

OPTIMIZING EMERGENCY EGRESS TO SAFE ZONES:
PLANNING FOR A MAJOR EARTHQUAKE
AT THE UNIVERSITY OF OREGON

by

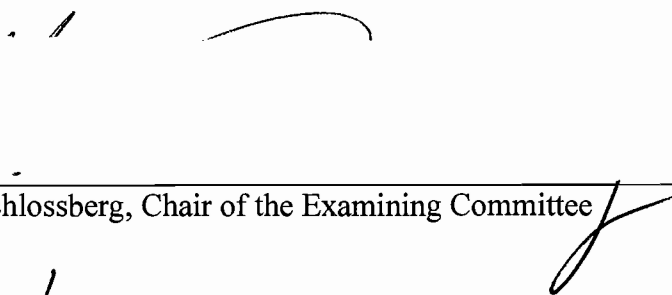
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A THESIS

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Public Policy and Management
and the Graduate School of the University of Oregon
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“Optimizing Emergency Egress to Safe Zones: Planning for a Major Earthquake at the University of Oregon,” a thesis prepared by Kathryn Joy Harris in partial fulfillment of the requirements for the Master of Community and Regional Planning degree in the Department of Planning, Public Policy and Management. This thesis has been approved and accepted by:



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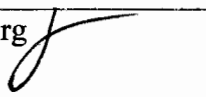
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Dr. Marc Schlossberg 

An emergency occurs, an alarm signals the need to exit immediately, and building occupants evacuate. But then what happens next? Presumably evacuees would gather in open areas of relative safety, or “safe zones,” where emergency personnel would communicate with staff, provide first aid, prioritize response needs, and announce next steps. The *National Response Framework* is increasingly becoming integrated into universities’ emergency management, but additional guidelines for the development, management, and implementation of campus safe zones are still needed. To address this challenge, case study research of twenty west coast universities was conducted to determine commonalities among campus evacuation planning processes. Geographic Information Systems (GIS) analysis was then used to illustrate opportunities and

challenges of safe zone planning at the University of Oregon. This research indicates that while universities share similar planning objectives, collaboration among universities and integration of spatial technology can significantly optimize emergency egress to safe zones.

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CHAPTER I

INTRODUCTION

When a fire alarm is activated, most building occupants know that they should exit the building immediately. They can usually exit from the door they used to enter the building, but where should they go once they have exited? Often the expectation is that evacuees would gather in open areas of relative safety, or “safe zones.” But what makes these areas safe? Are they safe because they keep evacuees from the building emergency or are other elements considered? What about if the evacuation is prompted not by an isolated building fire, as is usually the predominant evacuation planning assumption, but a larger scale disaster such as an earthquake that requires many buildings to evacuate at once? Who is responsible for managing large crowds who are potentially anxious, worried, confused, and even injured?

Universities are increasingly interested in safe zone designations and larger emergency management efforts for a variety of reasons. Recent events including Hurricane Katrina’s impact on Tulane and Louisiana State Universities (August 2005), the shootings at Virginia Tech (April 2007) and Northern Illinois Universities (February 2008), and the Midwest seismic event (April 2008), have shown that not only local and state governments, but also universities should develop emergency evacuation plans.

Background

Many universities have begun to incorporate the Federal Emergency Management Agency's (FEMA's) *National Response Framework's* guidelines for the development of a comprehensive, all-hazards approach to emergency response. This *Framework* includes the National Incident Management System (NIMS) and the Incident Command System (ICS), which provide a uniform set of processes and procedures for any level of jurisdiction to organize an emergency response. The implementation of these systems at universities has the potential to improve the response of its own personnel, as well as its communication with aiding entities, such as police, fire, and emergency medical service (EMS) providers.

While these national, time-tested approaches have proven to be successful management strategies for emergency response, there are still few resources to aid in the development and decision-making processes necessary for planning for specific emergency support functions such as evacuation. Since the *Framework* addresses governmental jurisdictions, those evacuation resources that do exist are with consideration of entire geographic regions and not finite campus environments. Like small communities, universities support a wide range of activities, schedules, and needs. However universities must also take responsibility for its young student populations who it provides residence for, who do not own a car, and who expect leadership and direction, especially in unusual situations.

On the other hand, compared to cities or regions, universities often have several more resources to support a detailed evacuation planning process. Registrar data of class

sizes, locations, and times provides university emergency planners with the leverage to predict the types and needs of populations that could be affected in a potential emergency. Facility Services personnel possess detailed plans of infrastructural elements and a holistic understanding of the layout of campus buildings and open spaces. Student Affairs divisions, including a Health Center and Housing, have numerous resources and capabilities to provide assistance in an emergency, especially when city response services are limited.

Methodology

This paper reviews how peer universities are developing their evacuation safe zone programs, including the identification of safe zone hazards and resources, the management systems developed to organize emergency egress, and the methods of implementation and outreach employed to educate building occupants on these procedures. Geographic Information Systems (GIS) was then used to illustrate research findings and recommendations, based on a potential earthquake scenario that would require the use of all evacuation safe zones at the University of Oregon.

Purpose and Contributions of this Research

The purpose of this thesis is two-fold. First, since there is no existing literature on evacuation safe zones in campus environments, this research compiles the strategies west coast universities are employing to plan, manage, and implement emergency evacuation

programs. The second purpose is to evaluate a pragmatic application of these findings using Geographic Information Systems (GIS).

This analysis provides several important contributions to the emerging field of emergency management research. First, this is a comprehensive collection of the most prominent concerns in university evacuation programming: planning, management, and implementation. Second, the application of GIS illustrates the discussed planning issues, and evaluates how realistic it is to account for all of these elements when delineating evacuation safe zones.

Document Organization

This thesis is organized into five chapters. Following this introductory chapter, the second chapter reviews the relevant literature including the development of comprehensive emergency management; an overview of evacuation studies; the planning process, management, and implementation of evacuation plans; and how spatial analysis capabilities in GIS can be used to optimize emergency evacuation planning.

The third chapter explains the methodology used for this analysis and is broken into two distinct parts. The first part notes how case study universities were identified and researched using online documents and phone interviews to gather information about evacuation safe zone planning, management, and implementation strategies. Then the second part of the methodology explains how the predominant lessons learned from case study research were applied to the University of Oregon using Geographic Information Systems (GIS). This use of GIS allowed for the illustration of the researched elements as

well as analysis of how realistic these standards and expectations are in a university campus environment.

The fourth chapter presents the results. This chapter first includes a narrative of findings specific to topics within the subjects of safe zone planning, management, and implementation. The second part of the chapter reveals the results of the GIS spatial analysis for the University of Oregon main campus.

This document concludes with a fifth chapter, with a discussion of the implications of this study and recommendations for future research. This includes an interpretation of what are the main successes and challenges of evacuation safe zones for universities, as well as the role of GIS in optimizing evacuation safe zone planning.

CHAPTER II

LITERATURE REVIEW

Emergency management has only recently begun to emerge as a field of academic study and there is limited literature available for study. Existing literature tends to address broad systematic approaches such as comprehensive emergency management, types of emergency response activities, or particular disaster events. This study draws upon literature from each type of approach, while noting the differences between city and university environments. Engineering and social science literature is also referenced to highlight essential points for consideration of evacuation planning, management, and implementation. This section concludes with a review of the uses of Geographic Information Systems (GIS) technology to date, by outlining the predominant expectations of its use during an emergency response and potential applications for evacuation planning.

Comprehensive Emergency Management

During the Cold War, most emergency planning focused on response to a specific type of natural or technological disaster situation and a nuclear attack (Perry and Lindell 2003). However emergency managers have since recognized that different types of disasters often require similar response needs and have begun to embrace a

comprehensive approach to emergency management (Perry and Lindell 2003).

Comprehensive emergency management is an all-hazards approach, where a single plan is developed to respond to several different types and sizes of emergencies: from a human-caused disaster like a terrorist attack to a natural disaster like an earthquake (Perry and Lindell 2003).

Comprehensive emergency management planning also addresses all four temporal phases of a disaster cycle: response, recovery, mitigation, and preparedness (Tierney, et al. 2001; Perry and Lindell 2003). As soon as an emergency event is detected or threatens, actions are taken to respond to the immediate needs of disaster victims (Tierney, et al. 2001). Depending on the situation, response activities may include evacuation, search and rescue, medical triage, and mass care and shelter. Then once immediate response needs have been attended to, recovery actions repair, rebuild, reconstruct, and otherwise restore the affected area to a pre-disaster state (Tierney, et al. 2001).

Sociological research reveals that for most of human history, disasters have been considered random and “collective misfortunes” that can only be dealt with by response and recovery actions (Dynes and Drabek 1994, 5). However with the development of industrialized societies has come the idea that technology and advanced engineering can “solve” disaster-related problems (Dynes and Drabek 1994, 6). This ideology is most applicable to the mitigation phase, when actions are taken prior to an emergency in order to decrease vulnerability in terms of life safety and/or structural damage (Tierney, et al. 2001). Whereas mitigation generally focuses on modifications to infrastructure, the

preparedness phase more directly addresses social units by helping plan what people—whether responders or average citizens—would do if an emergency occurred (Perry 1985; Tierney, et al. 2001). Preparedness usually involves one of two types of actions: those that issue an alert that an emergency impact is imminent and those that enhance the effectiveness of emergency operations (Perry 1985). The development of evacuation plans fits into the later category since it helps minimize the number of people who require search and rescue assistance and keeps evacuees out of the way of responder access.

Evacuation

McEntire defines evacuation as “the movement of people away from potential or actual hazards for the purpose of safety” (2007, 122). Evacuation can be used in response to protect lives from the effects of natural disasters including major storms, floods, hurricanes, volcanic eruption, wildfire, or earthquake (Zelinsky, et al. 1991; Cova and Church 1997). Evacuation can also be used to protect lives in response to a variety of technical, industrial, or human-caused incidents such as warfare, terrorism, bomb threats or detonations, fire, and hazardous material releases (Zelinsky, et al. 1991). One study has estimated that technological disasters have led to 25 evacuations involving over 5,000 or more people over a 15-year period, worldwide (Sorensen, et al. 2004, 5). Evacuation decisions, or lack thereof, following several technological incidents in the late 70s and early 80s including the reactor accident at Three Mile Island near Middletown, Pennsylvania, in 1979, and the toxic gas release from the Union Carbide subsidiary in Bhopal, India, in 1984, have also attracted the attention of evacuation researchers

(Zelinsky, et al. 1991). For instance, though there were emergency evacuation plans for the Middletown community, neither the plant managers nor local or state authorities implemented the plans when they were needed most during this response (Zelinsky, et al. 1991). As a result terrified citizens were left to make sense of confusing media reports and to fend for themselves (Zelinsky, et al. 1991).

City and University Evacuation Planning

Though most evacuation research focuses on community-wide evacuations, several of these lessons can be applied to other types and scales of evacuations including campus-wide building evacuations at universities. Like small communities, universities support a range of land uses including residential, commercial, academic, and sometimes medical facilities (Alam and Goulias 1999). Also like a small community, a university's students, faculty, staff, and visitors have a wide variety of needs and participate in different types of activities and schedules. Yet even building-level evacuation research is usually limited to indoor infrastructural elements, and does not address the evacuation planning process that dictates where people should go once they have exited a building, who is responsible for providing leadership in these situations, or how occupants know what to expect in the first place (Santos and Aguirre 2004).

Planning Process

Dwight D. Eisenhower once said, "...I have always found that plans are useless, but planning is indispensable" (Canton 2007, 189). This is because plans capture intent

at a specific point in time and are often produced by a single, isolated consultant or office—not as part of a multi-disciplinary approach over time (Canton 2007). If the main purpose of an emergency operations plan's development is to meet a specific policy, it is unlikely that the plan will adequately address the information needs of training, exercises, or even an actual response (Canton 2007). Therefore the planning process must include practical consideration of numerous variables including the expected numbers and even types of evacuees per safe zone, in order to help predict the potential vulnerabilities to injury (Alam and Goulias 1999).

Management

Once estimations are made on the scale of potential evacuations, a management system is needed to help ensure that established emergency procedures are followed. Studies show that compared to an alarm, the sound of a voice is a more effective way to notify building occupants of when to evacuate and what to do (Benthorn and Frantzich 1999; Gwynne, et al. 1999). Occupants are also more likely to comply with evacuation announcements when they come from a credible source (Perry 1985). Though occupants of public buildings can be especially vulnerable to the effects of group behavior, they are also more easily influenced by authority figures (Gwynne, et al. 1999). For instance during the World Trade Center attacks on September 11th, 2001, many occupants could not or would not make the decision to evacuate, and instead looked to leadership for direction (Kemp 2003). These leaders may be used to reinforce the severity of an incident and need to evacuate, relay building-specific evacuation procedures, and direct

evacuees to the nearest exit and safe zone (Gwynne, et al. 1999). However the effectiveness of this assistance often depends on the leaders' level of experience and related training, confidence to maintain responsibility and assert themselves in stressful situations, and familiarity with the occupants they are assisting (Gwynne, et al. 1999).

