophysical hazards as related to land use planning and public welfare. This Summary Report sets forth the nature, extent and location of the earthquake, mass wasting and snow avalanche hazards affecting Juneau. The Technical Supplement presents the work and findings of the consulting teams engaged in this investigation, as well as reports of related investigations which were done in the past. Now these technical findings must be translated into action which will permit the Planning Commission and Borough Assembly to make decisions concerning the use of land in the hazardous areas of Juneau.

Not all natural hazards prevent development. Policies have been established, and legislation enacted, to bring about public works projects to mitigate the disasterous effects of some natural hazards.

The national policy for funding of flood control projects under the auspices of the Corps of Army Engineers and the Flood Plain Insurance Subsidy Program are two examples. The series of dams, dikes and levees constructed to control the rivers of the United States has made available a large amount of land for use which had been heretofore unsafe. However, there is no reasonable way to make this land <u>totally</u> safe from flooding. Consequently, communities have imposed certain flood plain land use controls upon development of flood prone land.

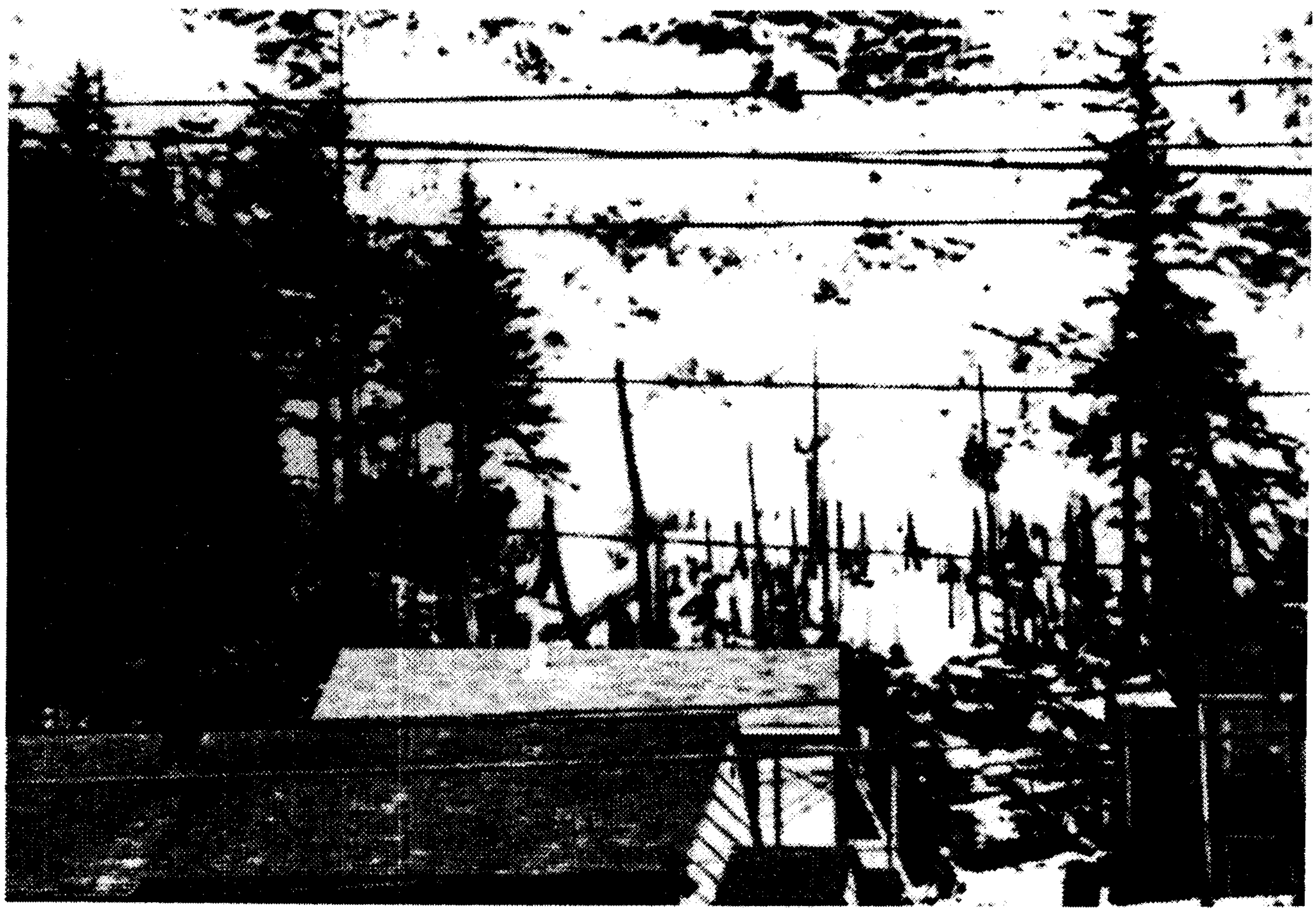
Seismic hazard zoning and building regulations such as those included in the Uniform Building Code are another example of the policies which influence the extent and type of development. Though not so dramatic as flood plain zoning in terms of land use development and control, communities adopting UBC regulations dealing with the construction and design of buildings in earthquake prone areas are recognizing an existent danger, and attempting to deal with potential loss of life or damage to property.

