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Earthquake Hazards in the Pacific Northwest of the United States

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EARTHQUAKE RISK REDUCTION PROSPECTS FOR THE PUGET SOUND AND PORTLAND AREAS

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Foreword

This paper is one of a series dealing with earthquake hazards of the Pacific Northwest, primarily in western Oregon and western Washington. This research represents the efforts of U.S. Geological Survey, university, and industry scientists in response to the Survey initiatives under the National Earthquake Hazards Reduction Program. Subject to Director's approval, these papers will appear collectively as U.S. Geological Survey Professional Paper 1560, tentatively titled "Assessing Earthquake Hazards and Reducing Risk in the Pacific Northwest." The U.S. Geological Survey Open-File series will serve as a preprint for the Professional Paper chapters that the editors and authors believe require early release. A single Open-File will also be published that includes only the abstracts of those papers not included in the pre-release. The papers to be included in the Professional Paper are:

Introduction

Rogers, A.M., Walsh, T.J., Kockelman, W.J., and Priest, G.R., "Earthquake hazards in the Pacific Northwest: An overview

Tectonic Setting

Paleoseismicity

Adams, John, "Great earthquakes recorded by turbidites off the Oregon-Washington margin"

Atwater, B.F., "Coastal evidence for great earthquakes in western Washington"

Nelson, A.R., and Personius, S. F., "The potential for great earthquakes in Oregon and Washington: An overview of recent coastal geologic studies and their bearing on segmentation of Holocene ruptures, central Cascadia subduction zone"

Peterson, C. D., and Darienzo, M. E., "Discrimination of climatic, oceanic, and tectonic forcing of marsh burial events from Alsea Bay, Oregon, U.S.A."

Tectonics/Geophysics

Goldfinger, C., Kulm, L.D., Yeats, R.S., Appelgate, B., MacKay, M., and Cochrane, G., "Active strike-slip faulting and folding in the Cascadia plate boundary and forearc, in central and northern Oregon"

Ma, Li, Crosson, R.S., and Ludwin, R.S., "Focal mechanisms of western Washington earthquakes and their relationship to regional tectonic stress"

Snavely, P. D., Jr., and Wells, R.E., "Cenozoic evolution of the continental margin of Oregon and Washington"

Weaver, C. S., and Shedlock, K. M., "Estimates of seismic source regions from considerations of the earthquake distribution and regional tectonics"

Yeats, R.S., Graven, E.P., Werner, K.S., Goldfinger, C., and Popowski, T.A., "Tectonic setting of the Willamette Valley, Oregon"

Earthquake Hazards

Ground Motion Prediction

Cohee, B.P., Sommerville, P.G., and Abrahamson, N.A., "Ground motions from simulated M_W=8 Cascadia earthquakes"

King, K.W., Carver, D.L., Williams, R.A., and Worley, D.M., "Site response studies in west and south Seattle, Washington"

Madin, I. P., "Earthquake-hazard geology maps of the Portland metropolitan area, Oregon"

Silva, W.J., Wong, I.G., and Darragh, R.B., "Engineering characterization of strong ground motions with applications to the Pacific Northwest"

Ground Failure

Chleborad, A. F., and Schuster, R. L., "Earthquake-induced ground failure associated with the April 13, 1949, and April 29, 1963, Puget Sound area, Washington, earthquakes"

Grant, W. P., Perkins, W. J., and Youd, L., "Liquefaction susceptibility maps for Seattle, Washington North and South Quadrangles

Earthquake Risk Assessment

Wang, Leon R.L., Wang, Joyce C.C., and Ishibashi, Isao, "GIS applications in seismic loss estimation model for Portland, Oregon water and sewer systems"

Implementation

Kockelman, W. J., "Techniques for reducing earthquake hazards--An introduction"

Booth, D.B., and Bethel, J.P., "Approaches for seismic hazard mitigation by local governments--An example from King County, Washington"

May, P.J., "Earthquake risk reduction prospects for the Puget Sound and Portland Areas"

Perkins, J.B., and Moy, K.K., "Liability for earthquake hazards or losses and its impacts on Washington's cities and counties"

Preuss, Jane, and Hebenstreit, G. T., "Integrated hazard assessment for a coastal community: Grays Harbor"

Contents

List of Tables

Illustrations

ABSTRACT

This discussion addresses prospects for reducing earthquake risks in the Puget Sound and Portland areas. Major cities and counties in the region are categorized with respect to current and prospective earthquake risk reduction efforts. This understanding of differing situations within the region provides a basis for considering four state or regional-level implementation strategies that might be undertaken as new information about earthquake risks is developed. These range from a relatively passive strategy of hazards information dissemination to more active efforts to seek policy reforms or influence practices.

INTRODUCTION

One of the important lessons of the U.S. Geological Survey hazard assessment program in Utah and California is that simply providing technical information about earthquake risks is an insufficient basis to stimulate changes in local practices or policies. As local officials know all too well, a host of political and economic considerations come into play when considering land use or building regulatory issues. Moreover, it is unrealistic to assume that earthquake risks are high on the agendas of state or local officials.

Recognizing the need to think systematically about future implementation issues, this review summarizes research addressing risk reduction prospects within the Puget Sound and Portland areas. This is not a primer on the practices to employ for different risk situations, nor a civics lesson about how to influence city hall. Rather, the intent is to provide an understanding of existing policies and practices -- a baseline if you will -- and an understanding of key features of the political-economic landscape likely to shape future opportunities and obstacles to local risk reduction efforts. An understanding of factors likely to shape risk reduction efforts in this region provides the necessary understanding for designing strategies for implementing state or regional-level risk reduction programs.

In thinking about earthquake hazards in the Puget Sound-Portland region, it is important to remember that the scientific research within the region is still evolving. Scientists seem to agree that a major earthquake in this region, on a scale of the Olympia earthquake in 1949 or Seattle-Tacoma earthquake in 1965, is certain to recur. Moreover, some USGS research suggests the possibility of seismic events in this region of much greater magnitude than previously documented. One contribution of this chapter is to suggest how risk reduction efforts might be altered as more is learned about the extent of seismic hazards and the risks they pose.

In depicting the political-economic landscape for earthquake policies, the research reported here has of necessity been fairly limited in scope. The geographic focus consists of counties, the larger cities, and selected utilities and ports within the Puget Sound and Portland areas. (The specifics are provided in the next section.) The topical foci are the land use and building practices of the local jurisdictions as they relate to seismic hazards. State policies are discussed as they concern local policies and practices, but this effort is not intended to provide an agenda for state-level policy action. Professional practices of the engineering and design community are touched upon as they relate to local policy.

The discussion is organized as follows. The first part provides details about the setting with respect to both the jurisdictions under study and data collection. The second part discusses relevant officials' sense of risks posed by earthquake hazards. The third part describes the current status of earthquake risk reduction policies and practices in the region. The fourth part provides a discussion of the opportunities and potential constraints to enhancing earthquake risk reduction in considering the political-economic landscape among relevant cities and counties. The implications for future actions as more is learned from the research efforts about seismic hazards in this region are discussed in part five.

THE JURISDICTIONS UNDER STUDY

A fairly broad geographic area comprising thirteen counties within the Puget Sound area -- Clark, Cowlitz, Grays Harbor, Island, King, Kitsap, Jefferson, Mason, Pierce, Skagit, Snohomish, Thurston, and Whatcom counties -- and six counties within the Willamette Valley area -- Clackamas, Marion, Multnomah, Polk, Washington, and Yamhill counties -- were selected for this study. The corresponding cities over 10,000 population within these counties are listed in table 1. For ease of communication, these 19 counties and 43 cities are referred to as a single region in what follows.

Within the nineteen-county region under study, there are 97 incorporated cities, over 200 school districts, over 200 other special districts, and 22 port districts. The "other" special districts consist of separately governed entities such as water and sewer districts, public utility districts, drainage districts, road districts, soil conservation districts, and metropolitan councils of government. Within many of these cities and other local jurisdictions there are multiple agencies with responsibilities (and overlapping authorities) for addressing public safety. Earthquake risk reduction efforts in this region could ultimately affect over 500 jurisdictions and, as of 1987, 4.7 million people.

Some sense of the potential vulnerability is provided by a few statistics about the region's stock of buildings and other property. As of 1988, the total value of property in the region is estimated to be $180 billion. The value of new construction in 1987 of apartments, office and commercial buildings, and industrial buildings is reported by the Census Bureau to be nearly $1.5 billion. This is almost a 50 percent increase in value of new commercial construction over 1980. Because many newcomers -- some who are leaving "earthquake country" in California -- are entering the region, the population and associated assessed value figures for this region will certainly grow over the coming decade.

The region's cities over 10,000 population, counties, and utilities and port districts were chosen for inclusion in the study. These are the areas with the greatest populations and property values. Within the 13 Washington counties under study, there are 27 cities over 10,000 population including Bellingham, Bellevue, Everett, Olympia, Seattle, Tacoma, and Vancouver. Some 3.3 million people resided in these 13 counties as of 1987. Within the six Oregon counties under study, there are 16 major cities including Beaverton, Gresham, Portland, and Salem, comprising a 1987 population of 1.4 million people.

The research findings reported here are based on interviews, conducted over a six-month period, beginning in September 1988, with a total of 177 individuals. The interviewees fell into three categories:

- Those directly responsible for land use and building regulation in each of the 43 cities and 19 counties;
- Public works or other utility personnel responsible for water and sewer utility functions for municipal systems in 41 of the cities; and
- Engineering directors of six of the larger port districts -- Bellingham, Everett, Olympia, Portland, Salem, and Tacoma.

The interviews for cities and counties entailed talking with the planning director and the chief building official (or an individual they designated). The study's focus on risk reduction, rather than response to seismic events, led to the decision to exclude emergency services personnel except in a few jurisdictions where such personnel had broader set of responsibilities. In many jurisdictions, relevant personnel in the mayor's, city manager's, or county administrator's office were also interviewed. Additional interviews were conducted with state officials in relevant state-level building regulatory and land use agencies. In-person interviews lasting 30 min to 1 hr each were conducted at the state level and within the larger jurisdictions. The remaining interviews were by telephone.

The interviews were used to develop "profiles" of each of the cities' and counties' earthquake related policies and practices and to develop the information that follows. Draft profiles were shared with key individuals in each jurisdiction and revised to correct factual errors in the draft.