Implementation

Effective evacuations are often due in part not only to responsible management but also greater familiarity with the building and safe zone environment (Gwynne, et al. 1999). No alarm or assistance can ever replace the value of a building occupant's familiarity with evacuation procedures and features such as the locations of alternate exits (Gwynne, et al. 1999). However this awareness can be achieved by conducting evacuation drills to identify route preference and to educate occupants on where the closest and safest exits are located (Gwynne, et al. 1999).

Geographic Information Systems (GIS) in Emergency Management

When the use of Geographic Information Systems (GIS) is mentioned in the context of emergency management, most assume it is in regards to its use during response. It is no surprise that many are hesitant to trust a high tech program's capability to produce accurate information for split second decisions in the heat of a response. To cynics who merely acknowledge GIS's capability to make "pretty maps," after using GIS in the response to the terrorist attacks on September 11th, Alan Leidner, Director of

Citywide GIS for the New York City Department of Information Technology and Telecommunications, could only respond, “This stuff saves lives” (Greene 2002, p.ix).

An overwhelming supply of raw data on a computer might be a disaster on its own, but the integration of additional data sets can inform better decisions (Amdahl 2001; Montoya 2003). GIS’s greatest value is as a data consolidator that allows the user to integrate, store, process, and produce spatial information (Greene 2002; Gunes and Kovel 2000). As a result, decision makers can quickly prioritize response needs, coordinate responder efforts, provide public guidance, aid the flow of resources, visualize incident site constraints, and produce public relations information (Cova 1999).

To be useful during a response, emergency planners primarily use GIS to help formulate response plans during the preparedness phase (Cova 1999; Gunes and Kovel 2000). This requires the compilation and development of databases that can address information needs expected in a response (Cova 1999). Since evacuations to safe zones include an exceedingly complex set of unpredictable elements, GIS can serve as a valuable tool for proactively analyzing potential evacuation challenges and opportunities during preparedness planning and for rapidly making decisions during a response (Cova and Church 1997; Sorensen 2004). A risk map can be created with different layers of information to identify potential natural hazards such as trees, technical hazards such as hazardous materials, and vulnerabilities such as demographics of potential evacuees or utilities (Cova 1999; Helbing, et al. 2000). A university campus cannot be rearranged to create the most ideal environment for evacuation safe zones, but a GIS mapping process

can help identify issues, and even weigh the costs and benefits of potential mitigation strategies (Drabek, et al. 1991).

CHAPTER III

METHODOLOGY

Due to the limited amount of available information about campus-specific evacuation, interviews and online research were conducted for twenty case study universities. Existing literature was also referred to when it was available. Most evacuation policy has been developed with building fire scenarios in mind and assumes that evacuees are safe once they are outside of the affected building(s). However many other types of disasters may require the evacuation of all buildings campus wide and present several more hazards to take into consideration. For this reason this research considered an earthquake scenario.

Case Study Research

Case study universities were identified based on similarities to the University of Oregon (UO). West coast universities in Alaska, California, Oregon, and Washington were researched because these states are all vulnerable to seismic events (See Table 1). The UO main campus is approximately 295 acres, and case study campuses ranged from 620 to 1489 acres. Enrollment was also considered in identifying appropriate case study

Table 1. Case Study Universities

University	Location	Campus Size (acres)	Student Enrollment	Density (students / acre)
Stanford University	Palo Alto, CA	8,180	19,782	2
University of California, Davis	Davis, CA	5,300	30,475	6
University of California, Santa Cruz	Santa Cruz, CA	3,008	15,825	5
California State Polytechnic University, Pomona	Pomona, CA	1,438	16,717	12
University of California, Irvine	Irvine, CA	1,500	24,745	17
University of California, Santa Barbara	Santa Barbara, CA	1,022	21,410	21
University of California, San Diego	San Diego, CA	1,200	27,500	23
University of California, Berkeley	Berkeley, CA	1,232	34,953	28
Washington State University	Pullman, WA	600	17,583	29
University of Alaska, Anchorage	Anchorage, AK	348	16,242	47
Oregon State University	Corvallis, OR	400	19,753	49
Western Washington University	Bellingham, WA	215	12,979	60
University of Washington	Seattle, WA	643	39,251	61
University of Oregon	Eugene, OR	295	20,394	69
University of California, Los Angeles	Los Angeles, CA	419	38,476	92
California State University, Sacramento	Sacramento, CA	300	34,000	113
University of Southern California	Los Angeles, CA	287	33,500	117
San Diego State University	San Diego, CA	283	33,285	118
San Jose State University	San Jose, CA	154	31,906	207
San Francisco State University	San Francisco, CA	134	29,628	221
Portland State University	Portland, OR	49	24,999	510

universities. There were 20,394 students at UO in fall 2007, and case study university enrollment ranged from 14,982 to 39,251 students. (*Refer to Bibliography for references.*)

Internet research was then conducted to gather evacuation information posted by each of the case study universities. This information was found within publicly available emergency plans or outreach materials outlining procedures for faculty, staff, students, and/or visitors. Since the topics and depth of information available on this subject varied considerably, phone interviews were conducted to supplement the information posted on the Internet.

A staff member involved in emergency planning at each case study university was identified. These representatives' position titles included: Emergency Management Coordinator, Emergency Services Coordinator, or Facility Safety Office Manager. The departments with these positions also varied and included: Emergency Management, Environmental Health & Safety, and Facilities Services. All identified personnel received a recruitment e-mail, follow-up e-mail, and follow-up phone call. In some cases, the contact forwarded the information to another staff member who was more qualified and/or had had greater involvement in the university's evacuation planning process. Interviewees' names and universities were kept anonymous.

Eight phone interviews were conducted, lasting 30 to 90 minutes each. An interview script guided these conversations and included questions about safe zone evacuation purpose, planning process, management, implementation, and review and revision (See Table 2). Following each interview, notes from the interview were

Table 2. Case Study Interview Guiding Questions

PURPOSE	<p>Was the purpose of designating safe zones to:</p> <ul style="list-style-type: none"> ▪ Collect individual's statuses? ▪ Provide emergency services? ▪ Communicate next steps?
SIZE	<p>When an emergency occurs, does an evacuees safe zone depend on:</p> <ul style="list-style-type: none"> ▪ Building? ▪ Exit door used? <p>Have you been able to account for the potential number of evacuees per zone?</p>
HAZARD I.D.	<p>Have you identified potential safe zone hazards for the following elements:</p> <ul style="list-style-type: none"> ▪ Pedestrian challenges or barriers? ▪ Utilities (overhead and underground)? ▪ Trees? ▪ Buildings? ▪ Hazardous materials? <p>Do you have a formal prioritization process to account for these hazards?</p>
ACCESS	<p>Do you plan to provide medical services within safe zones?</p> <p>Do all safe zones have direct access to a road?</p> <p>Have you pre-designated:</p> <ul style="list-style-type: none"> ▪ Helicopter landing zones? ▪ Transportation staging areas?
MANAGEMENT	<p>Do you have an evacuation management system with positions to:</p> <ul style="list-style-type: none"> ▪ Notify occupants to evacuate? ▪ Communicate with responders? <p>Is your evacuation management appointed:</p> <ul style="list-style-type: none"> ▪ Primarily on a volunteer basis? ▪ On a departmental basis?
IMPLEM.	<p>Do building occupants learn where to go because:</p> <ul style="list-style-type: none"> ▪ Safe zones are noted on evacuation maps? ▪ Evacuation drills are conducted? <p>Do you have a formal schedule to review and revise safe zones?</p>

compiled into a written summary and then shared with the interviewees to ensure that all comments were captured accurately. A summary table was also developed to highlight common traits among the case study universities.

Geographic Information Systems Analysis

Results of the literature and case study research then informed the use of GIS to illustrate and analyze emergency evacuation safe zones for the University of Oregon main campus in Eugene, Oregon. The Environmental Studies Research Institute (ESRI) Geographic Information Systems (GIS) software ArcMap, and existing campus GIS files and datasets developed by the University of Oregon's InfoGraphics Lab were used to illustrate existing zones and identify potential hazards and resources near and within safe zones. Based on research findings, GIS was also used to delineate revised safe zones for the University of Oregon campus. These new zones were then evaluated to predict the distribution and number of evacuees per safe zone.

First the University's current "Emergency Management Area Zones" were drawn by creating new polygons for each zone. The existing information in the University of Oregon's Emergency Operations Plan only listed the buildings per zone, so the boundaries of each zone were estimated when mapped.

Then the potential hazards discussed in the case study findings were identified using existing campus GIS files (See Table 3). Potential pedestrian challenges and barriers were only visually accounted for. Potential utility tunnel hazards and building debris were accounted for using 15' and 50' buffers, respectively.

Table 3. Elements of GIS Analysis for the University of Oregon

FEATURE	UO GIS FILE	USE
Pedestrian challenges and barriers	<ul style="list-style-type: none"> ▪ Campus walkways ▪ Streets 	<i>Visually accounted for.</i>
Utilities	<ul style="list-style-type: none"> ▪ Vault access ▪ Water vaults ▪ Electric vaults ▪ Tunnel manholes ▪ Tunnels 	Created 15' buffer around each utility feature.
Trees	<ul style="list-style-type: none"> ▪ Campus trees 	Created proportionate symbology to represent the potential fall radius for each tree.
Buildings	<ul style="list-style-type: none"> ▪ Campus buildings 	Created 50' buffer around each campus building.
Hazardous materials	<i>No GIS file available.</i>	Used Registrar room use information to identify buildings with science labs and the Central Power Station.
Fire hydrants	<ul style="list-style-type: none"> ▪ Fire hydrants 	Created 15' buffer around each hydrant.
Streets	<ul style="list-style-type: none"> ▪ Streets 	<i>Visually accounted for.</i>
Potential number of evacuees	<i>No GIS file available.</i>	<i>Used Registrar information.</i>

Proportional symbols were used with tree height information to illustrate the potential fall radius of all campus trees. Hazardous material storage areas were identified using the Registrar's occupancy data per type of room information. A new map was not created for this because only the cluster of science buildings and Central Power Station were identified. There was no available information on the location of other potential hazardous materials storage areas such as for custodial or grounds keeping services.

The buffer analysis tool was also used to show how far evacuees should stand from potential resources so that they would not interfere with responder access. A 15' buffer was drawn around each fire hydrant and utility access point (identified in the following GIS files: water vaults, vault access, electric vaults, and tunnel manholes). This distance of 15' was chosen because that is how far one must stay away from a fire hydrant when parking. It was presumed that if this area is large enough for firefighter access that it would also be adequate for responders needing to access campus utilities.

Using the identity tool, open space polygons were divided into additional polygons so that there were separate polygons accounting for the potential hazard or resource areas and remaining open space where evacuees could still congregate. The area of each of these polygons was calculated in order to analyze the difference in open space available for safe zone designation before and after accounting for a potential hazard or resource. Athletic surfaces were not included as open space because these areas are not necessarily immediately accessible. These would more likely be used for response services such as mass care and shelter. Parking lots were also not included as open space due to their potential seismic hazards and use for response services such as medical triage.

Evacuation safe zone delineations were then revised based on the results of this analysis. Existing walkways and roads were used to outline these zones when possible so that evacuees would be able to more easily identify their designated safe zone and would not interfere with responder accessibility. Then potential numbers of evacuees per safe zone were estimated using classroom occupancy data provided by the University

Registrar's Office. These numbers were then compared to the total calculated area of each revised safe zone to determine where there may not be enough space to accommodate all evacuees.

CHAPTER IV

RESULTS

The following narrative elaborates on the case study interview findings (See Table 4) and is supplemented and supported with Internet research of related case study university evacuation policies and procedures. This section begins with universities' purposes for developing safe zones and then presents information on how these safe zones were developed. Next are the results of management structure and means of implementation of safe zone programs. Then the means of implementation for educating the university community on evacuation procedures and the ongoing review and revision schedules for evacuation plans are presented. This section concludes with the results of Geographic Information Systems (GIS) analysis when case study findings were applied to the redevelopment of evacuation safe zones for the University of Oregon main campus.

Planning

Regardless of what point universities are at in their planning process, whether developing evacuation safe zones for the first time, or revising established zones, several issues must be considered including purpose, size, hazards, and accessibility elements.