On the other hand, the inability of communities to act effectively and adopt the necessary legislation which can prevent development of hazardous areas can have far reaching consequences. A case in point, which is directly applicable to Juneau is the Yodlin disaster of Sunday, January 24, 1971, at Stevens Pass in Chelan County, State of Washington. Four people were killed and six injured when a snow avalanche struck an area where about forty vacation cabins were clustered. The recreational development had been allowed to be built despite reported warnings that the area was prone to avalanches. As a result of the disaster a suit for damages has been filed against the Board of County Commissioners and the Planning Commission of Chelan County, Washington. The plaintiffs contend that the governing body is liable for damages for allowing development to occur in an area which was known and documented to be susceptible to snow avalanches.

Altering land use patterns is by no means an easy task in an established community. The patterns have been set, improvements made and a vested interest developed. Changes or the imposition of stricter land use controls invariably become a controversial issue.

Other factors influencing zoning and planning desicions, such as cultural dictates, community design philosophy, or economics may be changed. However, natural hazards, for the most part, cannot be changed by man's actions. The application of land use controls based on known natural hazards thus assumes prime importance.

The following section offers a series of recommendations which, if incorporated into existing land use control and development regulations, would constitute a body of legislation recognizing and dealing effectively with geophysical hazards.



RECOMMENDATIONS

RECOMMENDATIONS

The authority and responsibility for the planning and development of a community is given to the Borough Assembly by the state and is defined in the Alaska Statutes. At the local level the general body of law and regulations is contained in such documents as the Zoning Ordinance, Subdivision Ordinance, Comprehensive Plan, etc. A basic legal premise behind these documents rests in the theory that controls are drawn up for the purpose of providing for the general public welfare. A quote from paragraph 49.25.101, Purpose and Intent of the Comprehensive Zoning Ordinance of the Greater Borough of Juneau is illustrative.

> "The several purposes of the ordinance are: to implement the comprehensive development plan for the Borough, to encourage the most appropriate use of land; to conserve and stabilize the value of property; to aid in the rendering of fire and police protection; to provide adequate open space for light and air; to lessen the congestion on the streets; to give an orderly growth to the Borough; to prevent undue concentrations of population; to improve the Borough's appearance; to facilitate adequate provisions for community utilities facilities such as water, sewerage, electrical distribution systems, transportation, schools, parks, and other public requirements, and in general to promote public health, safety and general welfare." (emphasis added)

Since the regulatory powers of the Borough Assembly are derived from this theory of law, the premise adopted by this report, and upon which the following recommendations are predicated, is that the government has a direct responsibility to impose land use controls which will eliminate or minimize danger to life and property due to known geophysical hazards.