The discussion is organized as follows. Risk perceptions among different categories of respondents are first described in showing a general awareness of risk among elected and appointed officials, but limited concern. This is followed by a discussion of the variation among local jurisdictions in risk reduction policies and practices. Recognition of this variation leads in the final section to a discussion of strategies for improving risk reduction prospects.

DIFFERING RISK PERCEPTIONS

One aspect of this research entailed characterizing different risk perceptions. One set of questions gauged elected officials' sense of the likelihood of significant property damage, deaths, or injuries from a seismic event in the next 20 to 30 yr. Another set of questions addressed building officials' and engineering directors' sense of the vulnerability of the building stock or facilities within their jurisdictions to a major seismic event occurring within the region.[2]

ELECTED OFFICIALS' RISK PERCEPTIONS

Information about elected officials' risk perceptions helps to depict the broad political context for considering earthquake risk reduction. The results evidence a general awareness of seismic risks in the region, with a somewhat greater awareness in Washington state. Some respondents reported reading about the USGS research in local newspapers, commented about media reports of earthquake swarms, or recalled the 1965 or 1949 earthquakes. On the other hand, there appears to be discounting of the risk. Whatever the risk perception, given other more pressing concerns, earthquake hazards appear to of relatively little concern to elected officials.

These findings are consistent with similar investigations in other regions of moderate to high seismic risk, including California (see, for example, Berke and Wilhite, 1988; Drabek, Mushkatel, and Kilijanek, 1983; Mushkatel and Nigg, 1987). The fact is that earthquake risks fall at the less dreaded and more accepted ends of the spectra of politicians' and the general public's selective attention to various risks.

A summary of elected officials' responses is provided in figure 1. This profile suggests a general awareness of the potential for a moderate earthquake, with a lesser sense of the potential for a major earthquake.[3] Because no one knows the absolute risks posed by these hazards, it is more appropriate to refer to relative comparisons of risks as represented by "deviation scores."[4] In addition, the tendency for some respondents to rate all risks very highly and other respondents to rate all risks with lower scores is accounted for by using relative scores.

Figure 1 shows that chemical spills are considered the most noteworthy risk. Moderate earthquakes are second in importance among Washington cities and third in importance among Oregon cities. Major earthquakes are considered less significant risks than major landslides but more significant than dam failures. While major earthquakes are presumed to be more damaging than moderate earthquakes, elected officials appear to discount the likelihood that major earthquakes will occur and thus rate them as a less significant risk.

The results for county elected officials (not shown) are somewhat different than the city results. For both Oregon and Washington counties, flooding is reportedly the most important risk, followed in decreasing order of importance by chemical spills, landslides, moderate earthquakes, major earthquakes, and dam breaks.

These results suggest an awareness level among elected officials that corresponds to some degree with the way in which seismic risks have been characterized in this region in the past. Earthquake risks are perceived to be lower in Oregon than in Washington. Yet, policymakers in both Oregon and Washington discount the potential for significant damage or loss of life, whereas specialists would argue that even moderate events can be very damaging.

In both states, moderate earthquakes are perceived to be more probable than major earthquakes. On the absolute rating scale (0 to 100), the mean rating in Oregon cities for the likelihood of significant effects of a moderate earthquake is 28 and of a major earthquake 18. The corresponding figures for Washington cities are 48 and 34. Earthquake risks are generally perceived to be lower by county officials. On the absolute rating scale (0 to 100), the mean likelihood rating in Oregon counties for significant effects of a moderate earthquake is 29 and of

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[2]The responses concerning the elected officials were indirect as they involved asking an appropriate administrative-level respondent in each jurisdiction: "On a scale of 0 to 100, how likely do you think most officials in this jurisdiction think the chances are in the next 20 to 30 years of significant property damage, injuries, or loss of life are from each of the following ..."

[3]A "moderate" earthquake was defined as Richter magnitude 5.5-6.5 and "major" earthquake as Richter magnitude 6.6-7.5. Duration, depth, and location were not specified. Most respondents seemed to key into the labels "moderate" and "major" more than the limited magnitude information that was offered. Note that "great" earthquakes were not addressed.

[4]The "deviation scores" are calculated for each respondent by subtracting the average rating of all hazards for that respondent from the respondent's ratings for each hazard.

a major earthquake 14. The corresponding figures for Washington counties are 31 and 15.

BUILDING OFFICIALS' RISK PERCEPTIONS

Perhaps more important barometers for future risk reduction efforts are building officials' perceptions of earthquake risks. This research attempted to get at these views in two ways. First, information was collected concerning the extent of various categories of potentially earthquake vulnerable buildings in each jurisdiction. This in itself engendered quite impressionistic responses from building officials because none of the jurisdictions maintains building inventories. Second, relevant respondents were asked to assess the impacts of the occurrence of various events upon the building stock (or facilities) within their jurisdiction.

In addressing the degree of the existing risk, an assumption of this research is that communities with both larger stocks of certain types of potentially hazardous buildings and larger populations are relatively more vulnerable in comparison to cities with smaller populations and less hazardous building stocks.[5] Three classes of buildings were considered to be potentially vulnerable: (1) unreinforced masonry buildings; (2) tilt-up concrete buildings built before 1975, typically used as warehouses, light industrial facilities, or for other similar purposes; and (3) reinforced concrete frame buildings built before the early 1960s, typically comprising three- to ten-story buildings used as office buildings, schools, or apartments.

As summarized in table 2, unreinforced masonry buildings appear to pose the most prevalent existing risk in the region's cities. Reinforced concrete frame buildings are more common in Washington cities than Oregon cities. Tilt-up concrete buildings built before the mid-1970s are about equally prevalent among cities in the two states.

The unincorporated areas of counties are of somewhat less concern with respect to this risk definition. Most unincorporated county areas in the region under study tend to be rural or suburban in nature comprised mainly of single family homes and newer commercial construction. The most noteworthy prospective hazardous building type, reported to be "somewhat" or "very common" among one-third of the counties, are tilt-up concrete buildings built before 1975.

To get at the sense of risk that such potentially hazardous buildings pose, relevant respondents were asked to think about the damage that might follow from various events.[6] Because they were told to assume the occurrence of the event, their responses can be considered an indication of their sense of the vulnerability of the building stock (or facilities) within their jurisdiction. The obvious caveats concern both lack of specific information about the location and duration of the seismic events and the difficulty that respondents have in envisioning the damage that might follow.

Figure 2 summarizes the city results, computed as "deviation scores." Building officials perceive the greatest potential for damage from major earthquakes, followed in order by moderate earthquakes, major flooding, and major landslides. On the absolute rating scale (0 to 100), the mean Washington cities' likelihood of significant damage assuming a major earthquake occurred in the region is 46 (range 10 to 90). Assuming a moderate earthquake occurred, the mean rating is 27 (range 0 to 75). The corresponding figures for Oregon cities for a major earthquake are 44 (range 15 to 85) and for a moderate earthquake event, 21 (range 5 to 60). County building officials in Washington and Oregon reported similar damage perceptions.

One reassuring aspect of these results is that the building officials' sense of prospective damage is consistent with their sense of the prevalence of the different types of hazardous buildings. Among cities, the correlation

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[5]The degree of hazard itself should also be considered. In considering potential lateral forces created by earthquakes, the Uniform Building Code, 1988 Edition (International Conference of Building Officials, 1988) designates the Puget Sound area a "zone 3" indicating higher risks than areas designated a "zone 2" and redesignated in 1988 to a "zone 2B" to reflect special characteristics.

[6]Specifically, they were asked: "Please think about what damage would follow if the following events actually occurred. On a scale of 0 to 100, how would you characterize the potential for damage to a significant number of structures from ..."

between prevalence of unreinforced masonry buildings and likelihood of significant damage from a major earthquake is a moderately strong .41.[7] The corresponding correlations between prevalence of tilt-ups and prospective damage is .46 and between prevalence of reinforced concrete frame buildings and prospective damage is .14.

UTILITY AND PORT OFFICIALS' RISK PERSPECTIVES

Utility and port personnel viewed earthquake hazards as a potentially broader risk than flooding or landslides. The latter are likely to only affect a part of the utility system, whereas earthquake-related ground shaking would occur throughout the system. In considering risk management, utility and port respondents cited efforts to protect the more valuable aspects of their facilities -- piers and cranes for ports, and reservoirs, storage facilities, and treatment plants for water or sewer utilities. Nonetheless, approximately one-third of the respondents from water utilities identified reservoirs as potentially vulnerable in the event of a major earthquake. An equal number cited concern about major water transmission lines within their system.

Utility personnel had comparable perceptions of damage potential to those of building officials. Both Oregon and Washington utility respondents rated major earthquakes as having the highest damage potential, followed in order by moderate earthquakes, major flooding, and major landslides. Unlike the comparable responses for the building stock, Oregon utility personnel as a group reported slightly higher likelihoods of damage from moderate earthquakes (mean 22) and major earthquakes (mean 47) than the corresponding likelihoods reported by Washington utility personnel. Washington respondents had much broader ranges of likelihood of damages.

Utility personnel reported considerably more experience with occasional flooding and landslide damage -- transmission breaks in part of the system, broken connections to households, and so on -- than with earthquake damage. Only Seattle water and the Kent municipal water systems reported more than minor damage from the 1965 earthquake. The response to flooding and landslides, particularly among the larger utilities, has been to build greater redundancy into the systems. Given this and the localized nature of flood and landslide impacts, it is not surprising that personnel from larger utility systems tended to have lower perceived likelihoods of significant damage from major flooding (r= -.41) or from landslides (r= -.31) than the likelihoods reported by smaller utilities.[8] In contrast, the perceived likelihoods of significant damage tend to increase with utility size for moderate earthquakes (r= .27) and for major earthquakes (r= .16).

Engineering personnel at the six major ports that were part of this study reported damage likelihoods that generally correspond to the perceptions of municipal utility and building personnel. However, the likelihood data and the qualitative responses to the interviews evidenced a lower sense of the likelihood of prospective earthquake damage to port facilities. The likelihood of prospective damage from major earthquakes averages 40 (on the 0 to 100 "absolute" scale) with a range of 20-50. Port personnel tended to be more confident than the utility officials that seismic forces had been adequately considered as part of facility design.

CURRENT RISK REDUCTION POLICIES AND PRACTICES

The following discussion addresses relevant policies, the degree of discretion permitted by those policies, and the range of practices that appear to be employed at present with respect to building regulation, land use, and engineering practices within the region. Some clarifying distinctions between "policies" and "practices" are useful to make at the outset (see May and Williams, 1986).