Table 4. Case Study Interview Results

		Interviews							
		1	2	3	4	5	6	7	8
Purpose	Collect individual's statuses	●	●	●	●	●	⊙	●	--
	Provide emergency services	●	○	⊙	○	○	●	●	--
	Communicate next steps	●	●	●	●	●	●	●	--
Size	All building goes to same safe zone	⊙	⊙	●	--	--	⊙	●	●
	Depends on exit door used	⊙	⊙	○	●	--	⊙	○	--
	Account for potential number of evacuees	⊙	⊙	⊙	○	○	●	●	--
Hazard I.D.	Pedestrian challenges / barriers	⊙	●	●	●	○	●	●	--
	Utilities: overhead and underground	○	--	●	--	●	○	●	●
	Trees	○	○	●	○	--	●	●	--
	Potential building debris	○	○	●	--	--	●	--	●
	Hazardous material storage areas	○	--	●	○	●	●	●	--
	Prioritization process for hazards	○	--	○	--	⊙	○	⊙	--
Access	Provide medical services within safe zones	●	--	⊙	○	●	⊙	○	--
	Safe zones have direct access to a road	●	--	⊙	●	⊙	⊙	●	--
	Pre-designate helicopter landing zones	⊙	●	●	○	●	○	●	--
	Pre-designate transportation staging areas	○	⊙	●	○	⊙	⊙	●	--
Management	Notify occupants to evacuate	●	⊙	●	●	●	●	●	--
	Communicate with responders	●	⊙	●	●	●	●	⊙	●
	Appoint primarily on a volunteer basis	●	●	●	●	●	●	○	●
	Appoint on a departmental basis	○	⊙	○	⊙	⊙	⊙	⊙	--
Implem.	Safe zones are noted on evacuation maps	○	○	●	--	●	●	--	●
	Conduct evacuation drills	●	●	●	●	●	●	●	--
	Formal schedule to review safe zones	○	⊙	○	●	●	●	--	--

Legend: ● = Yes ○ = No ⊙ = Somewhat -- = No Response

Purpose

Universities have assigned several different names such as Evacuation or Emergency Assembly or Management Areas, Zones, or Points to what are called “evacuation safe zones” in this paper. When an emergency requires the evacuation of one or more campus buildings, designated evacuation safe zones are used to optimize safety, collect individuals’ statuses, stage responders, and communicate next steps.

Evacuees are not necessarily out of harm’s way once they are outside of a building. Depending on the emergency situation, there are numerous potential outdoor hazards that could inflict injury. The designation of safe zones allows for the identification, mitigation, and/or avoidance of these hazards in order to maximize evacuees’ safety (San José State University). Safe zones also help optimize the safety of responders by helping keep evacuees from interfering with responders’ access to the emergency itself (San José State University; University of California, Davis).

Once most evacuees are within a safe zone, leaders usually collect information on the number and severity of injuries, remaining building occupants who might need assistance (such as individuals who are mobility-impaired), and missing persons (Interviews 1, 2, 3, 4, 5, and 7; San José State University). Several universities require department staff and instructors to maintain rosters to be used for roll call during this process (Interviews 1, 3, and 5; San Francisco State University; Stanford University). When roll calls are not possible, leaders may conduct a headcount or ask individuals to see if their peers who were sitting near them in the classroom are present at the evacuation safe zone (University of Southern California). Since it can be difficult to

determine who is missing in campus environments where most occupants are transitory, some universities focus on determining whether or not a building has been fully evacuated (Interview 6).

Once needs are determined within each safe zone, university staff may help direct emergency responders to locations with the highest priority response needs, such as search and rescue and medical triage (Interview 6; University of California, Berkeley EMA; San Francisco State University). In addition to expected responders such as fire, police, and emergency medical services (EMS), other supporting organizations and volunteers may also assist in a campus wide emergency (University of California, Berkeley EMA). For instance, a Community Emergency Response Team (CERT) is a voluntary organization that trains its members in search and rescue and basic first aid (Interview 1). At one case study university, CERTs provide evacuation chairs for mobility-impaired individuals and assist in crowd control so that evacuees stay clear of walkways and streets needed for responder access (Interview 1).

Just as the safe zones can facilitate effective communication from evacuees to responders about needs, responders are also able to take advantage of mass communication within the zones (Interview 1, 2, 4, and 6; San José State University). Since emergency response services within a zone are often limited to first aid, these next step messages may include information on the availability and locations of food, water, shelter, counseling, and/or transportation services (Interviews 3, 5, and 6).

Predicting Needs

Once the purpose of evacuation safe zones has been determined, the planning process continues by predicting the types of emergencies that are likely to require an evacuation, setting guidelines for making the decision to evacuate, and evaluating the potential number of evacuees in relation to available open space.

Some universities have recently adopted planning processes that include more frequent review and revision of their evacuation safe zones (Interview 1 and 5; Stanford University). These universities are embracing the general shift in emergency management towards a comprehensive all-hazards approach that includes the biggest or most likely types of emergencies, such as fire, earthquake, building collapse, and hazardous material release (Interviews 3, 4, and 6; University of Washington EEOP). Other universities have accounted for every type of emergency they could think of, including: wildfire, flooding, terrorist attack, and bomb threats (Interview 5).

Depending on the type and size of emergency event, evacuation may not always be the best strategy to protect life safety (California State Polytechnic University, Pomona). Cal Poly Pomona advises its faculty to keep students in the classroom until directed to evacuate by emergency personnel. However some universities direct their occupants to evacuate immediately if a chemical spill occurs or they smell gas or smoke, see fire, or otherwise fear for their safety (University of California, Davis; California State Polytechnic University, Pomona; University of California, Los Angeles). State policy often dictates that evacuations shall occur in the event of an emergency or upon notification of fire, fire alarm, or orders of an authority having jurisdiction (University of

California, Los Angeles; University of California, Santa Cruz ERP). University policies also usually state that all alarms must be treated as emergencies (Interviews 3 and 6).

When possible, all building occupants are directed to the same safe zone in order to better account for evacuees and communicate with responders (Interviews 1, 3, and 6). There may be more than one zone designated for very large buildings, in which case there would be a reliance on radios or runners to communicate individuals' statuses between these areas (Interviews 1, 4, 5, and 6).

The Occupational Safety and Health Administration (OSHA) standard 1910.36(c)(2) states that: "the street, walkway, refuge area, public way, or open space to which an exit discharge leads must be large enough to accommodate the building occupants likely to use the exit route." Estimating the potential number of evacuees per safe zone during the planning process provides the opportunity to determine whether or not additional safe zones are needed (Stanford University).

Most university buildings are multi-use and require evacuation planning to consider student, faculty, staff, visitor, and animal populations (Interview 5). Since the numbers of occupants are constantly changing based on the time of day, day of the week, and month of the year, it can be very difficult to account for the potential number of evacuees. It is assumed that the highest occupancy rates are usually during weekday mid mornings and afternoons when most students attend classes (Interviews 3 and 6). The number of potential evacuees can be roughly estimated based on maximum building occupancy standards or institutional knowledge, but is rarely quantitatively accounted for in comparison the available safe zone area measurements (Interview 1). If exact numbers

are accounted for, they are more frequently the numbers of faculty and staff because the locations of their offices are the easiest to account for (Interview 1). Some universities do not calculate the potential number of evacuees or safe zone sizes because they do not expect or require evacuees to stay within the safe zones after checking in (Interview 5).

More often the topography or compact urban environment of a campus dictates the amount of space available for evacuation safe zones (Interviews 1, 2, 3, and 4). There is not a tried and true formula to determine how much space is required per the potential number of evacuees (Interview 3). One study calculated the approximate area around an individual to be a 12” radius if within touch and an 18” radius for a “no-touch zone” (Gwynne, et al. 1999). However evacuation safe zones are ultimately prioritized for safety, not necessarily comfort (Interview 3).

Identifying Potential Safe Zone Hazards

Universities can help identify the safe(st) zones for evacuees by becoming cognizant of hazards within campus open spaces, including: pedestrian challenges and barriers, utilities, trees, buildings, hazardous materials, and parking lots.

Sometimes there is more than one evacuation safe zone per building because research shows that pedestrians prefer a straight route with minimal change in direction, and will avoid walking along borders such as streets, walls, and other obstacles (Helbing 2001; Interview 6). It is usually assumed that the existing walkways most evacuees will use already comply with the Americans with Disabilities Act (ADA) Standards for Accessible Design. Yet walkways should still be evaluated for emerging hazards such as

tree roots that could create cracked or uneven pavement (Interview 3). Though most universities strive to be inclusive of accessibility issues for individuals with mobility impairments, these considerations are often deferred to a separate department or division (Interviews 1 and 3). In most emergency situations there is the expectation that individuals with mobility impairments will go to a designated safe points within the building and await evacuation assistance from qualified response personnel, such as firefighters (Interview 1). These cases assume that responders will assist individuals with mobility impairments all the way to the safe zone—not just to right outside the exit door—so that other features of the built environment such as walkway stairs do not further impede their travel to safety.

The expectation of evacuees to cross a road to reach their safe zone is another potential pedestrian hazard. Not only would crossing a street potentially interfere with responders' access, but also could put pedestrians at risk of being hit by a vehicle especially if the road is an arterial (Interview 1).

A seismic event could cause some utility poles to fall and bring down power lines, which would be dangerous for evacuees standing nearby (California State University, Northridge; Stanford University). Many universities also have underground utilities such as steam or gas lines that could burst in a seismic event (Interviews 3 and 5; Stanford University). Some universities are frequently made aware of the location of underground utilities due to construction projects (Interview 3). In other cases utilities have not been accounted for, sometimes because the evacuation safe zones were developed with a fire scenario—not a potential seismic event—in mind (Interviews 1 and 6).

In an effort to avoid designating safe zones where there would be the greatest likelihood for trees to fall, some universities coordinate with grounds keepers to identify the most well-rooted trees (Interview 3; Stanford University). For instance, eucalyptus trees have shallow roots and are avoided when designating safe zones because they could easily fall due to a severe storm or seismic event (Interview 3). Falling trees are less of a consideration in regions where permafrost keeps trees relatively small (Interview 4).

Following a seismic event, evacuating to a safe space away from buildings can help prevent further injuries created by falling glass, building ornamentation, and debris (California State University, Northridge; Interview 3; San Diego State University). In most cases the minimum distance between a building and its safe zone is 40 to 50 feet, as dictated by fire code (Interviews 2, 4, 5, and 6). Some universities have extended this to 100 or 300 feet when possible (California State University, Northridge; Interview 2; Oregon State University).

Hazardous material storage areas include sites where cleaning or landscaping chemicals are stored, and chemistry laboratories. These are of concern because containers could break and dangerous plumes could result if certain potent chemicals mix. One way to avoid this danger is to keep relatively small quantities of chemicals at a time (Interview 3). Some universities have managed to create and maintain a detailed chemical inventory that is shared with the fire department, police department, and university emergency management (Interview 5). This way responders at least know where the potential hazardous material dangers could be and can avoid directing evacuees to these areas.

Depending on the type and response needs of an emergency event requiring evacuation, parking lots may often be utilized since these are some of the only open spaces at urban campuses (California State University, Northridge). However these areas could be dangerous if a seismic event or aftershock causes cars to roll (Interview 6).

Most universities have not developed a system to prioritize these hazards in a particular order but instead have done their best to remain conscious of the potential dangers and mitigate when possible, such as during new construction (Interviews 3 and 6). A university's Environmental Health & Safety department is an obvious choice to include in this conversation (Interview 5).

Providing Accessibility

In addition to avoiding campus hazards, planners must also remember that one of the main purposes of safe zones is to “improve the effectiveness and delivery of emergency services” (University of California, Berkeley EMA). This requires consideration of potential response activities that could occur in safe zones (such as medical care) and access requirements for emergency vehicles to deliver service and/or supplies (Stanford University). Accessibility planning may also include the development of transportation staging areas to transport evacuees to an off-campus shelter.

As mentioned earlier, the main response service provided within evacuation safe zones is minor medical care. Though volunteers such as Community Emergency Response Team (CERT) members may provide basic first aid, more serious injuries are treated by emergency medical services (EMS) (Interview 6). Therefore it is essential that

evacuation safe zones are accessible to a road to expedite the delivery of supplies or facilitate ambulance transportation of the seriously injured (Interview 3). In some cases, triage areas may be set up near the entrances of parking lots (Interview 3).

To transport individuals with severe, life-threatening injuries some universities with greater amounts of open space have identified helicopter-landing zones (Interview 3). In denser urban campuses some buildings have helipads on top of them (Interview 6). University medical centers may also have helicopter-landing pads (Interview 1). In some cases campus buildings formerly used as medical centers still have maintained helipads (Interview 2).

For on the ground transportation access, some safe zones are located near or along a road (Interviews 1 and 4). When campus open spaces are in quadrangles encompassed by buildings, concrete pathways provide direct access to a road (Interview 5). Remote or secluded safe zone locations require special planning and procedures for how to walk injuries out to the road (Interview 3).

Transportation staging areas are designated locations where evacuees can board buses to leave the campus. The transportation may be to a nearby shelter or an area of refuge further away, depending on the type and scale of the event. Some university disaster plans have pre-designated transportation staging area locations at large parking lots (Interview 3), routine campus shuttle service stops (Interview 6), or one-way roads with bus areas normally used during athletic events (Interview 2). Other universities consider but do not pre-designate specific locations for transportation staging because it would depend on the type and location of the emergency (Interview 5). At these

campuses, personnel in the Emergency Operations Center (EOC) would be responsible for deciding the location of transportation staging areas (Interview 5).