The specific recommendations which follow deal with each of the geophysical hazards on an individual and aggregate basis. No attempt has been made to provide a set of blanket recommendations covering legislation which would provide for every instance and treat all hazards equally since not all of the hazards present equal danger to life and property.

In addition to and supplementing the recommendations set forth in each of the separate Geophysical Hazard Investigation reports contained in the Technical Supplement, we specifically recommend the following:

A. <u>Legislative Recommendations</u>

1. That the Planning Commission submit to the Borough Assembly the draft of a resolution instituting a temporary moratorium on any changes to land uses which would have the effect of increasing population densities in those areas determined by this investigation to be high hazard areas (see Fig. 11). This moratorium to be in effect only so long as to permit the Planning Commission to prepare formal revisions to the Comprehensive Plan and to submit to the Borough Assembly a legislative package containing revisions to the Comprehensive Plan, Zoning Ordinance, Subdivision Ordinance and Building Code. The moratorium should be automatically terminated upon action of the Borough Assembly on this legislative package.
2. That the City and Borough planning programs be revised to incorporate effectively the constraints to community development imposed by the existence of geophysical hazards. This can be accomplished by changes and ammendments to the Comprehensive Plan, Zoning and Subdivision Ordinances in the following manner:

a) Comprehensive Plan

(1) Amending the Comprehensive Plan Map to incorporate those areas within the City and Borough of Juneau designated as high and potential hazard areas in the Composite Hazard Map (Fig. 11) of this report.

(2) Incorporation of textual changes reflecting the necessity for imposing limitations on the use of land in hazard areas, particularly in terms of population exposed to dangers as a result of geophysical hazards.

(3) Revision to the planned development pattern of the Comprehensive Plan so that open space or very low density land uses are allocated to areas of high hazard. (Refer to Fig. 11).

(4) Eliminating from long and short range development plans any public facilities which would have the effect of concentrating people in hazard areas, or which provide necessary community services.

(5) Planning for development in hazard areas which will tend to eliminate the loss of life and minimize property damage should a catastrophic event occur. Uses to be considered are parking, warehousing, open recreation space, storage, etc.

b) Zoning Ordinance

The Zoning Ordinance of the City and Borough of Juneau should be amended to account for geophysical hazards. It is suggested that the method for control of land use in affected areas be by the adoption of two overlay districts which reflect the degree of danger to life and property from such hazards. The designation of these districts could be:

H-1 High Geophysical Hazard District

H-2 Potential Geophysical Hazard District

The geographical limits of these two districts, and the controls on land uses within these districts is identified on the Composite Hazard Map (Fig. 11) in this report.

The purpose of these overlay zones is not intended to eliminate the existing and future uses of land affected by geophysical hazards, but to control, modify and change the density and the use of such land so that loss of life and property may be either totally avoided or minimized, in the event of the occurrence of a geophysical disaster.

(1) H-1 High Geophysical Hazard District

Purpose: The purpose of the H-1 District is to recognize that certain lands within the City and Borough of Juneau are affected by geophysical hazards which constitute a severe danger to life and property. Therefore, it is deemed appropriate that the Borough Assembly take action which will impose such controls as necessary to limit the density and development of such affected land in order to prevent loss of life and property. The Borough Assembly may, from time to time as warranted, create and superimpose H-1 Districts upon other existing districts in addition to those affected at the time of adoption of this ordinance.

Land classified in a H-1 District shall, in addition, retain its original classification in one of the regular districts as listed in Article IV. The zoning of such land shall then be designated by a combination of symbols, e.g. R-5H-1, RMMH-1, etc.

A. Existing Uses

1) Any lawful use of land and/or building or structure existing or under construction at the time this ordinance was adopted, may be continued. However, all such land and/or buildings and structures automatically become subject to the provisions of Section 49.25.505 at the time of adoption of this ordinance.