Policies, as the term is used here, refer to officially adopted laws or regulations that appear in the form of

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[7] All correlations in this report are Pearson's 'r'.

[8] The correlations reported in this paragraph were calculated using "deviation scores" for risk perceptions and omitting relevant outliers. Previous flood experience and future damage potential were very weakly related (r=.04) and previous landslide experience and future landslide damage potential were weakly related (r=.28). Insufficient variation in earthquake damage experience prevented analysis of the relationship between past earthquake experience and future damage perception.

state law at the state level and local ordinances at the local level. Policies may be very general in establishing broad goals. They may be very specific in writing standards into legislation or referencing specific standards. Or, they may be very directive in mandating particular actions by other levels of government. Policies often have associated implementing regulations that provide specific guidelines for what is to be done to comply with a given policy. At the state level, such regulations appear as part of administrative codes subject to state-level rule-making procedures.

One important category of policies considered here are state mandates that either require local governments to adopt policies consistent with certain state goals or require local governments to comply with state policies. For such policy mandates, it is possible to talk about the state mandate itself (a state-level policy) and the local policy that is adopted in response to it. The state mandate may provide discretion in the way the local governments formulate policy, or the local policy may be tightly prescribed. For example, Oregon's state-wide land use planning mandate requires local adoption of comprehensive plans consistent with 19 state planning goals. The planning mandate comes in the form of state law that sets forth broad planning goals and associated regulations specify the steps for local compliance with the mandates. The local comprehensive plans officially adopted by local governments establish local land use policies.

Practices, as the term is used here, refer to the actions of local building officials, land use administrators, and other governmental officials in carrying out their functions. Practices are governed by "policy" through laws and implementing regulations. The policy or associated guidelines may be sufficiently vague to allow for discretion in carrying out the policy. As a result, there is room for differences between policies "on paper" and actual practice. In some situations, there may be no applicable policy, leaving considerable room for variation in practice. Because of this variation, the realities of existing practice are often difficult to discern.

BUILDING REGULATORY POLICIES AND PRACTICES

Building regulation is a shared governmental function for which the states of Oregon and Washington specify state building codes and local governments implement and enforce the codes through local ordinances and building regulatory practices. The state codes are based on the Uniform Building Code (UBC) (International Conference of Building Officials, 1988) as amended in each state. Discretion in building regulation comes both through local amendments to the state code (prohibited in Oregon) and through building officials' exercise of discretion as permitted by amended UBC provisions and relevant local ordinances.

Oregon's building regulation mandate provides for a stronger state role in the building regulatory process than is provided for in Washington state. The range of practices, and room for discretion, in carrying out UBC provisions related to seismic hazards is greatest with respect to existing hazardous buildings.

State Building Codes and Enforcement.--Perhaps the greatest contribution to limiting the growth of earthquake risks in this region has been the adoption by Oregon in 1974 and by Washington in 1975 of state laws and associated administrative provisions establishing state building codes.[9] Some may not think of state building codes as big steps forward, given that some 80 percent of the Washington cities and 60 percent of the Oregon cities under study had building codes with seismic provisions prior to these mandates -- typically adopted in the 1950s or 1960s. Fewer counties had codes prior to the state mandates. Yet, the establishment of state codes was important in filling in gaps in jurisdictions where building codes of any kind did not exist and in establishing a means for continual updating of the codes to reflect latest changes in relevant UBC provisions. Neither state has enacted, or even considered, state policy mandates governing seismic retrofit of existing hazardous buildings beyond the relevant UBC provisions concerning change in use or occupancy categories.

As summarized in table 3, the two states' mandates are similar in approach but differ in some important specifics. Both statutes, as amended, establish state building codes, mandate local compliance with those codes, and

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[9]Each state has on the books laws that specify seismic design for public facilities and "public places of assembly" dating to 1963 in Oregon (Oregon Revised Statutes 456.965 "Public Structures") and 1955 in Washington (Revised Code of Washington, Chapter 70.86, "Earthquake Resistant Standards"). Each of these has been superseded by relevant state building code provisions. The extent to which these provisons were enforced in the 1950s and 1960s is unknown, but likely to be limited given the lack of state-level enforcement mechanisms at that time.

create mechanisms for updating the codes and monitoring local code compliance. The states adopt relevant structural code provisions by referencing and amending provisions of the Uniform Building Code.[10] As newer versions of the UBC have been produced, both states have adopted them with amendments. The 1988 edition has been recently adopted with amendments as the basis for each state's structural building code.

Suffice it to note that because of differing seismic zone delineations for Oregon (now "2B") and Washington ("2B" and "3") and differing state-level amendments, there are important differences in seismic provisions between the two states. Oregon also has adopted the CABO One and Two Family Dwelling Code (Council of American Building Officials, 1986) as a basis for the state code governing residential construction.

The main differences in the two mandates have to do with the degree of local discretion permitted in amending state provisions. Oregon does not permit any type of amendment by local jurisdictions. The code is a genuine "state code" for which the implementing responsibility is delegated by the state to local governments.[11]

Washington state permits amendments to the state building code as long as those amendments do not weaken code provisions. Since 1986, state-level review and approval of amendments affecting one- to four-unit residential buildings has been required. The local discretion in amending the code combined with the existence of municipal building codes prior to the state mandate has led to a greater variety of local codes in Washington than in Oregon.

Although there are time lags in local updating of ordinances to be consistent with new versions of state building codes, there is little apparent problem with localities having policies that fail to meet the state mandates. The critical question about the effectiveness of the state building codes is the extent to which seismic provisions are enforced. This comes down to the capabilities of the relevant local building departments -- the quality of plans review and inspection -- and the exercise of local building officials' discretion where permitted by the codes. Oregon has attempted to strengthen enforcement capabilities for all aspects of the code by requiring certification of building officials, plans examiners, and inspectors.

The data concerning local building regulatory enforcement are very sketchy. A recently completed Washington state study of code enforcement noted "a perception, and even public acknowledgment, that the level of building code enforcement varies throughout the state" (Washington State Building Code Council, 1989).[12] Some building officials who were interviewed as part of this study hinted at political pressures to be less stringent in code interpretations. Others, including some building officials in relatively small jurisdictions, evidenced a very aggressive attitude. The overall impression from the interviews is that current levels of enforcement for new commercial construction is adequate. There appears to be considerably more variation in aggressiveness in enforcement regarding renovation of commercial structures, reflecting both differences in building officials' attitude and exercise of discretion.

Data about building department staffing provide a limited basis for gauging enforcement capabilities with respect to seismic provisions. Only 15 percent of the Washington and 20 percent of the Oregon cities in this study reported having structural engineers as part of the building department staff. (The corresponding figures for the counties under study are 33 percent in Oregon and 12 percent in Washington.) Seattle's building department has the greatest staff capability comprised of a construction review staff numbering 19, of which six are licensed structural engineers, four have other engineering certification, and the remaining nine have building construction or architectural degrees. Some 60 percent of the cities reported sending complex drawings out for plan review to the regional office of the International Conference of Building Officials or hiring consultants for the review. Not surprisingly, the smaller jurisdictions reported more limited capacity in interpreting seismic provisions. This

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[10]Other codes govern electrical, mechanical, fire, and other aspects of construction.

[11]The delegation of responsibility for codes follows a hierarchy in Oregon (see Oregon Building Codes Agency, 1988). If a municipality chooses not to enforce the state code, responsibilty falls to the relevant county. If the county does not choose to enforce the state code, the responsibilty falls to the state. Enforcement of the structural code has been delegated to the cities and counties included in this study.

[12]The limited nature of the data is underscored by the fact that only 17 people showed up to provide public testimony at the five regional hearings held by the Building Code Council on this topic.

difficulty is summarized by one building official's comment that "I often have questions about what the seismic provisions are based on; It is hard for a non-engineer to tell."

The enforcement gaps in some of the smaller jurisdictions and more rural counties prior to the state codes is illustrated by quotes taken from interviews with some building officials:

> We were derelict prior to 1975 or so in keeping up with UBC changes, but we are now tightly tied to state law.
>
> There were blatant problems in the 1970s with bad engineering practice that we were unable to address.
>
> Shifting the building function back and forth between the city and county made consistent code compliance difficult.

Local Building Policies and Practices.--Some may argue that the existence of state building codes in Oregon and Washington makes considering local building regulatory policies and practices less important for understanding earthquake risk reduction in this region. With respect to new construction for engineered buildings this is probably a reasonable argument. Given the apparent relatively good enforcement of seismic provisions as applied to such structures, the degree of risk for engineered buildings built since the early 1970s (or even the early 1960s in larger cities) is essentially determined by UBC seismic provisions in place at the time the buildings were constructed. Judgments that seismic risks are low for such construction presumes good engineering practices were followed in building design and the seismic zones were properly designated in the codes in place at the time of construction.[13]

Local policies and practices are especially important to consider for two situations: (1) existing, potentially hazardous buildings -- URM's, tilt-ups, and reinforced concrete frame buildings profiled in an earlier section of this report; and (2) building and excavation provisions concerning steep slopes and unstable soils. The variation in local policies and practices concerning these categories stems from multiple sources of code provisions and latitude within those codes. What follows in this section is a discussion of variation in policies and practices concerning existing buildings.

There are two relevant UBC discretionary provisions that address the trigger for application of the UBC to existing buildings undergoing renovation. Section 104 states that "additions, alterations, or repairs" may be made without requiring the existing building to comply with all of the code requirements. Section 502 further defines the trigger as to whether or not the buildings are undergoing changes in "character of occupancy or use," as defined in the section, while providing an important discretionary exemption for proposed uses that are less hazardous than existing use. These provisions leave room for interpretation when buildings are remodeled in stages or for which the use change can be debated.[14]

The main UBC discretionary exemption that applies to older, potentially earthquake prone buildings are provisions concerning "historic buildings" contained in UBC Section 104(f). This section provides discretion in meeting current code requirements for buildings certified as having special architectural or historical significance. The key provision is that the restored building or structure be no more hazardous than the existing one.

Local ordinances referencing other model codes provide an additional basis for differing policies and practices in Washington and to a lesser extent in Oregon. Some jurisdictions incorporated provisions of the Uniform Code for Abatement of Dangerous Buildings in ordinances addressing dangerous buildings. That code provides discretion to the building official in addressing dangerous buildings. A few building officials reported using such ordinances as a basis for requiring demolition of earthquake vulnerable buildings, but such actions were rare. In addition, some jurisdictions' ordinances made specific reference to the Uniform Code for Building Conservation to establish guidelines for renovation of existing buildings.