Management

Management structures are developed to provide leadership to help accomplish the intended purposes of safe zones and ensure that procedures are followed. For the purposes of explanation here, university employees who participate in evacuation management systems are referred to collectively as an Evacuation Team (though this group is known as a “Zone Crew,” “Building Emergency Team,” or “Emergency Management Area Coordinator Program” at other universities) (See Figure 1). This team can be divided into three main subgroups: Evacuation Coordination, Safe Zone Coordination, and Planning Committees. Evacuation Coordination members’ primary duties are in the preparedness and response in relation to a specific area of a building, and include: Faculty and Staff, and Floor Evacuation Wardens. Safe Zone Coordination members are responsible for organizing evacuees and information on response needs for a particular evacuation safe zone, and include: Building Evacuation Coordinators, Safe Zone Assistants, and Safe Zone Captains. Evacuation Planning Committees’ primary duties are related to the maintenance of evacuation plans, policies, and procedures during the preparedness phase, and may include multiple Building Committees and a Building Evacuation Coordinator Advisory Council (See Table 5). The following subsections outline how case study universities have developed these teams, and the primary

Figure 1. Evacuation Team Organization

PREPAREDNESS	EVACUATION TEAM ROLES	RESPONSE
Orients students and visitors on emergency evacuation procedures.	Faculty & Staff	Helps direct occupants to the nearest exit and safe zone.
Helps develop and update building emergency plan.	Floor Evacuation Wardens	Tells occupants to evacuate and provides status report to Building Evacuation Coordinator.
Designates Floor Evacuation Wardens, coordinates education and planning for all building occupants, and helps coordinate drills.	Building Evacuation Coordinators	Tracks information from Floor Evacuation Wardens and reports building status to Safe Zone Assistant.
<i>No primary preparedness duties.</i>	Safe Zone Assistants	Organizes information per zone and relays reports to Safe Zone Captain.
Oversees designation of Floor Evacuation Wardens and helps designate Building Evacuation Coordinators.	Safe Zone Captain	Meets arriving personnel and provides status reports, relays information to the Emergency Operations Center, and coordinates activities with Field Incident Commander.

Table 5. Evacuation Planning Committees

Role	Members	Report to	Preparedness
Emergency Management Advisory Committee	<ul style="list-style-type: none"> ▪ University Directors 	University Administration (such as the President’s Small Executive Staff)	<ul style="list-style-type: none"> ▪ Develops emergency management policy and related programs
Building Evacuation Committee	<ul style="list-style-type: none"> ▪ All Floor Evacuation Wardens within a Building 	Building Coordinator (chair of committee)	<ul style="list-style-type: none"> ▪ Meets quarterly
Building Evacuation Coordinator Advisory Council	<ul style="list-style-type: none"> ▪ Max. 10 Building Coordinators ▪ <i>There should be representatives from diverse facility use and building types on campus</i> 	Emergency Management Advisory Committee	<ul style="list-style-type: none"> ▪ Advises Emergency Management personnel regarding changes in emergency procedures that affect the Building Coordinator’s role ▪ <i>May be a subcommittee or working group that reports to the Emergency Management Advisory Committee</i>

responsibilities during the preparedness and response phases for each position or committee.

Evacuation Team Development

Though at one case study university there is a 50-50 balance between faculty and staff involvement (Interview 3), other university Evacuation Teams are primarily made up of staff (Interview 6). Administrative staff members tend to be the most fitting for these positions because they are generally stationary and tend to know the most about the building and its occupants (Interviews 3 and 6). Evacuation Team position appointments might also be dependent on an individual's physical location in an office—i.e. the person sitting furthest away from the exit and is likely to be the last person out (Interview 6).

In some cases, especially in regards to committee, building, or safe zone leadership, appointments are made on a departmental basis (Interviews 2, 4, 5, 6, and 7). However it makes more sense for building-specific evacuation roles to be appointed on per building basis instead of a per department basis, since one department might be scattered throughout several campus locations (Interview 1).

University employees usually join an Evacuation Team on a voluntary basis (Interviews 1, 2, 3, 4, 5, 6, and 8), though it can be difficult to find an adequate number of volunteers, especially since evacuation programs do not necessarily receive an adequate level support and attention from university administration or the fire department (Interview 1). In some situations evacuation duties are attached to a staff position description where these responsibilities are already implied, such as in Residential Life or

Facility Services departments (Interviews 1, 3, and 5). However adding Evacuation Team responsibilities to a job description can become a complicated issue with union employees (Interview 2). While the Human Resources departments at some universities have granted permission to assign evacuation responsibilities to job descriptions, they have recommended that this not be pushed if employees do not wish to be involved (Interview 1). Experience has shown that Evacuation Team members are most effective when they willingly participate (Interview 3). Evacuation Team members are also expected to identify an alternate who can carry out the evacuation management function in the primary's absence (University of California Irvine; San José State University). If both members are present during an evacuation, the alternate may be expected to assist where needed.

A university's Emergency Management department usually oversees the Evacuation Team, conducts training, and provides planning assistance during the development of building-specific emergency plans (Interviews 1 and 3). Newly identified Evacuation Team members may be encouraged to attend an initial training team-taught by staff from the following university departments: Emergency Management, Police (or Public Safety), Environmental Health & Safety, and the Fire Marshal's Office (University of California, Berkeley EMA). Quarterly or semi-annual meetings may also provide an opportunity to review National Incident Management System (NIMS) and Incident Command System (ICS) concepts, emergency kit contents, triage methods, and evacuation procedures (Interview 3; University of California, Berkeley EMA).

Faculty and Staff

A successful evacuation requires adequate preparedness and often begins with university employees who have the greatest amount of daily interaction with other staff, students, and visitors. Some universities require that faculty orient their students with a brief overview of emergency evacuation procedures on the first day of class (University of Washington EEOP; California State University, Northridge). This briefing may include notifying students that evacuation is required when an alarm system is activated and locating the nearest exits (University of Washington EEOP). Faculty should also provide an opportunity outside of class to discuss evacuation plans individually with any students who may require special assistance (California State Polytechnic University, Pomona). Faculty may be expected to carry a class roster to aid in roll call at an evacuation safe zone (California State Polytechnic University, Pomona; University of Southern California; University of California, Los Angeles; Western Washington University).

Staff should also be familiar with evacuation procedures so that they can help inform visitors who may be unfamiliar with the building or campus layout (University of Washington EEOP). Cal State Northridge requires all employees to review posted emergency procedures and evacuation routes, upon initial receipt and on an annual basis (California State University, Northridge). Administrative staff may also be responsible for maintaining a department or office roster for safe zone roll call (Interviews 1, 3, and 5; Stanford University, University of California, Los Angeles).

Both faculty and staff are expected to participate in drills and training as required (University of Washington EEOP). In an emergency evacuation faculty and staff are expected to help direct building occupants to the nearest emergency exit and designated safe zone. Once at the safe zone, they may utilize their class or department rosters for roll call in order to help determine whether there are missing persons who might be trapped in the building and need to be rescued (Oregon State University).

Floor Evacuation Wardens

Floor Evacuation Wardens (a.k.a. “Floor Captains,” “Floor Monitors,” “Floor Wardens,” “Evacuation Wardens”) are primarily responsible for helping evacuate and collecting information on the status of a specific area of a building and its occupants. There is usually a minimum of one warden per floor or wing (Interviews 1, 3, 5, and 6), per lab (Interview 6), and per department (Interview 5). Depending on the size and layout of the building there may be two or more per floor or wing (Interviews 1 and 3). In general, the individual should be able to sweep their assigned area and evacuate within two minutes (Interview 1).

In the preparedness phase, Floor Evacuation Wardens may assist in the development and maintenance of a building emergency plan (University of California, Santa Cruz ERP). They might also compile a list of room numbers within their area to use as a check-off tool to verify that all rooms have been evacuated (University of California, Santa Cruz ERP).

During a response, Floor Evacuation Wardens may be an essential means of communicating the need to evacuate during emergencies such as a bomb threat or natural gas leak, where fire alarms may not be activated (San Diego State University). Oftentimes the warden is trained to sweep his or her assigned building area in a clockwise motion, notifying occupants that they must leave the building immediately (Interviews 1 and 3). This communication is most effective when the warden is also able to direct building occupants to the nearest emergency exit and evacuation safe zone (University of Southern California; University of California, Irvine). Since no Floor Evacuation Wardens are expected to put themselves in danger, they are often encouraged to go where they would expect people to be unaware or complacent, such as restrooms or supposedly vacant classrooms, instead of every room (Interview 1; Oregon State University).

Once at the safe zone, Floor Evacuation Wardens notify the Building Evacuation Coordinators of any problems including injuries, trapped or missing persons, and significant building damage (University of California, Irvine). Wardens may then assist with crowd control duties including conducting headcounts, disseminating emergency instructions or information, and helping ensure that evacuees do not re-enter the building until cleared to do so by emergency responders (University of Southern California).

Building Evacuation Coordinators

There is usually at least one Building Evacuation Coordinator (a.k.a. “Building Manager,” “Building Coordinator,” “Evacuation Director”) per campus building who is

responsible for acting as a liaison between Evacuation Teams and evacuees (Interviews 1, 3, and 6; University of California, Berkeley BCP). In the preparedness phase, Building Evacuation Coordinators are responsible for designating Floor Evacuation Wardens, identifying alternates (for themselves and the Wardens), and ensuring new wardens are appointed if someone no longer wants or is able to fulfill their duties (Interview 1; University of California, Irvine). Coordinators are also responsible for maintaining and annually submitting their building's emergency plan, providing evacuation education opportunities for building occupants, and helping coordinate evacuation drills (University of California, Berkeley BCP). In order to maintain consistent expectations and preparedness across the campus, university emergency management schedules training meetings for Building Evacuation Coordinators (University of California, Berkeley BCP). The Coordinators may also serve as building liaisons to other campus departments and units such as Environmental Health & Safety, Facilities Services, Public Safety, and Human Resources (University of California, Berkeley BCP). Part of this duty might include notification of routine services, interruptions, or construction affecting the building (University of California, Berkeley BCP).

During a response, Building Evacuation Coordinators are the primary contact point for their assigned building. Coordinators communicate with Floor Evacuation Wardens to determine building status, including injuries, trapped or missing persons, and significant building damage (University of California, Berkeley BCP; University of California, Irvine; University of Southern California). It is the Coordinator's responsibility to then communicate this information to the Safe Zone Assistant or

Evacuation Safe Zone Captain (Interview 3). If the evacuation is caused by a building-specific event, the Building Evacuation Coordinator may act as a liaison with Environmental Health & Safety and emergency responders (University of Washington).

Safe Zone Assistants

Each safe zone may have one or more Safe Zone Assistant (a.k.a. “Role Takers,” “Recorders,” “Sign Holders”) who is primarily responsible for providing organizational assistance during an emergency response (Interview 5). These assistants help compile and prioritize status reports on injuries, trapped or missing persons, and damage from the Building Coordinators, and then communicate response needs to the Safe Zone Captain (University of California, Santa Cruz). Safe Zone Assistants may also help coordinate evacuees into manageable groups (University of California, Santa Cruz).

Evacuation Zone Captains

There is one Evacuation Safe Zone Captain (a.k.a. “Zone Captain” or “Emergency Management Area Coordinator”) per evacuation safe zone (Interview 3). The Captain may be responsible for 1 to 12 buildings, and might be a Dean, Director, Department Chair, or an individual assigned by them (Interview 3; University of Southern California). In some cases this assignment roughly corresponds with schools on campus (Interview 6). In the preparedness phase, Evacuation Safe Zone Captains help oversee the appointments of Building Evacuation Coordinators and Floor Evacuation Wardens (University of California, Irvine).

During a response, Evacuation Zone Captains ensure that Evacuation Teams follow procedures such as conducting headcounts (University of Southern California). The Zone Captain receives status reports from the Safe Zone Assistant and provides arriving emergency personnel with information on the location of the emergency, the layout of the building, any problems that require assistance, and the location of personnel (University of Southern California). This information may also be communicated to responders in the Emergency Operations Center (EOC), especially if the incident requires planning for mass care and shelter or transportation away from campus (Interview 3; University of Southern California; University of California, Berkeley). Depending on the number and severity of injuries, the Zone Captain may help establish a process to deal with injuries (Interview 3). The Zone Captain may then relay information back to Building Coordinators including reports on the temporary suspension of programs, building closure, special alerts, and the location of shelter, first aid (if not provided within the safe zone), and transportation staging areas to leave campus (Interview 5; University of California, Irvine; University of Southern California).

Building Committees

The University of California, Berkeley, has developed preparedness Building Committees that may be chaired by the Building Evacuation Coordinator (University of California, Berkeley). This was done at the request of the Chancellor and was initially formed by senior academic or administrative managers in each building. Committee

membership includes representatives from all departments or units within the building, and individuals involved in evacuation management such as Floor Evacuation Wardens. Quarterly meetings of each committee provide an opportunity to review building emergency plans, voice concerns, and appoint primary or alternate Evacuation Team members including the Building Coordinator. The Building Coordinator may be appointed as the committee chair if they are within the largest department or unit of the building (determined per assigned square feet) or each department or unit may rotate the responsibility every two years. If the dominant unit stores or uses hazardous materials, the Building Coordinator should be knowledgeable in that area (University of California, Berkeley).