2) Affected land and/or building or structure affected by the superimposed provisions of this ordinance will continue to be regulated by the provisions of the regular districts as listed in Article IV at the time of adoption.

3) No use shall be allowed to enlarge, or any action taken by the owner which would cause an increase in density above ten (10) persons per acre.

B. <u>New Uses</u>

1) Revisions to existing uses and the establishment of new uses of land and/or building or structure may be considered by the Planning Commission. The revision of an existing use or the establishment of a new use will be permitted in this district only after the issuance of a conditional use permit subject to the provisions of Section 49.25.600.

2) The Planning Commission shall periodically review the development pattern of areas upon which this district has been superimposed. The Planning Commission shall also make periodic recommendations to the Borough Assembly for revisions to the

development patterns of areas affected by this district which may then be incorporated into the Comprehensive Plan.

3) No use shall be permitted which would cause an increase in density above ten (10) persons per acre.

C. Appeals

Any person aggrieved by the provisions of this ordinance may appeal in accordance with the provisions of Section 49.25.600 or Article VIII.

(2) H-2 Potential Geophysical Hazard District

Purpose: The purpose of the H-2 District is to recognize that certain lands within the City and Borough of Juneau are affected by geophysical hazards which constitute a significant danger to life and property. Therefore, it is deemed appropriate that the Borough Assembly take action which will impose such controls as necessary to limit the density and development of such affected land in order to prevent loss of life and property. The Borough Assembly may, from time to time as warranted, create and superimpose H-2 Districts upon other existing districts in addition to those affected at the time of adoption of this ordinance.

Land classified in a H-2 District shall, in addition, retain its original classification in one of the regular districts as listed in Article IV. The zoning of such land shall then be designated by a combination of symbols, e.g. R-5H-2, RMMH-2, etc.

A. Existing Uses

1) Any lawful use of land and/or building or structure existing or under construction at the time this ordinance was adopted may be continued. However, any such use which permits a density in excess of twenty (20) persons per acre automatically becomes subject to the provisions of Section 49.25.505 at the time of adoption of this ordinance.

2) Affected land and/or building or structure affected by the superimposed provisions of this will continue to be regulated by the provisions of the regular districts as listed in Article IV at the time of adoption.

3) Any change in the existing use of any land and/or building or structure falling under the regulations of this district will be permitted only after the issuance of a conditional use permit subject to the provisions of Section 49.25.600.

4) No use shall be allowed to enlarge, or any action taken by the owner, which would cause an increase in density above twenty (20) persons per acre.

B. New Uses

1) Revisions to existing uses and the establishment of new uses of land and/or building or structure may be considered by the Planning Commission. The revision of an existing use or the establishment of a new use will be permitted in this district only after the issuance of a conditional use permit subject to the provisions of Section 49.25.600.

2) The Planning Commission shall periodically review the development pattern of areas upon which this district has been superimposed. The Planning Commission shall also make periodic recommendations to the Borough Assembly for revisions to the development patterns of areas affected by this district which may then be incorporated into the Comprehensive Plan. No use shall be permitted which would cause an increase in density above twenty (20) persons per acre.

C. <u>Subdivision Ordinance</u>

1) Incorporation into the text of the Subdivision Ordinance of the requirement for a special review by the Platting Board of subdivisions proposed for areas where known geophysical hazards exist. The purpose of this review would be to determine the extent and severity of hazards to the proposed subdivision.

2) Revision to the Ordinance which would grant authority to the Platting Board to deny acceptance of a proposed subdivision on the basis of exposure to geophysical hazards.

3) Incorporation of the provision that no waiver of review will be granted for land affected by geophysical hazards.

4) Amending Sections 49.35.130(b) and 49.35.170(b) of the Subdivision Ordinance to require that all areas with a proposal subdivision which are exposed to geophysical hazards be delineated and noted on the Preliminary and Final Plats.