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[13]Note that Oregon's zone classification has been changed somewhat, particularly in the 1988 edition of the Uniform Building Code. This in itself provides a basis for wondering about risk posed even by the "newer" engineered buildings.

[14]This is less true for tilt-up concrete buildings. They undergo changes of ownership, but changes in type of occupancy are less frequently involved. As a result, most building officials felt they had little basis for requiring seismic upgrades of this type of building.

The third source of differences came from those jurisdictions that had created their own provisions concerning building renovation. Seattle has gone the furthest in this regard (see Perbix and Burke, 1989; and Skolnik and Wood, 1975), beginning in 1973 with the enactment of amendments to the Seattle Building Code which states:

> In cases where total compliance with all the requirements of this building code is physically impossible and/or impracticable, the applicant may arrange a pre-design conference with the design team and the building official to identify design solutions which will provide equivalent protection. The building official may waive specific requirements in this building code which he/she has determined to be impracticable. (sec. 104 of the 1985 edition of the Seattle Building Code)

Other exemptions in the Seattle code provide for discretion in the applicable lateral seismic forces for "parts and portions" of buildings built before July 26, 1967.

The only other examples of locally adopted seismic policies for existing buildings among the jurisdictions under study were parapet provisions enacted in Tacoma and Seattle.[15] Tacoma's ordinance was adopted after the 1965 earthquake (ordinance number 17842; May 18, 1965). The ordinance made it possible to declare buildings with unanchored parapets dangerous and therefore requiring abatement. Seattle's provisions, contained in a section of the Seattle Building Code, are similar in making it possible to declare buildings with unanchored parapets unsafe. There have been various spurts in enforcement of the parapet provisions. In Seattle, for example, the city reportedly actively looked for problem parapets in 1975 after a large chunk fell from a now demolished hotel. Some 200 building owners were cited at the time.

Important differences in practices with respect to existing buildings concern negotiations for seismic upgrading of buildings undergoing renovation. Seattle's building code appears to codify what in fact of necessity is existing practice in many jurisdictions. Seattle, Tacoma, and Portland appear to have gone the furthest in establishing administrative procedures for negotiating seismic requirements as part of building renovation. Portland is particularly innovative in this respect, having established a Structural Advisory Committee comprised of external structural engineers. The committee advises the building official about appropriate requirements for design changes as part of major renovations. The volume of renovations of URM buildings alone has been sufficient in these jurisdictions -- numbering roughly 20 to 30 per year in Seattle, 2 or 3 per year in Tacoma, and 20 per year in Portland -- to justify having such procedures. Within jurisdictions with less experience with major renovations of potentially earthquake hazardous buildings, the practices are less formalized but sometimes guided by the Uniform Code for Building Conservation.

LAND USE AND SECONDARY HAZARDS

The contrast between state-level land use planning mandates in Oregon and Washington states is between Oregon's relatively strong state mandate for addressing areas subject to seismic hazards and Washington's relatively weak mandates. However, the differences in the resultant local policies and practices are not that great when considering seismic hazards other than landslides. The following discussion outlines the state policies, then turns to the variation in local policies and practices with respect to differing categories of secondary seismic hazards.

State Land Use and Environmental Mandates.--The primary state-level land use planning mandate in Oregon relevant to earthquake hazards comes from provisions contained in legislation first enacted in 1973 as the Oregon Land Use Act. The legislation established 19 state-wide planning goals and required local governments to develop comprehensive plans to be reviewed for consistency with the state-wide planning goals (see Oregon Land Conservation and Development Commission, 1986). Goal Seven sets forth a state-wide goal "to protect life and property from natural disasters and hazards." The guidelines for Goal Seven call for identification of areas subject to natural hazards and development of "appropriate safeguards" as part of the planning process.

The state mandate and associated guidance provide discretion in responding to Goal Seven. Among the Oregon jurisdictions under study there was full compliance with the state mandate when measured in terms of the existence of a state acknowledged comprehensive plan. The implementation of Goal Seven appears to be very strong

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[15]UBC seismic provisions concerning parapets and chimneys are contained in section 3704(c) of the 1988 edition.

with respect to flood hazards (in complying with FEMA flood insurance mandates), moderately strong for landslide hazards (in identifying areas of potential landslides and considering compatible land uses), and weak for other earthquake hazards. Planners cited lack of awareness of earthquake hazards and difficulties identifying areas other than steep slopes possibly subject to earthquake hazards as a primary limitation on their ability to apply land use measures to earthquake risk reduction. State personnel involved in reviewing local comprehensive land use plans reported very few instances in which seismic hazards other than landslide hazards were even mentioned as an issue in their reviews.

The most relevant Washington state mandate for consideration of earthquake hazards is the State Environmental Policy Act of 1971 (SEPA).[16] This legislation and associated administrative regulations require cities and counties to adopt procedures for environmental review and designation of mitigating actions for certain categories of development (for example, planned developments, annexations, shoreline development) likely to have "significant" environmental impacts. Because many categories of development are exempted and the nature of mitigating actions are not specified, the SEPA process is a relatively blunt instrument for calling attention to seismic hazards.

Administrative amendments enacted in 1984 to the SEPA regulations allowed cities and counties to designate "environmentally sensitive areas" which would allow for review of land use and development proposals that might normally be exempt from SEPA review. This more recent SEPA provision has served as the basis for several of the "sensitive areas ordinances" discussed in the following section.

The federal flood insurance program, authorized by Congress in 1968 and substantially strengthened in 1973 by providing disincentives for communities failing to participate, provides a different set of mandates for local adoption of ordinances for management of land use and development within flood prone areas. In this discussion, the flood insurance provisions are relevant to localities potentially vulnerable to earthquake-induced water waves (tsunami). Such provisions are potentially relevant to a number of coastal communities in Oregon and Washington, but relatively few of the relevant jurisdictions were included in this study (see Urban Regional Research, 1988).

<u>Local Policies and Practices -- Secondary Hazards</u>.--Given the array of existing local policies and practices with respect to secondary seismic hazards discussed below, some might conclude that such hazards pose little risk to this region. However, one of the central points about existing practice for secondary earthquake hazards is that with relatively few exceptions the relevant local ordinances do not prohibit development in potentially hazardous areas; they only control it to some degree. The minimum approach is to require appropriate "engineering" in the form of special piling or strengthened foundations for development along steep slopes or in areas with expansive soils. This is more or less routine as many building officials reported acting daily on geotechnical or soils reports they require under UBC provisions. More extensive approaches entail special review processes for development in areas with steep slopes or that are vulnerable to other seismic hazards.

The most specific local policies concern landslide hazards. Nearly 60 percent of the cities reported having some form of steep-slope or landslide hazard ordinance. (All of the Oregon counties and over half of the Washington counties reported having landslide provisons.) Those jurisdictions without specific steep-slope ordinances cited UBC provisions regarding excavation and foundations (UBC sections 2905 and 2910) as one basis for allowing building officials to request soils or geotechnical reports for proposed buildings. "Excavation and grading" ordinances based on appendix Chapter 70 of the UBC serve as the basis for some local ordinances requiring mitigating actions in areas subject to landslide hazards. Other jurisdictions have specific steep-slope ordinances that specify limits on construction and/or requirements for geotechnical reports and mitigating actions. And yet other jurisdictions had more generic "sensitive areas ordinances" that included special review and permit processes for development in mapped areas subject to landslide hazards.

Liquefaction and subsidence hazards appear to be dealt with less directly. The UBC section 2905 excavation and foundation provisions make general reference to "expansive soils," thereby providing building officials with a basis for requiring mitigating actions for areas subject to liquefaction and subsidence. However, building officials reported considerably more difficulty in deciding when to require the reports that trigger engineering solutions. Some

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[16]The State Shoreline Management Act of 1971 is less directly relevant. It establishes a cooperative program between the state and local govenments, under which specified local governments with coastal or riverine shorelines must establish plans for managing the shorelines.

officials appear to be very aggressive (for example, in requesting reports when in doubt) while others seem to be more restrained.

Sensitive areas ordinances are more comprehensive approaches in establishing map "overlay" zones that designate geographic areas subject to such hazards as expansive soils, steep slopes, and subsidence, as well as designate environmentally sensitive areas like wetlands. Once development is proposed within the designated sensitive areas, special review processes that include consultant reports or other actions are involved.

The specific requirements for development in sensitive areas vary among the ordinances. Two different examples are the King County sensitive areas ordinance and Bellevue's "natural determinants code." King County's ordinance is driven by geotechnical reports and negotiated mitigating actions. Bellevue's code is more prescriptive in specifying such things as the type of footings required for foundations of buildings in sensitive areas and in establishing a transfer of development credits for those who limit development in sensitive areas. Personnel involved with both programs report success in modifying development in areas subject to steep slopes, moderate success in areas subject to subsidence, and limited attention to other seismic hazards.

Seismic hazards only indirectly enter into longer-range zoning or land use decisions. Many Washington jurisdictions reported having comprehensive plans that make some reference to seismic hazards, but only in a general way. Oregon jurisdictions are required by the state land-use planning mandate to evaluate natural hazards as part of their planning processes. With the exception of landslide and flood hazards, the result appears to be fairly general discussion of earthquake potential.

The only way that jurisdictions in this study appeared to use land use as a longer-term response to seismic risks was property acquisition for open space. For example, Bellingham planners cited their extensive open-space acquisition program as one long-term means for addressing earthquake risks. In jurisdictions where such open space acquisition occurred, seismic concerns were a relatively minor impetus. The programs tend to be driven by desires to protect wetlands, limit vulnerability to landslides, protect marine bluffs, or increase flood risk reduction.

UTILITIES AND PORTS

The utilities and port engineers that participated in this study reported considering seismic hazards as a normal course of business in constructing new or upgrading existing facilities. "Good" engineering practices are presumed to provide adequate basis for facility designs providing seismic resistance. Interviewees reported only rare instances for which seismic factors entered into siting or land use considerations. Only a few of the utilities included in this study have initiated formal reviews of the earthquake vulnerability of their systems.

Professional Practices -- "Good" Engineering.--Facility design for a water system or a port is obviously very different than for the design of a major building. Utility personnel must consider a range of facilities including reservoirs, storage tanks, pumping stations, control centers, and transmission lines. Port engineering personnel address pier construction, cranes, loading and storage facilities, dry docks, and other ship repair facilities. Given the range of facilities involved, ports and utilities are heavily dependent upon experienced and knowledgeable engineering consultants for all aspects of facility design. The larger utilities and ports appear to have very sophisticated engineering units as well as expend sizeable funds -- several reported hundreds of thousands to millions of dollars per year -- on geotechnical and other engineering consultants for facility design.