Building Evacuation Coordinator Advisory Councils

A Building Evacuation Coordinator Advisory Council may also be developed to advise the university's emergency manager regarding changes in emergency procedures that affect evacuation management roles (University of California, Berkeley). The council may advise a university emergency management advisory committee on policy, procedures, and programs related to evacuation (University of California, Irvine). This council includes no more than ten Building Evacuation Coordinators and represents a range of campus facility uses and building types (University of California, Berkeley).

Implementation

Once the planning process and management elements of an evacuation plan have been developed, these policies and procedures must be implemented for the university community. This requires educational outreach to teach people what to do and then evacuation drills to see if they have retained this knowledge. The success of these strategies then helps inform the review and revision of emergency evacuation plans.

Educational Outreach

The beginning of each school year and term or semester provides an important opportunity to educate students about evacuation procedures (California State University, Northridge; California State Polytechnic University, Pomona; University of California, Los Angeles). This may occur during freshman orientation and/or the first day of class. Building evacuation procedures are also often included as a section of emergency procedures flipcharts that are distributed to classrooms, labs, and offices campus-wide (Interview 3; University of California, Irvine). These flipcharts sometimes also have blanks for departments to fill in more specific building or floor information including phone numbers, occupants' names, and supply locations (Interview 3).

Building evacuation maps are another way to educate building occupants on where to evacuate too. Though building code requires the display of evacuation maps to help occupants locate their nearest exits, there are not policies requiring the inclusion of other emergency-related information such as fire alarm pull stations, fire extinguishers, first aid supplies, accessibility locations for mobility-impaired individuals, or evacuation

safe zones (Interview 1; San Francisco State University). Evacuation safe zones may be identified and named based on a common landmark (Interview 3), or marked by signs with a symbol of a blue triangle enclosed in a white circle to note evacuation safe zones on its campus (Stanford University). However since these references may be confusing to evacuees unfamiliar with the names of campus locations, a photograph of the safe zone meeting points may also be included on evacuation maps (Interview 8).

The development of these more specific maps often remains the responsibility of each building and is included in the building-specific emergency plan (Interview 5). In other cases Environmental Health and Safety personnel develop these diagrams (San Francisco State University). These diagrams are usually posted at the base of stairs, elevator landings, and inside public doors (Interview 5; University of California, Santa Cruz ERP Appendix C; San Diego State University).

Evacuation Drills

Though most universities recommend that evacuation drills be conducted on an annual basis, legal requirements are based on the type of primary building occupant (Stanford University). For instance, universities are required by law to conduct biannual evacuations of their residence halls (Interviews 5 and 6).

The Stanford University Fire Marshal Office recommends that all buildings conduct evacuation drills annually (Stanford University). However sometimes evacuation drills are not conducted as frequently as is recommended because there are limited staff and resources to set up, properly evaluate, and debrief a drill for each

building (Interview 5). Therefore the focus is often placed in those buildings with the highest risk, including residence halls, childcare facilities, and clinics (Interview 1; San Diego State University).

Emergency management staff, the Fire Marshal Office's staff, and/or Fire Protection Services staff attend evacuation drills to watch and critique the drill (Interviews 1 and 5; Stanford University). A standard form allows for consistent documentation and can help lead a debriefing discussion of what went well and what should be improved (Interview 1; Stanford University). Form elements may include the time it took for all building occupants to evacuate, whether evacuees successfully assembled at the designated safe zone, and whether building alarms functioned properly (Stanford University). Oftentimes a copy of the evaluation form is provided to the Building Evacuation Coordinator so they can address evacuation concerns with building occupants and within the building's emergency plan (Stanford University).

Notice of an upcoming drill usually states an approximate range of days or times when the evacuation may take place (San Diego State University). University policy usually dictates that all building occupants are required to treat alarms as real and cooperate with Evacuation Teams (San Diego State University).

Universities that have had the opportunity to utilize evacuation safe zones in a drill or actual emergency often cite the human behavior as the greatest challenge. Student populations may have attitudes of invincibility and lack experiential validation of emergency planning. As a result students hide, do not want to be bothered, or simply leave the area without checking in at a safe zone (Interview 3). At one university when

evacuation drills were announced ahead of time, only 25-30% of residence hall occupants were present to participate in the drill (Interview 6).

Depending on the number of campus buildings, some universities experience over a hundred false alarms annually (Interview 1). These unnecessary evacuations can be expensive, disruptive, and decrease the likelihood of evacuation when it is truly required (McEntire 2007). Some may then think that evacuation drills take too much time, but a well planned evacuation drill need not take more than 15 minutes (Interview 6).

Evacuation drills may help identify which exits building occupants favor; since people tend to exit the building the way they entered, even if that is not the fastest or safest way (Interview 1; Gwynne, et al. 1999). But for the most part, drills do not challenge evacuees to see if they really know what to do. To address this concern, universities could implement different scenarios during evacuation drills that say a stairway or door is not available (Interview 1). This might cause a significant increase in evacuation time during the drill but would ultimately raise awareness of the importance of becoming familiar with alternate routes. Future drills could also be improved by encouraging building occupants to consider what they should do to assist individuals with mobility impairments (Interview 1).

Since people are likely to do what they are most familiar with, drills can be important first steps in educating building occupants on what to do in an evacuation circumstance (Interview 3). Drills can also help identify hazards, barriers, or challenges that then lead to more productive revisions of emergency plans and the location of safe zones (Interview 6). During these drills, safe zones have been especially successful in

facilitating good communication. This allows for status reports to be compiled quickly so that the university can capture a thumbnail of what is going on—and then provide briefings to university administration and the media (Interviews 3 and 6).

Review and Revision

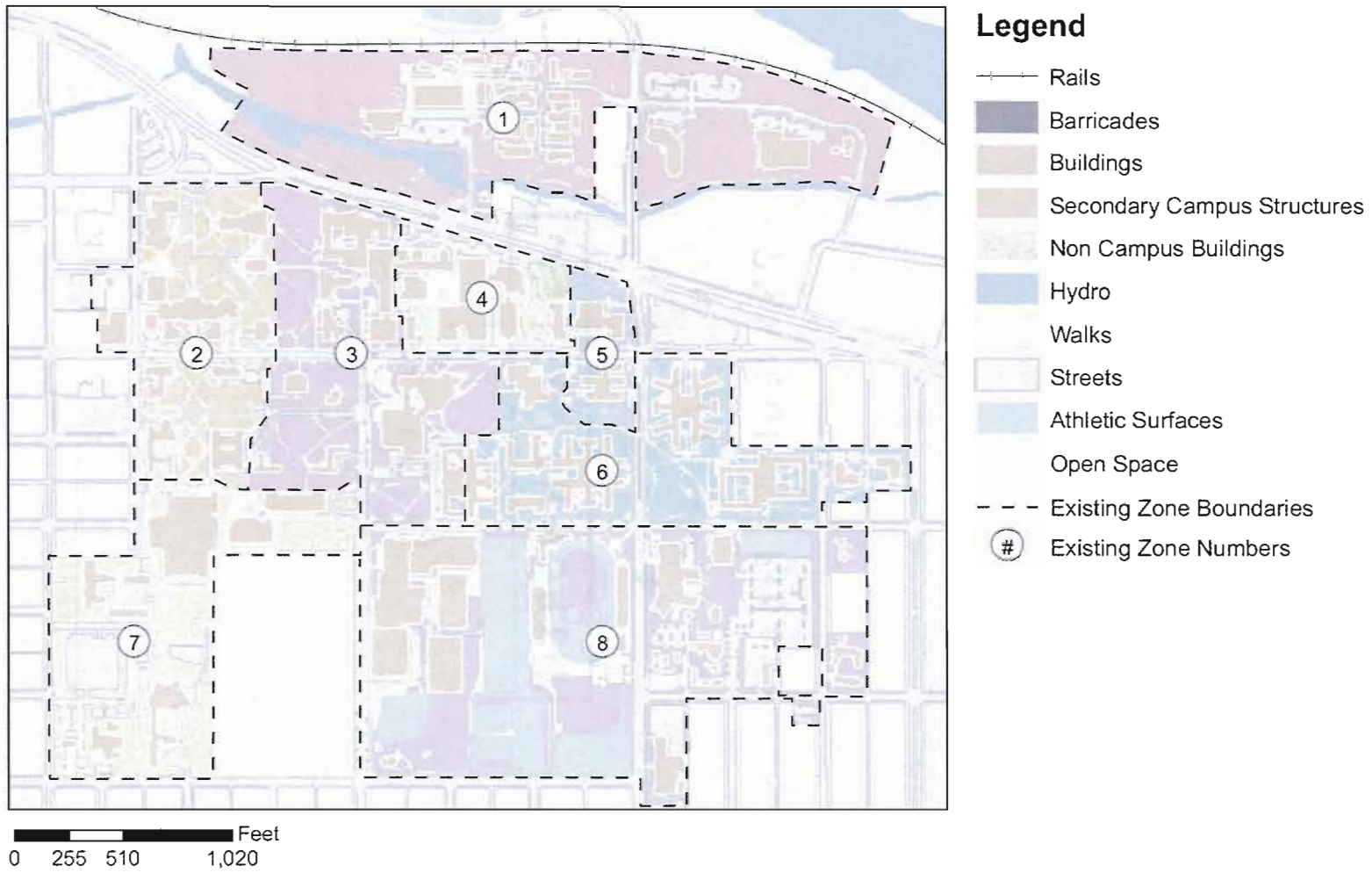
Evacuation safe zones are constantly under review and revision, though there is not necessarily a formal review schedule or process (Interviews 1 and 3). The impact of new construction often leads to a review of potentially affected safe zones (Interviews 1 and 6). It is expected that a building's Evacuation Team or other occupants will identify hazards and voice these concerns to the appropriate staff. Other universities have adopted an annual review process of evacuation safe zones that occurs in conjunction with an emergency planning meeting (Interview 6).

Geographic Information Systems (GIS) Analysis

The results of the case study research then helped inform how safe zones at the University of Oregon main campus could be optimized for a potential major earthquake. To do this, Geographic Information Systems (GIS) ArcMap software was used to map existing safe zones, account for potential hazards and resources, revise safe zone boundaries, and analyze the potential density of evacuees per safe zone.

First, the University of Oregon's eight main campus "Emergency Management Area Zones" were mapped (See Map 1). At the beginning of the analysis, there was 7,836,720 square feet of open space within the official boundary of the University of