3. It is recommended that the ordinance adopting the 1970 version of the Uniform Building Code as the governing building code for the

City and Borough of Juneau be amended as follows:

a. Redesignate Juneau as seismic probability area 3 instead of 2.

b. Require that soil tests be made by engineering geologists and foundations designed by structural engineers for all buildings proposed for construction in areas of poor soil conditions that would be severely affected in the event of a seismic occurrence. Refer to Fig. 2 for location. Waiver of this requirement should be made upon the discretion of the Building Official.

c. Prohibit or allow only limited building activity with very low permissible occupancy in mass wasting hazard areas as indicated on Fig. 6 of this report. Structures which would house facilities providing vital services to the general community, as well as those that would encourage concentrations of people on a permanent or temporary basis, would be prohibited in high hazard areas. All proposed building projects should be reviewed and approved by the Building Official for type, design, construction and occupancy prior to the issuance of a building permit.

Design criteria for the effects of a landslide on a building are dependent on a number of variable factors such as: building design, location of site, soil conditions, configuration of site, location and aspect of building in relation to potential hazard, etc. Therefore, it is recommended that each project planned in hazardous areas be studied individually and as part of this study, a detailed engineering geology investigation of the site be made by a qualified engineer. Furthermore, that all structures to be so located be designed by a qualified structural engineer. It is further recommended that evidence be submitted to the Building Official that these requirements have been met at the time of application for a building permit.

The following guidelines for design of buildings to be located in hazardous areas are recommended:

(1) Anticipated density of sliding material is 80 lbs/ft^3 moving at a velocity of 3 ft/sec.

(2) Buildings should be of reinforced concrete or structural steel frame construction.

(3) Buildings should have no planned occupancy on first and/or second floors, as determined by the slope of the site.

(4) Buildings constructed on slopes should be elevated on columns. Any walls on ground floor should have breakaway or knockout provisions.

(5) Buildings located on level sites beyond toe of slopes should have a minimum of 40 feet level horizontal clearance between the toe of the slope and any wall in the uphill side if solid walls are to be constructed. No openings are to be permitted in such walls, and the design should be able to withstand an equivalent fluid pressure of 60 lbs/ft^2 to a depth of 20 feet.

d. Prohibit or severely limit building activity in high hazard snow avalanche areas as indicated on Fig. 10 of this report.

Economical solutions to buildings which would permit occupancy with any degree of safety and withstand snow pressures exceeding 200 lbs/ft^2 is highly improbable. Limited building activity for certain uses not requiring human occupancy and not providing vital services to the general community may be permitted at the discretion of the Building Official. However, all such proposed projects should be made contingent upon his review and approval prior to the issuance of a building permit.

Allow only limited building activity with very low permissible occupancy in potential hazard snow avalanche areas as indicated on Fig. 10 of this report. All proposed building projects should be reviewed and approved by the Building Official for type, design, construction and occupancy prior to the issuance of a building permit.

Criteria for the design of structures in potential hazard areas should conform to the guidelines set forth in Table 1 of this report. Recommended design criteria for structures is as follows:

(1) Buildings are to be constructed of reinforced concrete walls and roofs.

(2) Wall panels and frame are to be designed to withstand pressures of 200 lbs/ft^2.

(3) Roofs designed to withstand equivalent uplift forces as would be generated by winds of 220 m.p.h.

(4) Building design should eliminate long term occupancy spaces and openings facing the direction of the anticipated avalanche, and relegate such exposure to non-occupied spaces as corridors and mechanical rooms.