Engineering practices relating to seismic considerations for such facility design might be considered more of an art than a science. Engineers who deal with such facilities do not have single reference sources like the UBC to provide guidance for seismic design. Instead, nearly a dozen different professional associations provide guidance or standards that address aspects of some of the facilities.[17] Knowing what guidelines might be helpful, what

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[17]For example, guidelines prepared by the Technical Council on Lifeline Engineering of the American Society of Civil Engineering address such things as oil and gas piping systems, buried pipelines, and other aspects of lifeline engineering. The American Water Works Association has created standards for welded steel water storage tanks. The American Concrete Association provides standards for concrete sanitary storage facilities used in treatment plants. Other compilations of existing practices have been published by the Structural Engineers Association of California or more recent cataloging of lifeline considerations undertaken by the Building Seismic Safety Council.

seismic forces to design for, and how to extrapolate from existing codes or standards to the particulars of the design situation are all involved in arriving at an appropriate design. Experience and professional knowledge are at the heart of this process.

This study sheds little light on the adequacy of engineering practices for seismic safety in this region. Utility and port engineering personnel interviewed as part of the study reported confidence in the consultants they had worked with over the years. Earthquake hazards appear to be one of many engineering design concerns, relegated to a lesser status by many of the respondents (particularly among ports) than high winds. While acknowledging potential vulnerability of aspects of water systems or of port facilities to seismic hazards, the general pattern among the interviews was that seismic hazards were thought to be pretty well addressed -- particularly in newer facilities.

Existing Facilities -- Limited Attention.--Only three of the utilities included in this study -- Everett, Portland, and Seattle water departments -- have initiated formal reviews of the seismic vulnerability of their systems. In two of these instances, a contributing impetus was an engineering director who had previous experience with seismic design considerations in California. Some of the other utilities reported addressing isolated aspects of their systems -- slope stability around some reservoirs, foundations in older pumping stations, spillways for dams. In these latter instances, seismic considerations typically came up as part of reviews undertaken for other purposes.

Many of the utilities reported on-going renovation programs for their major water transmission lines and other water mains. In some jurisdictions, the water system contains major elements that are quite old. Tacoma has a water transmission line dating to 1915; Everett has one dating to 1929. Even "newer" lines constructed in the 1930s or 1940s were reported by utilities for which cast iron and brittle cement piping is common. Replacement of older pipes with ductile iron pipes and use of flexible piping for joints are common practices as part of renovations. Although such renovations have primarily been undertaken to reduce future maintenance costs, they have an added advantage of increasing seismic resistance of water systems.

Ports appear to be in a somewhat different situation regarding older structures. Competitive pressures have been such that modernizing facilities has been an important part of the business. Except for one older wood pier used by one of the ports, all of those under study had substantially upgraded or replaced piers over the past few decades. The remaining older structures tend to be warehouses for which there are either plans to replace them or their use is limited to lesser valued purposes.

Land Uses -- Liquefaction Concerns.--Perhaps the greatest source of potential seismic vulnerability for ports results from the fact that port facilities in this region tend to be built on alluvial plains and extensive fill areas. Engineering personnel for some of the larger ports reported having geologic maps of their properties. Less well understood are the potential risks to facilities and other property associated with the hazard. One port engineer summarized his concerns by stating: "Liquefaction is a much grayer area than one might think."

The primary response to the liquefaction potential of such areas has been consideration of such potential as part of engineering designs. Very few instances were cited for which liquefaction potential was an important land use consideration. The examples respondents cited were of a proposed warehouse and other facilities for which more suitable sites were selected. The engineering directors commenting on these siting decisions reported confidence that engineering designs could have been developed to address the hazard. However, it made better economic sense to put the buildings elsewhere. Such choices are more limited when it comes to the design of piers or other water-dependent aspects of port operations.

ASSESSING THE POLITICAL-ECONOMIC LANDSCAPE

The realities of risk reduction policies and practices are shaped by a host of local political and economic factors influenced by state and other mandates. The preceding discussion provided an overview of risk perceptions and summarized current policies and practices. This section provides a closer look at the political-economic landscape among cities and counties as it relates to future risk reduction prospects.

Earthquake risks -- as defined by population and property exposure -- and the political-economic situation vary considerably among the jurisdictions under study. The following discussion takes these factors into account in attempting to categorize the cities and the counties according to existing and potential risk reduction efforts. The key to any such categorization is recognition of the similarities of cities (or counties) within categories and the differences between categories.

The cities under study sort out into two broad categories:

- Developed urban areas with potentially substantial existing risks; and
- Less developed or newly developed areas with less substantial existing risks.

Within each of these two broad categories, the cities can be further differentiated in terms of current approach to earthquake risks and future prospects.

RELATIVELY VULNERABLE CITIES

The first three categories of cities, summarized in table 4, contain 13 cities that are relatively vulnerable to earthquake hazards. Their vulnerability is a function of population size and development. The median population as of 1987 for these cities is 44,000; a figure that belies the fact that the three largest cities in the region are also in this broad grouping. The population size of these cities as a group has been fairly stable over 1980-1987. Among the 13 cities, the median population growth over the period 1980-87 is less than two percent.

The fact that these cities are already developed and not growing substantially in population has four main implications:

- There is considerable risk posed by unreinforced masonry buildings, reinforced concrete frame buildings built before the 1960s, and concrete tilt-up buildings built before the mid 1970s;
- Given the amount of existing development within these cities, potential property losses are substantial;
- Land use policies and practices with respect to seismic hazards are both relatively weak at present and likely to be relatively ineffective in the future. There is very little undeveloped land for which to apply traditional land use measures.
- The degree of earthquake risk reduction in these areas is largely determined by policies and practices concerning existing buildings and their renovation.

Valuable properties are being constructed in these cities (median 1987 commercial building permit values of some $20 million; range $1 million to $500 million). However, the value of new construction is a relatively small percentage of the total value of the building stock.

Consideration of some of the specifics of existing practices and the political-economic landscape lead to further differentiation of three categories among this broad grouping of 13 relatively vulnerable cities. The characteristics of each of the three categories are summarized in the following paragraphs.

The Pacesetters.--This group is comprised of the three largest cities in the region (average 1987 population of 360,000). Within the region, these cities have the most sophisticated building departments and the most experience in negotiating renovation of existing, potentially hazardous buildings. Seismic provisions within the cities' building codes date to the late 1940s or early 1950s, although these early provisions were very minimal in comparison to today's standards. These cities are also leaders in developing advisory groups for negotiating seismic upgrades, in establishing parapet ordinances, and in the case of Tacoma, instituting a strong motion instrument program.

Because of the capabilities of building departments in these jurisdictions, there is general confidence that these cities are doing as good a job as any in assuring adherence to current seismic standards for new construction.[18] The existence of separate city building codes in these jurisdictions means it is possible, except for Portland which is constrained by state law, for local strengthening of seismic standards. However, such modification would not necessarily come readily. One policy official, incorrectly referencing current practice, commented on the USGS effort:

> We've got conservative codes. They provide considerable protection. Right now, we're designing to what California has been designing for the past 20 years. But we're not going to start changing the codes just because of some new reports. There'd have to be considerable evidence before we

[18]The Building Seismic Safety Council "trial designs" review of implications of designing different classes of new buildings according to their recommended provisions showed that following the new provisions in Seattle would result in a lower construction cost than current Seattle codes (see Webber, 1985). Tacoma and Portland were not included in the trial designs.

make any changes. And if seismology has become an exact science, that's news to us.[19]

Sophistication, perhaps, brings better understanding of the risks but it does not necessarily engender actions to retroactively address existing risks. The building officials interviewed from these cities as a group had the highest ratings of any of the six categories for likelihood of potential significant damage from moderate earthquakes (mean 50) or major earthquakes (mean 80). In contrast, elected officials from these jurisdictions as a group appear to have the same degree of attention (or indifference) to earthquake hazards as officials from other categories of cities.

The political-economic climate is such that building officials for these jurisdictions doubt that retrofit programs requiring seismic upgrading could be instituted. As stated by one official: "We have kicked the idea [of a retrofit program] around at administrative levels, but it won't fly politically and there are technical difficulties in establishing appropriate standards."

These cities tend to be much less innovative with respect to traditional land use practices such as the use of overlay zones, open space zoning, and other measures to limit seismic risk. The comment of one planning director summarized the approach of this category of cities: "Besides landslide controls, we have done very little [in the way of land use measures]. The building department is in the driver's seat since they handle geotechnical reviews and building regulation."

The Resourceful Group.--This group contains five moderately populated cities (average 1987 population 42,000) distinguished less by having innovative seismic policies or sophisticated building departments, but more by initiating earthquake risk reduction practices. For example, Aberdeen city personnel have participated in tsunami warning studies and at the time of our interviews were funding a study of risks posed by unreinforced masonry buildings. Bremerton officials have condemned potential earthquake vulnerable buildings for being unsafe and have upgraded schools for seismic safety (both apparently controversial undertakings for the personnel involved). Olympia, Salem, and Renton have building departments that reportedly have been relatively aggressive in enforcing seismic requirements, particularly regarding residences.

The label 'resourceful' applies to this category because the impetus for risk reduction in these jurisdictions appears to have come through individual efforts to affect practices, rather than from external mandates or policy decisions. In most instances, an interested building official willing to endure criticism over being too stringent was a key ingredient for risk reduction efforts.

This presents a double-edge to the potential for future risk reduction efforts in these cities. On the one hand, there appears to be a strong base of support within relevant administrative levels for pursuing risk reduction. On the other hand, the political climate -- broadly defined in terms of elected officials and the building community -- and economic climate does not necessarily support further risk reduction efforts. As told by one official, "this jurisdiction struggled to institute its only retroactive ordinance -- requiring smoke detectors in certain situations."

Given the tenuousness of the risk reduction efforts in these jurisdictions, there is a potential that risk reduction efforts could backslide into the third category of relatively vulnerable cities. Practices change quickly as new directions are asserted by elected officials, key professionals leave, or budgets are further constrained.

The Restrained Group.--This group of five moderately populated (1987 average population 38,000), low growth cities consists of those cities for which state-mandated actions appear to be well integrated with building regulatory and planning practices, but sustained earthquake specific risk reduction policies or practices have not been initiated. Yet, the nature of the building stock is such that there is potentially a noteworthy earthquake risk in these communities.