Map 1. Existing University of Oregon Emergency Management Area Zones

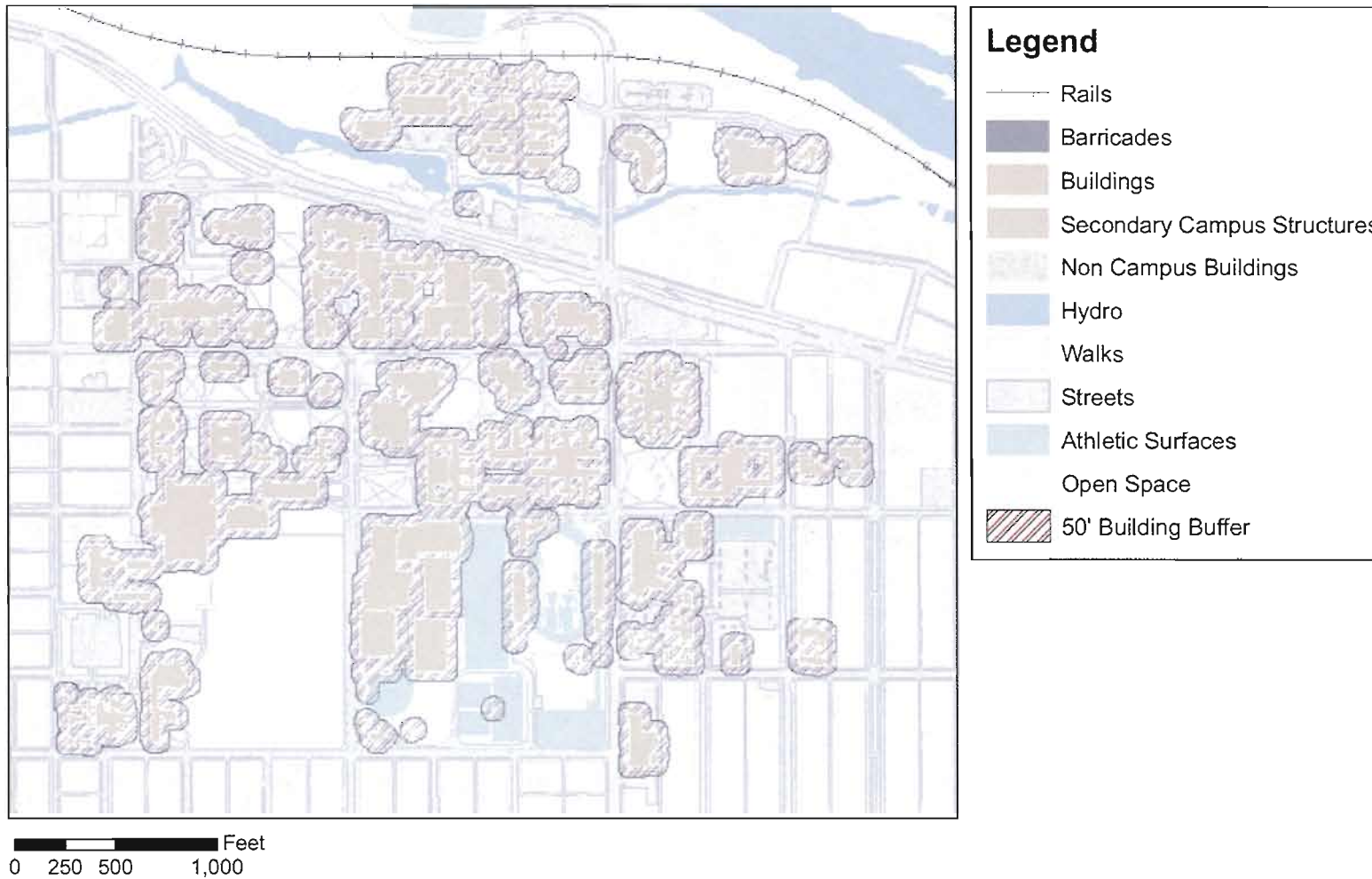


Oregon main campus. Once buffers were drawn to represent how far evacuees should stand away from potential hazards or responder resources, GIS was used to measure the differences these buffers made in the amount of available open space areas for evacuation safe zones (see Table 6). A quarter of campus open space was lost when a 50' buffer was applied around each campus building (See Map 2). When 15' buffers were drawn around fire hydrants nearly 1% of open space was lost (See Map 3). Utility access points and tunnels caused a loss of nearly 4% of campus open space when a 15' buffer was applied (See Map 4). When the buffers of all three categories were accounted for at the same time, only 5,634,060.73 square feet of open space available for evacuation safe zones remained (See Map 5).

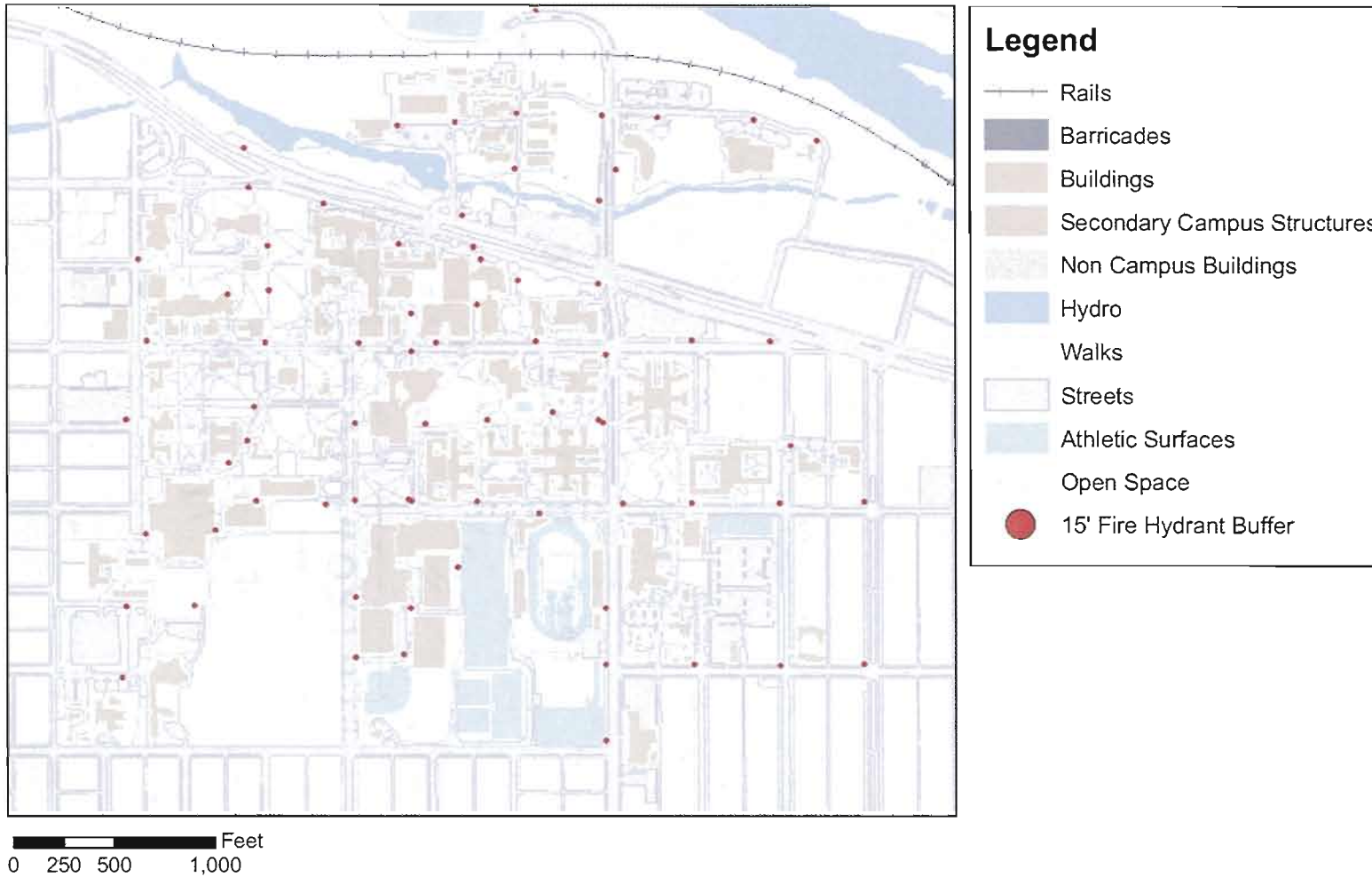
Table 6. Loss of Open Space due to Potential Building Debris, Fire Hydrants, and Utility Access

Elements	Loss of Open Space		Remaining Available Open Space (sq ft)
	Square Feet	Percentage	
Building Debris (50' buffer around each building)	2,081,297.14	26.56%	5,755,422.46
Fire Hydrants (15' buffer around each hydrant)	73,994.03	0.94%	7,762,725.37
Utility Access (15' buffer around each utility access point)	295,693.09	3.77%	7,541,026.51
TOTAL (All three elements' buffers accounted for at once)		28.11%	5,634,060.73

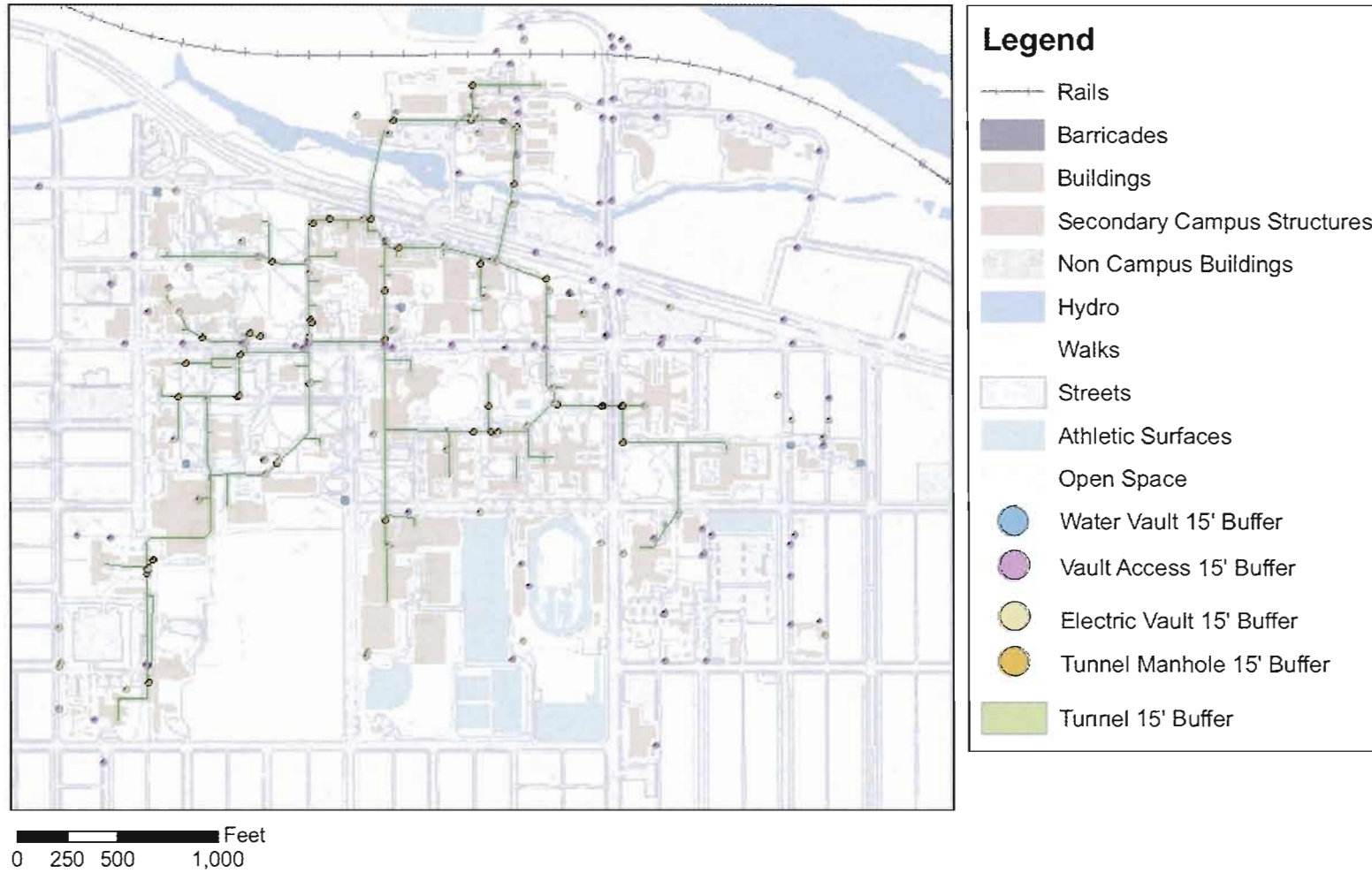
Map 2. University of Oregon Building Buffers



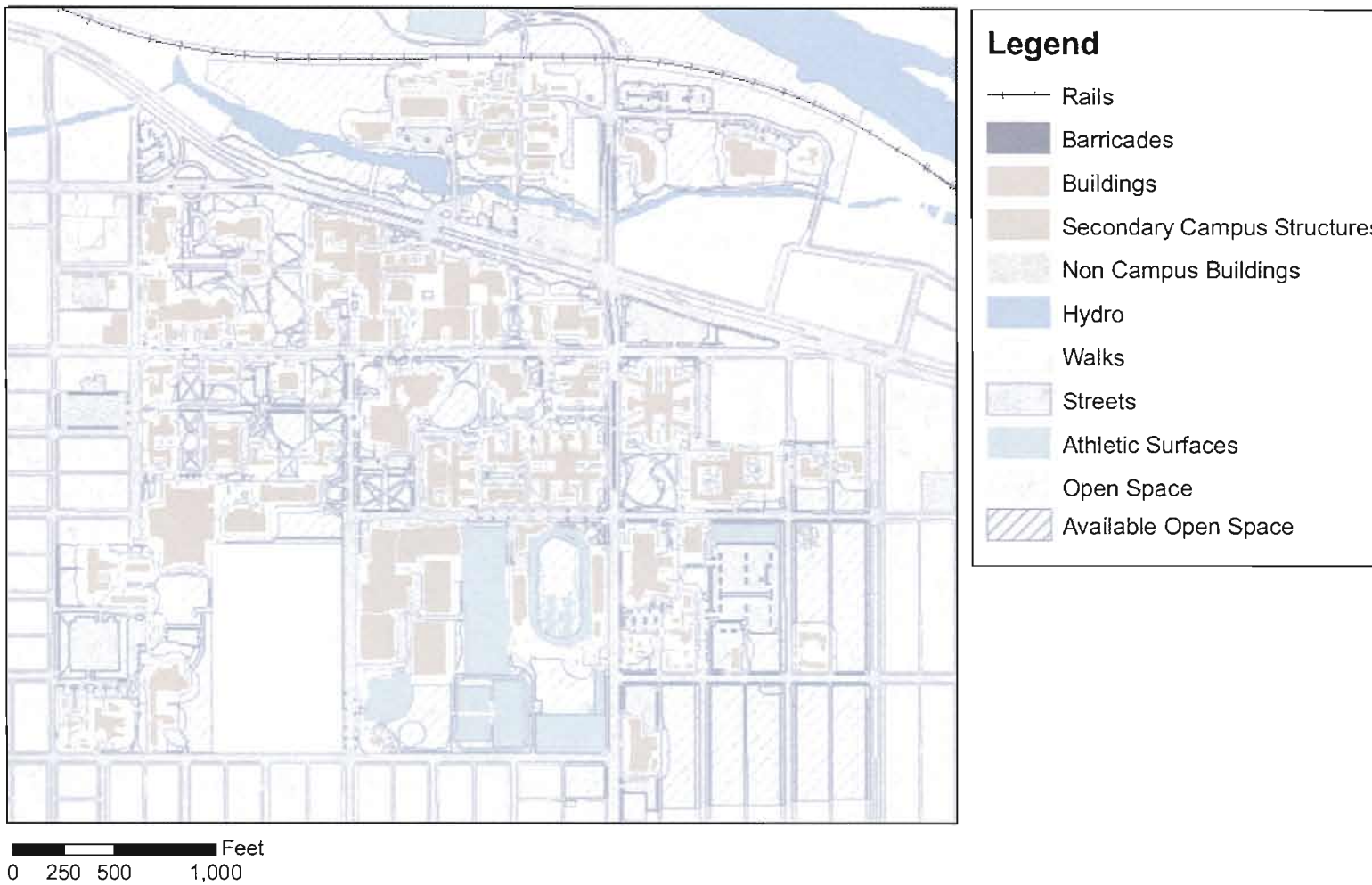
Map 3. University of Oregon Fire Hydrants and Buffers