B. Administrative Recommendations

The following recommendations are made for incorporation into the administrative policies of the City and Borough of Juneau:

1. That a policy and procedure be established whereby land acquired by the Borough from the State of Alaska could be made available for exchange with that of property owners in hazardous areas. This policy to also permit partial or total compensation, as the case may be, to land owners who sustain a real loss as a result of zone changes.
2. Institute a policy providing for a special capital investment fund for the specific purpose of acquiring property and improvements from those individuals whose property is located in highly hazardous areas and whose continued occupancy constitutes a serious threat to life. The acquisition costs should be based on replacement costs established at the time this policy goes into effect. Compensation for improvements made after such time would not be made.
3. Institute a policy of hazard disclosure. This would consist of posting of hazard areas on the zoning map, comprehensive plan map, assessor's maps and mandatory clause to be included in the deed to the property in such areas which would alert prospective buyers. Disclosure of hazards by real estate agents should also be made a requirement.
4. Institute a policy of tax adjustment for those properties located in hazardous areas.

Other Recommendations

The following recommendations are not to be construed as being effective alternatives to a set of legislative and administrative policie con- trolling land development and population in hazardous areas. Rather, they should be considered as complementary to such policies, and as additional means of providing safeguards against disasters.

Implementation only of these recommnedations would not constitute an effective program providing the required safeguards for people and property, since on each case they have inherent limitations. For example, a warning system may be extremely difficult to implement in the urbanized areas of Juneau. Warning systems have had only limited degrees of success, and then in basically rural areas. Furthermore, it is virtually impossible to predict precisely when an avalanche will occur. Consequently, a warning system has built into it the factor of "false alarms". Inevitably, a series of such false alarms is bound to occur which in turn result in the erosion of credibility in the system.

A vegetation retention and reforestation program has limited applic- ability. The danger of placing faith in such a program is that property owners might get a false sense of their own security. Vwge- tation on steep slopes will do a great deal to stabilize the soil and thick stands of trees will, to some degree, provide a buffer against avalanches. However, neither will guarantee total safety from avalanches.

Total reliance on defense structures in snow avalanche-prone zones can similarly be deceptive. It is true that structural defense testing programs have been underway for some time, and that some types of structures have been proved to have some value; however, the costs of the most effective structures have been very high, and their effectiveness, when weighed against the possible loss of many lives, has been limited.

The following recommendations have been made in order to apprise those responsible of all methods which are currently available to deal with the problems caused by geophysical hazards. Despite the limited effect that each of these recommendations may ultimately have on the preservation of life and protection of property, it cannot be argued that they have no value at all. Therefore, in order to provide a comprehensive report on geophysical hazards in Juneau and recommended action to deal with the problems, the following recommendations are made:

1. <u>Climate Monitoring</u> - it is recommended that a program for the monitoring of snowfall during the winter and of accumulation of debris and rocks on potentially hazardous slopes be instituted. Arrange for trained personnel or designate present personnel who could be trained, who combined with visual observations and telemetry devices, would serve to provide advance warning of potential hazards. The snow accumulation monitoring program should be carried on during the winter and early spring when the hazard of avalanche is the greatest. Local authorities should also be alert during periods of heavy rain in late fall and early winter when the probability of rock and mud slides occurring is greatest. A jointly run and financed program involving the U.S. Weather Bureau, U.S. Forest Service and the City and Borough of Juneau should be considered.

2. Warning Systems - concurrently, with the establishment of a climate monitoring program, there should be established a system of warning. This warning system should be effective enough so as to ensure that all people residing in hazardous areas can be contacted in sufficient time to evacuate their premises. The Civil Defense organization would be the agency that would be most logically responsible for issuing the requisite warning.

   In conjunction with the warning system, an evacuation plan should then be developed. This plan should consist of specific locations for people who are required to leave their homes during times of imminent danger. Locations for temporary lodging such as the National Guard Armory, schools and other suitable public buildings located in areas free from hazards should be made available with provisions for the establishment of temporary sleeping quarters and feeding the evacuees. Since most major public buildings in Juneau are not located within the boundaries of hazardous areas, several could be suitable for this purpose. The existing Civil Defense organization is already trained in these procedures and could form the skeleton for an evacuation team.