Many of the respondents from cities in this category gave the impression that earthquake risk reduction initiatives are constrained by political-economic circumstances that vary among jurisdictions -- resistant policy officials, existing URM buildings with concentrated ownership, vacant buildings not being renovated because of depressed economies, and so on. A noteworthy component is the relatively depressed economies in these cities as reflected in an average population growth from 1987-88 of less than one percent, and a median value of building permits issued in 1987 for apartments, office buildings, and industrial buildings of only some $3 million.

The challenge for future risk reduction efforts for this group of cities is building both a supportive political-economic climate and the capacity to undertake relevant measures. As a group, elected officials for these

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[19]Statement of the Director of Seattle's Department of Construction and Land Use, quoted from "Seattle could face 'great' quake but building officials skeptical," Seattle Business Journal, September 10, 1984, p. 20.

five cities had the lowest average ratings of the likelihood of significant deaths, injuries or damage in the next 20 to 30 years from a moderate earthquake (average score 19) as well as the lowest average ratings of likelihood of sigificant losses from a major earthquake (average score 13). These scores are about one-half of the corresponding averages reported for elected officials in the other two categories of relatively vulnerable cities.

LESS VULNERABLE CITIES

The second three categories of cities contain 30 cities for which earthquake risks are lower when compared with the more highly populated and more developed cities discussed in the preceding section. This is a relative judgment, as there still may be noteworthy earthquake risks within this broad category. The median population as of 1987 for these cities is 19,100. The newer development is reflected in the rapid growth rates for which cities in this broad category had a median population growth of 13 percent and a median growth rate in commercial building permits of 19 percent over the 1980-87 period.

The recent development of these cities and the lower population sizes has several implications when comparing this broad class of cities to the relatively vulnerable cities:

- Although there is an existing hazard posed by tilt-ups and URM buildings in at least some of the cities, the rate of development forces attention to seismic considerations for new construction.
- Because most of these jurisdictions still have vacant land for further development, there is potential for land use measures contributing to risk reduction.

Land use regulation is an especially volatile consideration as many of these jurisdictions cope with growth control issues. As such, there are both opportunities for linking earthquake risk reduction to growth controls and problems in throwing risk reduction into a highly charged political environment.

As is the case for the relatively vulnerable cities, this broad group of 30 cities can be further differentiated in terms of existing risk reduction practices and the general political-economic landscape. For this broad grouping, there are also three categories summarized in table 5 and discussed in the following paragraphs.

The New Sophisticates.--This group is comprised of ten of the fastest growing, moderate-sized cities in the region. The average 1987 population is 37,000 and the average population growth for this group of cities from 1980-87 is 32 percent. The average growth in value of building permits issued for apartments, commercial buildings, and industrial buildings over the same period is 105 percent.

The rapid growth, accompanied by development in many of these jurisdictions of commercial and manufacturing facilities, has been an important stimulus for increasing the capacity of building and planning departments. As a consequence, these cities have relatively sophisticated building and planning departments in comparison to more stagnant-growth cities of similar size.

Private engineering and design professionals have been important in increasing the sophistication of new construction within these communities. For example, Gresham city personnel cite the role of Japanese electronic firms and their California structural consultants in bringing greater sensitivity to seismic design within the city's building department. Auburn, Bellevue, Beaverton, Kent, Kirkland, Redmond, and Tigard are all cities that experienced substantial growth in commercial development. Mercer Island and Lake Oswego are somewhat different in that they are more residential in character and have lower growth rates. Their "new sophistication" comes from a combination of attentive building departments and more architecturally custom-designed homes than is found in most communities.

Given the rate of growth that cities in this category are experiencing, land use issues are perhaps the most volatile for this category as any. All of the cities in this category have some form of steep slope regulation, typically involving some form of map overlay zone designating areas where geotechnical reports are required prior to development. It is this group in general that has the greatest potential for linking future land use risk-reduction measures to growth controls.

The Measured Group.--This group of eight smaller, moderate growth cities consists of those relatively less vulnerable cities for which state-mandated earthquake risk reduction efforts appear to be integrated into normal practice. However, other risk reduction policies or practices are limited. The primary reason for designating these as "less vulnerable" are the smaller population amounts and lesser value of new commercial development, rather than the building stock itself. The average 1987 population for these eight cities is 16,500. Most of these jurisdictions have at least a few URM buildings within historic downtown areas. Building officials for this category of cities had a somewhat higher average rating of likelihood of significant damage from a major earthquake (57 on the 0 to 100 scale) than the corresponding rating of building officials in the preceding category (average score of 39). The reported seismic risk perception of elected officials was about the same for the two categories.

Jurisdictions within this group have potential for joining the "new sophisticates," but that potential appears to be limited by economic circumstances. There is not the scale of new commercial development or redevelopment that is taking place in the preceding category. The median value among this group for building permits issued in 1987 for apartments, commercial buildings, and industrial buildings is $1.3 million, compared with a corresponding value for the "new sophisticates" of $17.3 million.

These cities are not as sophisticated in their approach to land use and its relationship to risk reduction as are the "new sophisticates." Because growth is not as much of an issue among cities within this category, there has not been the pressure to develop land use controls that also have secondary benefits for earthquake risk reduction.

In comparison to other cities, there appears to be a reasonably strong recognition of earthquake risks by relevant city personnel for this category. However, their ability to act is severely constrained by economic circumstances. Whether or not a change in economic circumstances will occur, much less push some of these cities into the "new sophisticates" situation, is difficult to forecast.

The Non-Players.--This group is comprised of somewhat smaller cities (average 1987 population 16,000) for which seismic hazards appear to be of lesser concern both to elected officials and relevant city personnel. The "non-player" label reflects the feeling by officials in these communities that seismic considerations are not particularly relevant to them. The label is not meant to imply these jurisdictions are not enforcing seismic components of building codes or following reasonable planning practices.

Building officials for cities in this category had the lowest average scores for likelihood of significant losses from a moderate earthquake (score of 14 on the 0 to 100 scale) and from a major earthquake (average score of 30) than those of any category. These scores are approximately one-half of the corresponding average scores by building officials in each of the other categories of cities.

Whether or not the relative indifference is justified is difficult to judge -- thus the purpose of the overall USGS hazard assessment process. Building officials from these jurisdictions cite the fact that these communities are primarily residential in character, comprised of wood-frame buildings, with only newer commercial development.

The challenge for future risk reduction efforts for this group of cities is both documenting the extent of earthquake hazards and, to the extent that the hazards are noteworthy, convincing relevant personnel that the hazards translate into noteworthy risks.

COUNTIES -- ALSO DIVERSE

When considering risk reduction practices of counties, it is important to remember that relevant county policies and practices only apply, with a few minor exceptions, to unincorporated areas within the counties. In comparison to their municipal counterparts, the unincorporated areas have lower population sizes, less developed building stocks, and much lower densities of both population and structures. While these factors no doubt have led to a lower sense of earthquake vulnerability, the recurring flooding and landslides many of the counties have experienced in unincorporated areas serve as a reminder that these areas are not devoid of natural hazards.

Perhaps more than any place it is the unincorporated areas of the counties under study that are undergoing the most change. Unincorporated fringes of urban areas are rapidly becoming urbanized, while rural areas in many of the counties are rapidly becoming suburbanized.

Where counties stand on this growth curve and how they have responded to increased pressure for both building and land use regulation help to define the different categories considered in this section. As summarized in table 6, the counties can be sorted into three different categories.

The Leaders.--This group is comprised of the three most populated counties that surround the largest urban areas in the region. Nearly one million people are estimated as of 1987 to live in unincorporated areas of these counties. The growth experienced in the unincorporated areas of these counties can be characterized as increased urbanization accompanied by development of commercial, professional, and light manufacturing facilities. The counties are "leaders" by virtue of having relatively older building codes -- since the 1950s and into the 1960s, relatively larger building departments, and some land use provisions concerning seismic hazards.[20]

In comparison to the other categories of counties, this group appears to have a greater stock of existing, potentially earthquake vulnerable buildings. These primarily consist of tilt-up buildings built before the mid-1970s. Building officials for these counties rate the likelihood of significant damage from a moderate earthquake (average rating 48 on the 0 to 100 scale) as twice as likely as the corresponding rating for the other categories. They rate the likelihood of significant damage from a major earthquake (average rating 65) as 1.5 times more likely than the other categories of counties. These have large building departments with experience in reviewing complex structures, but the in-house structural review capacity (namely, structural engineers on staff) is more limited than is the case for the counterpart "pacesetter" cities.

More attention has been paid by the leading counties to land use considerations than by their counterpart "pacesetter" cities. Each of the counties in this category have some form of landslide land use controls in effect. King County has a sensitive areas ordinance that is commonly cited as an innovation in land use practices for risk reduction and preservation of environmentally sensitive areas.

Land use issues have been important considerations in growth debates that have occasionally involved episodes for which seismic considerations played a role. For example, seismic factors relating to landslides reportedly were a consideration in Multnomah County's decision to deny a permit for a metropolitan-area landfill. King County officials have been embroiled in debates over delineation of sensitive areas.

As one means of controlling growth, these counties are moving toward strengthening land use policies that may have beneficial side-effects for earthquake risk reduction. It is this arena that provides the greatest future prospects for addressing earthquake risks in these counties.

Transitional Counties.--This group of ten counties is comprised of those for which growth has entailed the greatest transitions. Noteworthy amounts of unincorporated area in these counties are rapidly being transformed from rural to suburban areas. The median growth rate in population of unincorporated areas of these counties from 1980 to 1987 is 17 percent. Building and planning departments are playing "catch up" with varying degrees of success in increasing their capacity to address future growth pressures.

For some of the counties in this category, "catch up" has consisted of establishing building departments and instituting land use practices. As noted by interviewees:

> In 1974 over one-half of the county was unzoned and there was no building code.
>
> There was no building code until 1971. Since then, enforcement has been progressive. You can't just institute such regulation over night.
>
> Our first major commercial building was built in 1980. There was no county-wide zoning until 1980.

Other counties in this category are much further along in developing their building departments and in land use planning. For these, the main issues have been codifying and strengthening building and land use practices.

A mixed reaction to growth pressures is reflected by the variation in the status of current building regulatory and land use practices. For example, a proposed comprehensive land use plan for Pierce County that contained zoning and steep slope provisions was voted down in a county-wide referendum in 1986. It seems that many voters thought the plan went too far in comparison to the past. Planning officials in three of the counties specifically mentioned political pressures to go slow in regulating growth.