Map 4. University of Oregon Utility Access Points and Buffers



Map 5. University of Oregon Available Campus Open Spaces



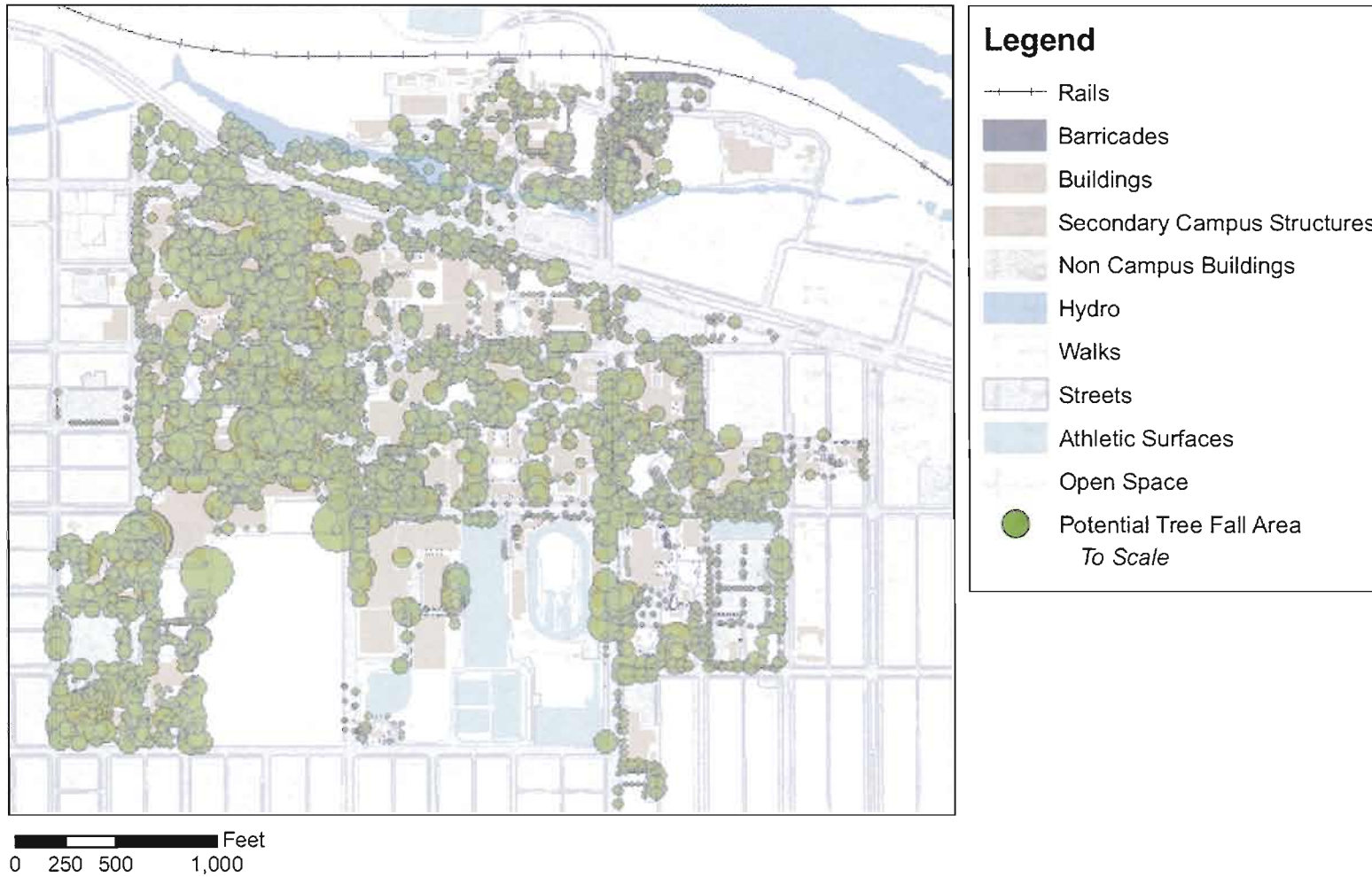
Other potential hazards and resources that could not be accounted for with a buffer were only visually accounted for. These elements included buildings with hazardous material storage areas and the potential fall radius of campus trees (See Map 6).

The eight existing zones were then revised into 15 zones, based on these potential hazards and resources (See Map 7). These zones grouped similar clusters of buildings but often divided existing zones that were split by a main road. The total area of available open space per zone ranged from 26,293 to 742,372 square feet. The average area of available open space per zone was 171,644 square feet.

Then the potential number of evacuees per safe zone was estimated using classroom occupancy data provided by the University Registrar's Office (See Table 7). The Northwest Campus Quad Area (Zone 3) had the greatest number of potential evacuees per safe zone (5,260) and the greatest density (16 square feet per person). This far exceeds earlier research's suggestion that evacuees should have at least an 18" circumference around them (or 26 square inches). The least dense evacuation safe zone had over 480 square feet per evacuee (Zone 13).

In comparing the existing University of Oregon Emergency Management Area zones to the revised safe zones, the greatest difference was that the existing zones were often broken up into smaller zones. However the greatest contribution of this additional analysis was the illustrations of potential hazards and resources. The created buffers around these features resulted in clear delineations of which open spaces are the safest areas for evacuees to congregate and which areas may not be large enough.

Map 6. University of Oregon Potential Tree Fall Areas



Map 7. Revised University of Oregon Safe Zones

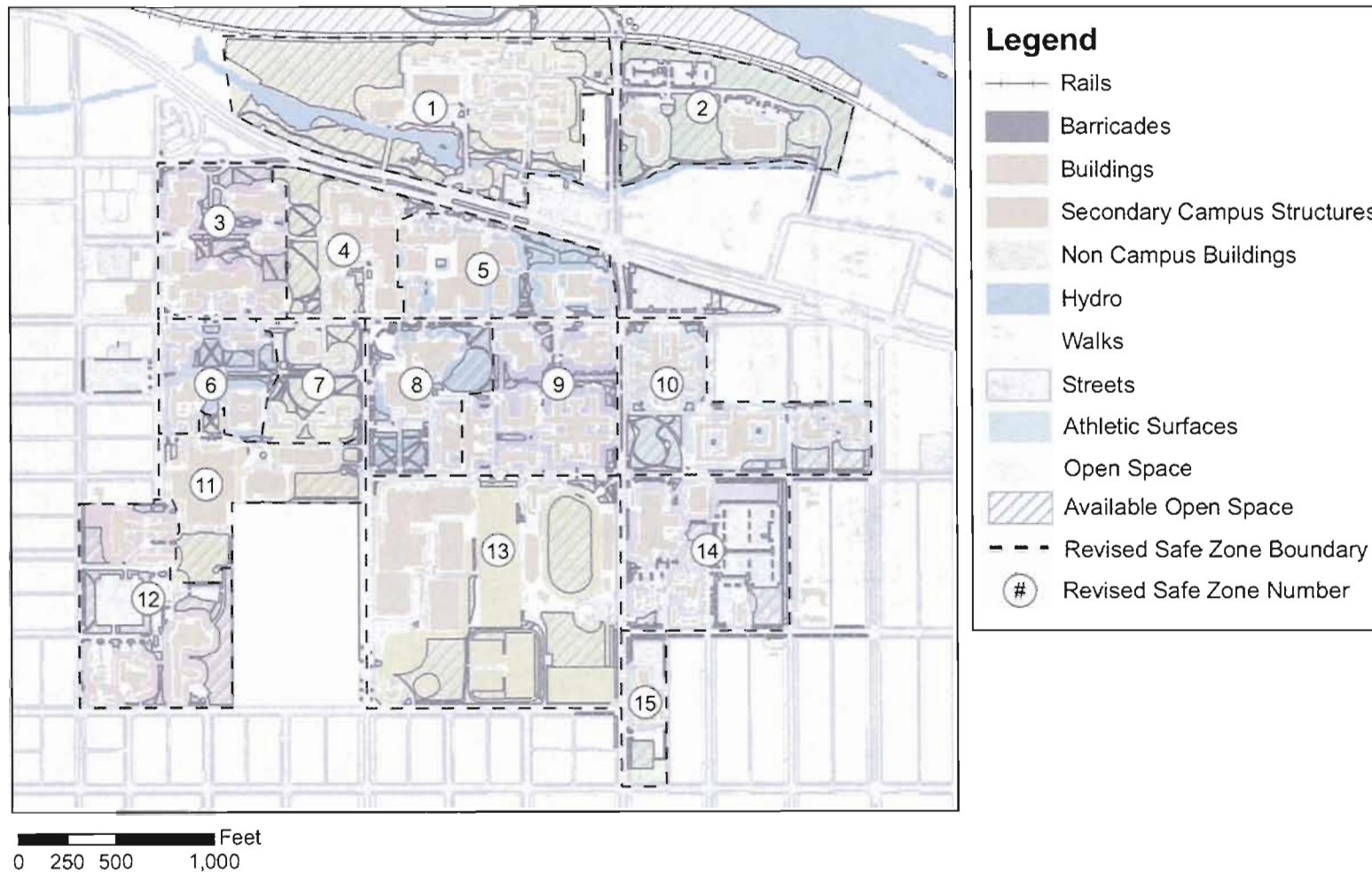


Table 7. Potential Number of Evacuees per Revised University of Oregon Safe Zones

Safe Zone		Buildings	Total Safe Zone Area (sq ft)	Estimated Potential Occupants / Safe Zone	Safe Zone (sq ft) / Evacuee
#	Name				
1	Millrace	Central Power Station, Facilities Services, Wilkinson House, Zebrafish International Resource, Millrace Studios, Fine Arts Studios, Woodshop	742371.91	<i>NO DATA</i>	-----
2	Riverfront	Riverfront Research Park, Riverfront Innovation Center	414738.67	<i>NO DATA</i>	-----
3	Northwest Campus Quad Area	McKenzie, Computing, Chiles, Lillis Business Complex, Peterson, Gilbert, Villard, Deady, Fenton	84915.36	5260	16.14
4	North Central Campus Area	Lawrence, Allen, Friendly, Pacific, Columbia	115804.03	4434	26.12
5	Science and Student Area	Cascade, Cascade Annex, Onyx Bridge, Volcanology, Klamath, Willamette, Streisinger, Huestis, Deschutes, Lokey Laboratories, Oregon	61485.25	3098	19.85
6	Midwest Campus Quad Area	Condon, Prince Lucien Campbell, Chapman, Schnitzer Museum of Art,	60409.63	2223	27.18
7	Central Campus Area	Johnson, Collier House, Susan Campbell, Hendricks	84783.48	428	198.09
8	EMU Area	Erb Memorial Union (EMU), Straub	110280.15	1215	90.77

(Table 7. Continued)

Safe Zone		Buildings	Total Safe Zone Area (sq ft)	Estimated Potential Occupants / Safe Zone	Safe Zone (sq ft) / Evacuee
#	Name				
9	East Residence Hall Area	Earl, Living-Learning Center North & South, Carson, University Health and Counseling, Walton	40173.31	1511	26.59
10	West Residence Hall Area	Hamilton, Bean, East Campus Graduate Village	128937.36	792	162.80
11	Library and Gerlinger	Gerlinger, Gerlinger Annex, Knight Library	121119.14	2544	47.61
12	Southwest Campus Area	Education, Education Annex, Beall Concert, Frohnmayer Music, Clinical Services, ECS	176755.09	2415	73.19
13	Athletic Fields	McArthur Court, Esslinger, Student Recreation Center, Covered Tennis Courts, Student Tennis Courts, Howe Field, Outdoor Program Barn, Outdoor Tennis Courts, Artificial Tennis Courts, Hayward Field, Bowerman Family	304757.40	633	481.45
14	Southeast Campus Area	Knight, Museum of Natural and Cultural History, Many Nations Longhouse, Olum, HEP, LERC & Military Science	101832.76	1093	93.17
15	Agate	Agate and Agate House	26292.57	166	158.39

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

An emergency situation could potentially require hundreds or even thousands of students, faculty, staff, and visitors to evacuate one or more university buildings. Since many different types and sizes of emergencies could warrant an evacuation, the purpose of this research was to explore universities' dynamic evacuation planning processes that include guiding policies, dedicated management, and diverse educational outreach. This chapter concludes with a discussion of key research and methodological findings, and suggestions for future research.