3. Retention of Vegetation

   a. It is recommended that an immediate moratorium with penalties for violation, be placed on the removal of any vegetation now existing in undeveloped areas classified as High Hazard in the Composite Hazard Maps. (Fig. 11)

   b. It is recommended that the City immediately undertake, in consultation with the United States Forest Service, a program of reforestation of selected areas within the High Hazard classification which are presently denuded or only partially vegetated.

c. Furthermore, no additional vegetation be removed in High Hazard areas which are presently developed, and that efforts be made encouraging landowners of presently developed High Hazard areas to protect those properties with a barrier of vegetation.

4. Defense Structures - an alternative for eliminating destruction as a result of natural hazards, especially in the case of snow avalanches, is to erect structures in the breakaway zones of snow avalanche areas to catch and retain snow. The cost-effectiveness relationship of defense structures may be questionable and detailed review would be required to determine in what locations are most suited and where they would be most effective.

   Research work has been conducted and is currently underway in various parts of the United States as well as Europe which has developed suitable structures. This alternative may be more desirable than one in which may accrue high costs to the community for the acquisition of land that would be no longer suitable for development or habitation because of the extreme hazard.

5. Excavations

   a. It is recommended that a policy be adopted prohibiting the disturbance or removal of earth materials in areas of active mass wasting or classified as Mass Wasting High Hazard.

   b. It is recommended that no excavation be permitted on the upper surface or lateral edges of any known historic or prehistoric landslide deposit, except that done by the City-Borough to remove overloaded upper portions. In the event that excavation at or near the toe of the slide cannot be avoided, supportive structures providing a restraining force equivalent to those of the material removed should be constructed immediately after excavation. Furthermore, any such excavation should be prohibited during periods of high precipitation, particularly the months of September, October and November.

GLOSSARY OF TERMS

ALLUVIUM - a general term for all fragment deposits resulting from the operations of modern rivers, thus including the sediments laid down in river beds, flood plains, lakes, stands at the foot of mountain slopes, and estuaries.

CHANNEL - a grove or gully eroded into the surface of the slope of a hill or mountain.

COHESION - the ability of individual soil particles to stick or adhere together through the action of temporary tension, cementation or weak electrical bonding of clay minerals and organic colloids.

COLLUVIUM - a general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity. Talus and cliff debris are included in such deposits.

DEBRIS - the material resulting from the decay and disintegration of rocks. It may occur in the place where it was produced or it may be transported by streams of water or ice and deposited in other localities.

DIP - the angle at which a stratum or any other planar feature is inclined from the horizontal. The dip is at a right angle to the strike (see definition).

GULLY - a small ravine. Any erosion channel so deep that it cannot be crossed by a wheeled vehicle or eliminated by plowing.

JOINT - fracture in rock, generally more or less vertical or transversed bedding, along which no appreciable movement has occurred.