The future prospects for risk reduction appear to be somewhat mixed for this category of counties. On the one hand, growth issues will inevitably continue to be an important factor pressing future land use and building regulatory decisions. On the other hand, the political climate -- broadly defined -- does not necessarily support strong land use regulation.

Rural Counties.--This group consists of seven counties for which growth is occurring, but the unincorporated areas have remained predominantly rural areas. As such, officials in these counties have not had to confront the growth issues that have affected policies and practices of the other two groups of counties.

One building official noted that "we have not had a subdivision of any kind," while another pointed out that "this is a one-man building department." The median growth rate in population of unincorporated areas of these counties from 1980 to 1987 is five percent. The median population of unincorporated areas of these counties is

[20]Because of the urbanized nature of Multnomah county, building regulation is somewhat different than the other two counties in this category. The incorporated areas that make up the county regulate building practices.

11,600.

Despite the rural nature of these counties, there have been noteworthy experiences with natural hazards. Grays Harbor officials evacuated 14,000 people in 1986 in response to a tsunami warning (flooding but no tsunami occurred). Jefferson and Skagit County officials have been embroiled in lawsuits stemming from deaths caused by landslides in logged areas. Cowlitz County officials have been at the center of a series of negotiations concerning flood and debris control relating to Mount St. Helens. Jefferson County contains Port Townsend which is an incorporated area with many unreinforced masonry buildings.

The constraints for future risk reduction efforts for this group of counties appear to have less to do with recognition of risks, and more to do with the costs involved. (The exceptions are the Oregon counties in this group for which there is little perceived seismic risk.) These jurisdictions simply do not have resources to undertake more extensive risk reduction efforts.

FUTURE IMPLEMENTATION CONSIDERATIONS

The preceding discussion provides a base for considering the implementation strategies that might be undertaken as new information about earthquake risks is developed for this region. Future research findings may provide a better quantitative understanding of the earthquake hazard in this region. Such information presumably is potentially relevant to all of the jurisdictions, and especially relevant to the "non-player" category of cities.

The assumptions about presumed degree of risk will change dramatically from the present if the scientific research documents a noteworthy probability of a "great" (M>=8.0) earthquake. Even under these circumstances, revisions in policies and practices will not automatically follow.

PROSPECTIVE IMPLEMENTATION STRATEGIES

Table 7 summarizes four prospective implementation strategies that range from a relatively passive strategy of hazards information dissemination to more active efforts to seek policy reforms or influence practices. The key target groups, examples of activities associated with each strategy, and the strengths and limits of the strategy are also summarized in the table. These are not mutually exclusive strategies in the sense that pursuing one strategy forecloses pursuit of another. However, the limitations of resources are such that choices must be made as to the implementation strategies to emphasize.

Evaluating the strengths and limits of the implementation strategies entails envisioning the likely responses that would follow each strategy. The scenarios that are depicted in the following paragraphs are based on the understanding of the political-economic landscape that was developed in the preceding section.

Hazards Information Dissemination.--This strategy consists of dissemination of new scientific information about earthquake hazards in the region through professional publications, newsletters, and meetings. The information would consist of such things as hazards maps available at a scale that would delineate relevant information for at least the major jurisdictions in the region. Demonstration uses of geographical information systems that translate hazards into the risks posed for people or structures might also be undertaken.

One strength of this approach is that it is fairly easy to implement. Several of these activities are already being jointly undertaken by the Federal Emergency Management Agency and the U.S. Geological Survey. This approach assumes that credible scientific information is essential for making the case for revising building regulatory or land use policies.

The key uncertainty for this strategy concerns who is likely to act upon the new information. Although the specifics depend both on the substance and form of the information, the preceding analysis suggests that only a few categories of cities and counties are either capable of or willing to act upon such information without further external efforts to influence risk reduction practices. Only the "pacesetters," "new sophisticates," and "leaders" appear to have both the technical in-house capacity and at least some willingness to respond to such information. The "non players" may be responsive to new information about earthquake risks, but it would probably take more than simply providing the information to get them to respond with risk reduction measures. For the remaining categories, there are too many other factors constraining response.

Other potentially responsive audiences are attentive professional groups such as the structural engineers associations of Washington and Oregon. These groups may be effective in translating the information into new engineering or design practices. Depending on the extent of change in risk assumptions that are involved and the credibility of the information, the professional groups might use the information as a basis for lobbying state building agencies and private code-writing authorities for changes in building standards.

Clearly, better hazards and risk information are necessary. However, this analysis of implementation prospects suggests that mere dissemination of such information -- without other efforts to influence policies or practices -- will lead to limited success in reducing the earthquake risk. The more capable cities and counties may make use of the information. However, it is likely that little will happen in the remaining jurisdictions. Some particularly attentive structural engineers, geotechnical consultants, and others in the design community may consider the new information as part of their practices. The longer run influence of such a strategy is closely tied to the effectiveness of relevant professional groups in lobbying for code changes.

Seek Mandate Revisions.--This strategy consists of directly seeking revisions in state-level building code or land use mandates. The specific changes that are sought will depend upon the nature of the information developed as part of the scientific research. This might include such things as new seismic zone delineation, new design standards, special provisions for particular categories of buildings, or better delineation of seismic hazards within land use mandates. Building codes could be changed either by state amendments or through the code revision process of the International Conference of Building Officials. Neither route would be easy, and both would require considerable technical justification for changes.

As evidenced in this study's findings concerning local policies, state building codes and land use mandates (in Oregon) dominate the framing of local policies within which there are relatively minor variations in local adoption. As such, this strategy could lead to desired changes in local policies. Moreover, the changes would be more or less uniform within each of the states.

There are three main limitations to this strategy for influencing risk reduction. First is the difficulty of achieving changes in state building codes, private codes, or state land use mandates -- particularly if noteworthy changes are involved. The second difficulty stems from the fact that the policies will only address future development and construction. Even with substantiation of noteworthy risks, retroactive state-level policies concerning such things as mandating seismic review or retrofit of existing, potentially hazardous buildings are very unlikely to be enacted in Oregon or Washington. The third difficulty stems from this study's finding that while local policies closely mirror state mandates, there is still considerable variation in local practices. The implementation of the policies and the exercise of building and land use officials' discretion is dependent upon the broader political-economic landscape.

In sum, a likely scenario for this implementation strategy is that appropriate changes will be made for new construction (or renovation) throughout the region. To the extent that the new provisions allow discretion in interpretation or implementation, there will be a varied response that is reflective of differing political and economic factors among different categories of cities and counties. Overall risk reduction in the region can be expected to be advanced, but the differentiation in categories of cities and counties is unlikely to change.

Influence Local Practice.--This strategy consists of efforts to influence the practices of building and planning departments in carrying out state mandates and local policies. This might entail such things as providing jurisdiction-specific seminars, preparation of guidelines for exercising discretionary judgments, providing technical assistance in land use planning or construction plan review, or funding geologists or structural engineers as part of local staffs. These actions could be targeted to, and differentiated among, specific jurisdictions or classes of jurisdictions.

This approach has several strengths. The targeting of different types of assistance is responsive to the variation in situations that the jurisdictions in this region face. The emphasis on practice, as opposed to policy, gets at important discretionary judgments concerning such things as renovation of existing buildings. In addition, there is a potential for developing several showcase risk reduction efforts that can potentially be transferred to other jurisdictions.

The limits of this approach stem from the constraints imposed by state mandates on local exceptions to those mandates. The Washington state building code allows, with appropriate state-level review in some instances, local jurisdictions to enact stronger provisions than state mandates. The Oregon state building code is much more constraining in not permitting exceptions to the code. As such, the effectiveness of this strategy is a function of the amount of discretion that exists within existing codes. The strategy stands to improve risk reduction efforts the most among those jurisdictions for which current risk reduction efforts are the weakest. It will do little for the "pacesetters," "new sophisticates" or "leading" counties.

Influence Private Practices.--This strategy consists of efforts to influence the practices of the private engineering and design community. This might entail such things as providing special seminars, funding production of special guidelines by professional associations, or providing some other form of professional development opportunities. These actions could be targeted to, and differentiated among, different types of professionals.

The strength of this approach stems from the prospective direct influence of such professionals' design and engineering recommendations in reducing earthquake risks. The payoffs are likely to be greatest among those sectors for which reliance on the judgments of design and engineering professionals is extensive -- illustrated by the utilities and ports that were included in this study. There also may be indirect benefits of changes in practices or knowledge leading to interest in lobbying for code changes.

There are obvious implementation difficulties for this strategy of identifying and reaching appropriate professionals, much less convincing them of the need for changes in practice. Presuming some success in these respects, the main limits to the effectiveness of this approach stem from the constrains under which the design and engineering communities practice their professions. In the absence of code changes, competitive pressures and client desires to reduce costs may restrict the extent to which practices exceed minimum code requirements. The main beneficiaries may be those professionals and supportive clients who already are making the greatest strides in addressing earthquake risks.

Insurance companies and financial institutions could potentially play important roles in endorsing (or requiring) new seismic design practices. However, among other factors, competitive pressures within these industries have limited the role that this region's insurance companies and financial institutions have played in stimulating stronger risk reduction efforts.

CONCLUSIONS

These research findings concerning earthquake risk perceptions, existing policies and practices, and the political-economic landscape provide plenty of room for differing interpretations of the current state of earthquake risk reduction in the region. Optimists might point to building officials general awareness of damage potential, the relatively sophisticated building and land use policies in some of the more populous jurisdictions, and the growth in earthquake engineering experience among private design professionals in this region. Pessimists might point to elected officials seeming indifference to earthquake risks, the limited attention to seismic hazards in several categories of cities and counties identified in this report, and the inevitability of a major earthquake that building officials acknowledge will likely lead to significant losses.

Further complicating matters is the fact that any summary evaluation is likely to mask the variation in situations that was discussed in this report. The discussion not only shows the extent to which jurisdictions face different relative risks, but also demonstrates the importance of considering the political-economic landscape for future risk reduction efforts. The current situation and future prospects for risk reduction look very different when considering the "pacesetters" than when considering the "restrained" group of cities, or when considering the "leaders" among counties as compared to the situations that the "rural" counties face. Future implementation activities associated with Federal research efforts will need to take these differences into account.