Discussion

Though the results of each main topic have already been noted in Chapter IV, the following subsections discuss key findings in regards to policy, participation, practice, and GIS analysis.

Policy

The case study research showed that most universities did not have formalized processes for identifying or prioritizing potential safe zone hazards. There was also little authority or backing to ensure that there were enough Evacuation Team participants to

cover preparedness and response management duties. Most universities had only consistently implemented evacuation drills required by law. Though interviewees understood the importance of drills, they had not been able to conduct drills with recommended or desired frequency because of a lack of necessary resources (i.e. trained staff, time, money). Formalized review and revision schedules were also rare among case study universities. A review schedule would provide opportunities to refresh an Evacuation Team's understanding of their duties and to raise evacuation planning concerns related to the building, its occupants, and the surrounding open spaces.

These findings indicate that program elements are properly addressed most often when they are required by policy. When there are not state or OSHA standards to dictate the extent of certain planning activities, it becomes the university's responsibility to develop policies for their building occupants' and evacuees' safety. Since these requirements could be nearly impossible to fulfill given the numbers of trained staff, it is also the university's responsibility to ensure that the departments they entrust with emergency planning are given adequate resources to do their jobs. The additional funds required may be difficult to find, but universities must recognize that such expenses are an investment in the success of their campus community.

Management

There are also some essential elements of an evacuation program that face greater challenges than limited funding. This research showed that it could be difficult for universities to recruit enough volunteers for Evacuation Team positions. The literature

noted that these leaders could be essential means of informing others of what to do. Both the case study research and literature review also showed that it is essential that evacuation leaders be involved because they want to be—not because they are required to as part of their job description.

In recruiting for these positions, universities should consider and emphasize the reasons why certain employees are best suited for Evacuation Team roles. For instance, the research showed that ideal candidates are staff members who are generally stationary and most familiar with the building and its occupants. On the other hand, faculty are the most fitting people to communicate procedures and directions to students. Other positions, from the Floor Evacuation Wardens to the Evacuation Safe Zone Captains, provide an organized chain of communication. This way information about response needs can be appropriately organized and prioritized in the field and then communicated to responders or the Emergency Operations Center. These statuses would otherwise be entirely left to responders, in which case much of their time might be wasted looking for the problems instead of simply responding to them.

When all of the different levels of positions can be filled, each role has a manageable span of control that does not exceed reasonable expectations of any volunteer. Therefore the expected duties may not seem as overwhelming to potential volunteers because they will realize they are just one part of a far greater system that will support them instead leaving them totally on their own. Opportunities to build this essential trust among Evacuation Teams must extend beyond appreciation lunches but need not require a major disaster either. Evacuation Team locations and safe zones can

be used for other campus events during the year to familiarize people with the available open space and develop working relationships. For instance, there are biannual University Days at the University of Oregon when the campus community is invited to volunteer to help beautify the campus. Instead of randomly assigning volunteers to different areas of the campus, volunteers could spread mulch and plant flowers within their safe zone. This would provide an opportunity for staff from neighboring buildings to interact as well as become more familiar with their safe zone environment.

Practice

Some case studies noted that one of the main challenges of evacuating to safe zones was human nature. However part of human nature is being a creature of habit. Regardless of the airline, everyone who flies in an airplane is given the same overview of safety procedures at the beginning of a flight. This is so consistent and expected that most frequent fliers could likely recite the safety presentation about locating the nearest exit and putting an oxygen mask on themselves before helping others. Elementary school students across the nation are also reminded of safety procedures and participate in safety drills including ones to practice evacuation. When directed by a fire alarm, teacher, or a loudspeaker message, all children are taught to immediately stop what they are doing and exit the classroom and building in an orderly fashion. In both of these cases, the same procedures are presented by leaders, reinforced with visuals such as maps or diagrams, and practiced on a routine basis. Why aren't these safety demonstrations and exercises also a routine part of life in university communities?

Outreach opportunities need to become routine so that any university occupant is aware of what to do in an emergency, whether they are a tenured faculty or visitor. Once emergency evacuation policies, plans, and procedures have been developed, related posters, flipcharts, web pages, and handouts in freshman orientation packets can effectively educate thousands of people with relatively little demand of personnel, time, or money. For instance, evacuation zones could be incorporated into an interactive online campus map. This way when visitors or students are looking to see where a room is located they will also see where they would evacuate to from that room. Evacuation drills can even further accustom campus populations on what to do and provide the opportunity to explain the reasoning behind instructions. These exercises are essential for helping highlight the areas of potential improvements to plans and procedures.

Use of GIS

Geographic Information Systems (GIS) technology is a valuable tool for developing, analyzing, and creating maps of safe zones. The software's capability to easily display several layers of information at once is ideal for accounting for potential resources and hazards. Though institutional knowledge or printed maps can be referred to for the locations of potential resources or hazards, GIS's buffer tool can be used to illustrate the distance evacuees should stay away from them. These buffers are useful individually, but optimal when all are accounted for at once to identify the truly safe(st) zones. Building occupancy information can then be compared to the spatial

measurements of these zones to determine if there is likely to be enough space to accommodate all evacuees.

Once these issues are accounted for and revised as needed, GIS easily produces new safe zone maps. These maps can improve Evacuation Team planning and training by providing a way to document institutional knowledge and allowing participants to be forewarned of potential hazards and resources in their areas of campus. Maps also make emergency evacuation plans and procedures more accessible to building occupants who might otherwise be unsure of where to go because they are unfamiliar with the campus locations or do not speak English.

Methodological Findings

Phone interviews were the most helpful in revealing the processes and decisions behind university evacuation plans. Though Internet research was helpful in certain contexts, evacuation information was sparse on many web pages. When these universities could not be contacted for a follow-up phone call, it was difficult to determine whether this lack of information was because evacuation plans did not yet exist or were just not publically available. Also even though the same script guided all of the phone interviews, the variations in responses or resulting discussions sometimes made it difficult to compare one issue equally across all case study universities.

Mapping techniques were beneficial to account for potential hazards and resources, as well as to revise existing emergency evacuation safe zones. It was advantageous to have access to existing campus GIS files that have taken years for the

University of Oregon's InfoGraphics Lab to develop. Significant time and expertise would be required to transfer existing facilities maps into GIS files, and map additional campus features such as trees. The greatest limitation of using the existing GIS files was that some did not contain metadata to explain the methodology used to create the file. Some attributes also had missing data, so that not all building occupancies could be accounted for. Also not all existing files had yet been updated to reflect new construction.

Recommendations for Future Research

As the academic field of emergency management research continues to grow, there are several additional aspects of university evacuation safe zones to explore including expanding the list of case study universities, evaluating the success rates of evacuation drills, considering the community's use of campus open space, developing additional GIS files for consideration, and incorporating participatory GIS into the review and revision process.

Expanding List of Case Study Universities

West coast universities were chosen for case studies because of their similarities to the University of Oregon and shared vulnerabilities of a potential earthquake. This pool of case study universities could be expanded to include universities with leading emergency management programs across the country, to not only strengthen findings but also reveal additional planning considerations for other types of hazards.

Evaluating the Success Rates of Evacuation Drills

The success of university evacuation plans could also be more accurately analyzed by compiling the results of several different evacuation drills. Elements to study might include the types of buildings, types and numbers of occupants, timing, and successes and failures.

Considering Community Use of Campus Open Space

Evacuation planning is likely to become more challenging, as more available open space is lost to new construction not only within university boundaries but also in its surrounding community. Oftentimes neighboring residents, businesses, and even schools expect to be able to also utilize a university's open space during an emergency. Clearly this further complicates planning efforts because universities then need to develop strategies to estimate and organize these populations in addition to their students and staff. General planning provides opportunities for the university and surrounding community to build off of each other's best attributes.

For instance, future research could compare the application of planning code principles to university campus construction, in regards to emergency management. For instance, many city planning codes require a certain number of parking spaces per square feet of a building. Are there similar requirements in regards to open space available for evacuation per a building's maximum occupancy? If not, could such a standard be developed and realistically enforced for new construction?

Universities must also recall their mission to not only create but also transfer knowledge to their communities. With such a great availability of information and opportunities for collaboration, universities hold an advantageous position to develop and explore the latest strategies and techniques for nearly any area of study including emergency planning and GIS. By its very nature, it is a university's responsibility to set an example for communities. If a university is not able to push the importance of evacuation planning, who will? There is great potential for universities to develop service-learning programs that can facilitate community enrichment through its application of young minds and new technologies.

Developing Additional Campus GIS Files

The GIS analysis could also be expanded upon to include more potential hazards or resources. The origin of evacuees could be more accurately assessed if a new GIS file mapped all exit doors and noted their degree of accessibility for mobility-impaired individuals. New GIS files could also be created to account for the spatial distribution of indoor environments. This could illustrate not only additional emergency elements, such as fire extinguishers or fire alarm pull stations, but also the areas of responsibility for each Floor Evacuation Warden.

However universities should also realize that the benefits of campus GIS extend far beyond emergency management. Though the initial development of GIS has focused its scope on geographical and infrastructural elements, future use is quickly expanding to illustrate numerous other types of spatial concerns. This research began with accounting

for fixed elements including buildings, utility access points, and trees. However this also revealed that there are countless possibilities for using GIS to account for human beings in space. This research only briefly touched on this potential by accounting for how much space would be needed per the expected number of evacuees per zone. Other options for future application of GIS in evacuation planning could include accounting for spaces for other activities such as medical triage posts within the zones or the routes of individuals from an office or classroom to their designated safe zone.

Incorporating the Use of Participatory GIS

Remembering that it is often the planning process, not the resulting document, that is the most important, universities could involve their communities in GIS data collection and maintenance. At first mention this could be an overwhelming prospect to those who have seen the plethora of available tools in GIS but are unfamiliar with how to use the program. Luckily despite the potential complexity of the program there are also simpler options such as those provided by the ESRI GIS program ArcPad. With this program, an automated questionnaire can be developed to guide the evaluation of characteristics of any location on a base map.

First a University's Emergency Management staff or perhaps a working group of an Emergency Management Advisory Committee would develop a list of evacuation-related evaluation criteria for indoor, outdoor, or both environments. Then one person (not necessarily a GIS expert) would enter these questions into an automated questionnaire using the program ArcPad. This questionnaire would look similar to online

surveys, with multiple choice, drop down menu, check box, and even fill in the blank answer options. This survey might ask: “Are stairs required to exit the building?” or “Are there utility lines overhead?” Up to this point in the process, all work would be done on a desktop computer.

However what makes this an ideal participatory option is the ability to then transfer this questionnaire onto a handheld Pocket PC device. This allows any user to evaluate a space as they physically explore their environment. Thanks to the simplicity of the questionnaire, a variety of university community members with differing needs and perspectives (who might not otherwise be involved in emergency planning) could then participate in the data collection. These populations could include Evacuation Team members, university safety personnel, students, internationals, and mobility-impaired individuals. Each time an individual was ready to evaluate an environment they would simply use the Pocket PC’s stylus to tap on their location on the base map. This way the information they enter into the program would be tied to that point on the map. Once a point was selected, the questionnaire would appear and the participant could then answer the questionnaire.

Then there would be two potential next steps. The first option would be that when participants were finished, this newly collected information on the Pocket PC would be uploaded to a desktop computer. It could then be analyzed and/or symbolized using the ArcMap program. Once many locations across a campus were evaluated, universities would greater and well-informed picture of where to direct mitigation efforts or revise emergency operations plans or safe zones. This could also be a helpful strategy

to update the GIS information. The second potential next step would be to do nothing at all with the collected information. This is because one of the greatest benefits of this process is directing someone to explore their environment with evacuation-related prompts in mind. The resulting familiarity and concerns that arise could lead to extremely valuable input for emergency planning or even just improved personal safety should an emergency occur.

It is almost certain that university evacuation planning and GIS technology will only continue to become more complex. Universities will have more types and sizes of hazards to consider, as GIS technology will have more features and capabilities. Collaboration between the two fields will help universities account for and even overcome emergency planning challenges, and optimize evacuation to safe zones.

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