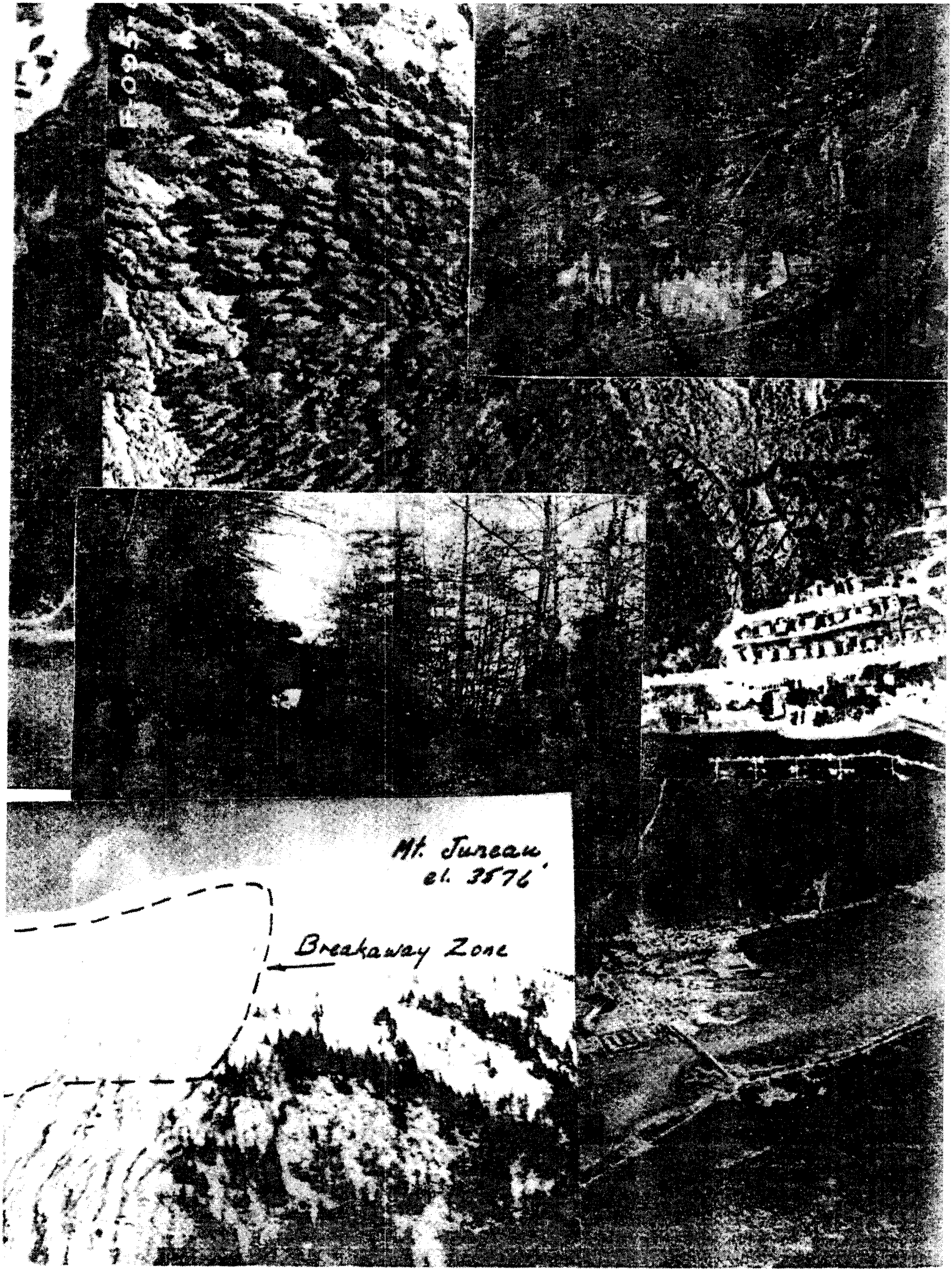
METAMORPHISM - the process by which consolidated rocks are altered in composition, texture, or internal structure or conditions and forces not resulting simply from burial and the weight of subsequently accumulated overburden. Pressure, heat and the introduction of new chemical substances are the principal causes, and the resulting changes, which generally include the development of new minerals or a thermodynamic response to a greatly altered environment.

PORE WATER PRESSURE - pressure produced by the head of water (its vertical height above an impermeable base) in a saturated soil and transferred to the base of the soil through the pore water.

STRIKE - the course or compass bearing of the outcrop of an inclined bed or structure on a level surface; the direction or bearing of a horizontal line in the plane of an inclined stratum, joint, fault, cleavage plane, or other structural plane.

TALUS - a collection of fallen, weak,non-firm material which has formed a slope at the foot of a steeper declivity.

TECTONIC - of, pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust. As applied to earthquakes it is used to describe shocks not due to volcanic action or to collapse of caverns or landslides.


Mt. Juneau
el. 3576'
Breakaway Zone

Daniel, Mann, Johnson, and Mendenhall

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