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Table 1. Cities in this Study

Oregon	Washington
Beaverton, Forest Grove Gresham, Hillsboro, Keizer, Lake Oswego, McMinnville, Milwaukie Newberg, Oregon City Portland, Salem, Tigard, Tualatin, West Linn, Woodburn	Aberdeen, Anacortes, Auburn, Bellevue, Bellingham, Bothell, Bremerton, DesMoines Edmonds, Everett, Kelso, Kent, Kirkland, Lacey, Longview, Lynnwood, Mercer Island, Mount Vernon, Mountlake Terrace, Oak Harbor, Olympia, Puyallup, Redmond, Renton, Seattle, Tacoma, Vancouver

Table 2. Existing Hazardous Buildings

	Cities Reporting Hazard	
	OR Cities	WA Cities
Unreinforced Masonry	31 %	52 %
Tilt-Up built before mid 1970s	25 %	22 %
Reinforced Concrete Frame before 1960s	13 %	25 %

Note: Percent of cities reporting that each building type is either 'somewhat' or 'very' common.

Table 3. State Building Code Mandates

State Mandate	*Provisions*	*Local Discretion*
OREGON – 1974 State Building Code (as amended)	Establishes State Building Code and agency with rule-making authority to update code provisions	Not able to amend provisions to meet local conditions (either upward or downward)
	1988 ed. of UBC with Oregon amendments administratively adopted in 1989 (regularly updated since 1973 ed.); CABO One and Two Family Dwelling Code also adopted	Local enforcement with county and state backup (structural provisons almost always locally enforced)
	Mandates certification of building officials, plans examiners, and inspectors	Discretion as provided within UBC with Oregon amendments
WASHINGTON – 1975 State Building Code (as amended)	Establishes State Building Code council with rule-making authority to update code provisions	Able to amend provisions to meet local conditions, as long as minimum state standards are met
	1988 ed. of UBC administratively adopted in 1989 (regularly updated since 1976 ed. w/ some technical modifications)	Solely local enforcement of building code provisions
	Building Code Council authority to review local amendments for residential structures with one to four units (since 1986)	Discretion as provided within UBC provisions and in adding local amendments

Table 4. Relatively Vulnerable Cities

Category of Cities	*Future Risk Reduction Prospects*	*Cities*
PACESETTERS -- Large cities with sophisticated building departments; weaker land use provisions	Good -- Potential for continued innovation for upgrades of existing buildings; retrofit provisons more difficult	Portland, Seattle, Tacoma
RESOURCEFUL -- Moderate size cities with initiatives spurred by individual efforts	Mixed -- Receptive but limited resource base and political support; practices easier to influence than local policies	Aberdeen, Bremerton, Olympia, Renton, Salem
RESTRAINED -- Moderate to larger size cities constrained by economic conditions or lower risk perception	Constrained -- Uphill effort to push seimsic issues given economic and political factors	Bellingham, Everett, Kelso, Longview, Vancouver

Table 5. Less Vulnerable Cities

Category of Cities	*Future Risk Reduction Prospects*	*Cities*
NEW SOPHISTICATES -- Rapidy growing cities for which building and planning efforts have been spurred by extensive commercial development	Good -- Land use considerations a key aspect of growth controls; capable and interested building departments	Auburn, Bellevue, Beaverton, Gresham, Kent, Kirkland, Lake Oswego, Mercer Island, Redmond, Tigard
MEASURED -- Smaller size cities with varying hazards addressed by 'normal' building and land use provisions	Mixed -- Potential limited by economic circumstances or other city-specific factors; practices easier to influence than local policies	Anacortes, Bothell, Edmonds, Lacy, Milwaukie, Puyallup, Mount Vernon, McMinnville
NON-PLAYERS -- Smaller size cities for which earthquake hazards are not considered to pose noteworthy risks	Low -- Need to be convinced there are noteworthy risks	Des Moines, Forest Grove, Hillsboro, Keizer, Lynnwood, Mountlake Terrace, Newberg, Oak Harbor, Oregon City, Tualatin, West Linn, Woodburn

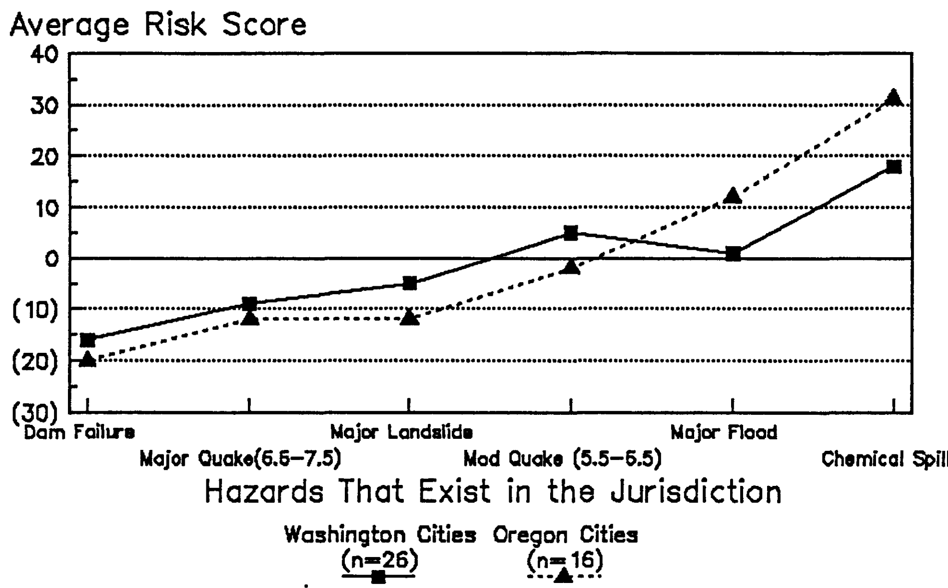
Table 6. Counties and Future Risk Reduction

Category of Counties	*Future Risk Reduction Prospects*	*Counties*
LEADERS -- More heavily populated counties near largest urban areas; established risk reduction efforts	Good -- Land use considerations a key aspect of growth controls; capable and interested building departments	King, Multnomah, Washington
TRANSITIONAL -- Counties with unincorporated areas being transformed from rural areas that forces attention to address building and planning concerns	Mixed -- Potential limited by county-specific factors; resistance to change evident in some counties	Clackamas, Clark, Island, Kitsap, Marion, Pierce, Snohomish, Thurston, Whatcom
RURAL -- Counties for which unincorporated areas have remained rural; hazards but limited population exposure and commercial buildings	Low -- Recognize risk and have undertaken some risk reduction for flooding and landslide; futher efforts not economically feasible	Cowlitz, Grays Harbor, Jefferson, Polk, Mason, Skagit, Yamhill

Table 7. Implementation Strategies for New Hazards Information

Strategy/Examples	*Target Group(s)*	*Strengths*	*Limits*
HAZARDS INFORMATION DISSEMINATION -- workshops, publications for hazard maps, loss estimates	Widely disseminated (targeting possible)	Easily implemented (status quo); info essential for risk reduction	Only more capable will act on the information; does little for less capable jurisdictions
SEEK MANDATE REVISIONS -- state building code & land use mandates	State agencies; Code-writing organizations	Uniform local policies; few entities to address	Limited to new bldgs or development; Practices will still vary among jurisdictions
INFLUENCE LOCAL GOVERNMENT PRACTICES workshops, fund staff, demonstration programs, technical assistance	Local building officials & planners	Can target jurisdictions with greatest needs; Does not require policy changes	Bldg officials say hands tied by code (especially Oregon); Cities w/most need may not want assistance
INFLUENCE PRIVATE PROFESSIONAL PRACTICES workshops, production of guidebooks, technical assistance	Architects, engineers (design & engineering community)	Can target specific; groups; does not require state/local endorsement	Competitive pressures may limit ability to exceed code minimums

FIGURE CAPTIONS



Scores are deviations from mean ratings across categories in each state; excludes responses of "don't know" and non-respondents.

Figure 1. Elected Officials' Risk Perceptions

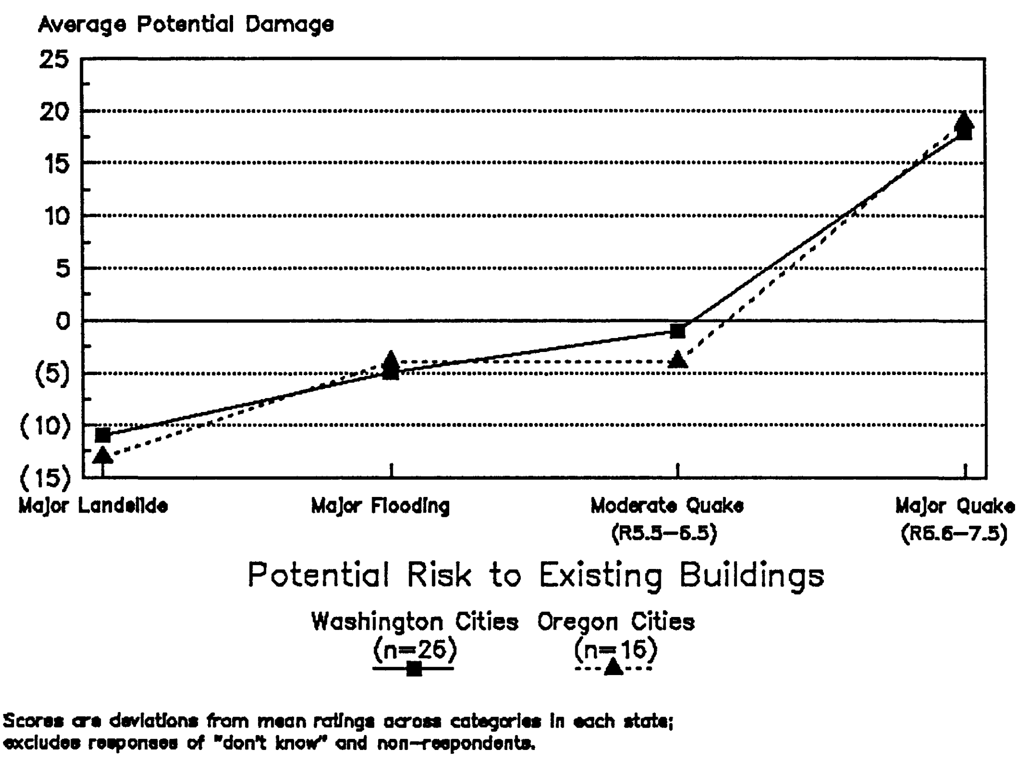


Figure 2. Building Officials' Risk Perceptions