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LANDSLIDE LOSS ESTIMATION

PILOT PROJECT IN OREGON

By

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Oregon Department of Geology and Mineral Industries

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NOTICE

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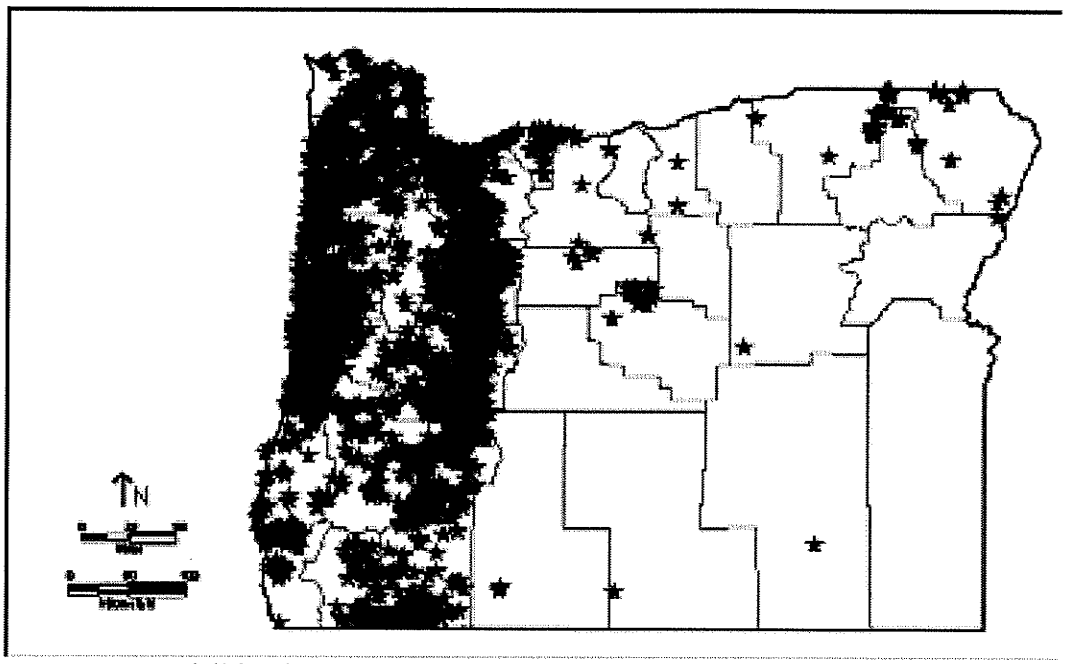

Landslides from the 1996 and 1997 storms (Hofmeister, 2000)

Executive Summary

In Oregon, economic losses due to landslides for a typical year are estimated to be over $10 million. In years with heavy storms, such as 1996, losses can be an order of magnitude higher and exceed $100 million. Oregon is one of seven pilot states funded by the U.S. Geological Survey to estimate losses. The study results are intended to illustrate the need to shift USGS current priorities to include mitigating landslide risks. Assuming ongoing population increases and current land use and construction practices, losses are expected to increase. High losses are expected in the areas of additional development on vulnerable hillslopes, stream banks, ocean bluffs and other coastal areas.

Introduction

The Department of Geology and Mineral Industries (DOGAMI) has conducted a limited survey to estimate losses incurred by landslide damage and obtain information on various landslide-tracking approaches. A large number of organizations, from both the public and private sectors, were contacted in an attempt to cover the scope of entities affected by landslides. The project goal was to allow the U.S. Geological Survey (USGS) and Oregon to better understand the magnitude and overall landslide effects in Oregon and to quantify estimated losses. The broader goal was to highlight the need for additional USGS and state surveys' landslide efforts in order to reduce the risk to the public.

This report describes the surveys that were conducted, presents the summary of losses, and provides some initial recommendations. The history of landslides, landslide mechanisms and hazards, landslide hazard mapping, landslide risk and landslide hazard mitigation were not addressed and are considered to be outside the scope of this study.

Findings to Date

From limited research, it is estimated that Oregonians spend over $10 million per year on landslide losses. During high rainfall years, however, repairs can be an order of magnitude higher. For one heavy storm in early 1996, for example, the total cost is estimated to be about $100 million. For a moderate storm year in 1999, losses are estimated to be intermediate at approximately $20 million.

The direct damage costs reported herein are substantial, yet the actual costs are even higher. In this limited study, we did not have the ability to capture comprehensive data, nor did we collect information on potentially significant indirect costs. For example, following the February 1996 storm, additional heavy storms were experienced later in 1996 and again in early 1997. Costs from those storms are assumed to be significant but have not been included in this study. In addition, 34 of the 36 counties were not directly contacted and their losses were not included. Because of this limited scope, these estimates developed for this study should be construed as minimum values of losses.

Most of the entities interviewed in this study do not closely track financial losses from landslides except in declared disaster events. The agencies that track landslide problems often do not closely track repair costs. Consequently, more research and a detailed survey are needed to better assess the real value of landslide losses.

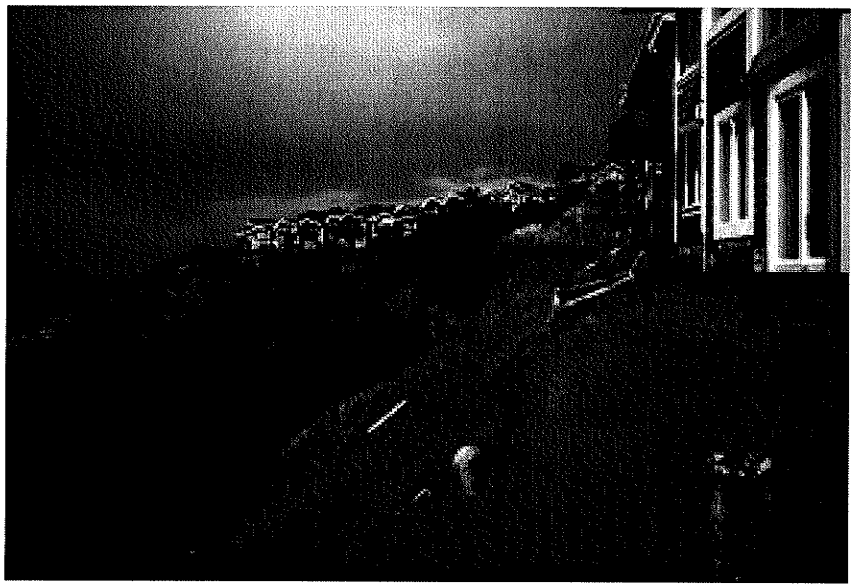

Figure 1. The Capes private housing community experienced landslide and coastal erosion damage associated with the 1997-8 El Nino event. Residents were evacuated and short-term mitigation was implemented. Long-term mitigation options, which need to accommodate coastal building regulations, are still being evaluated. Photo: Paul Komar

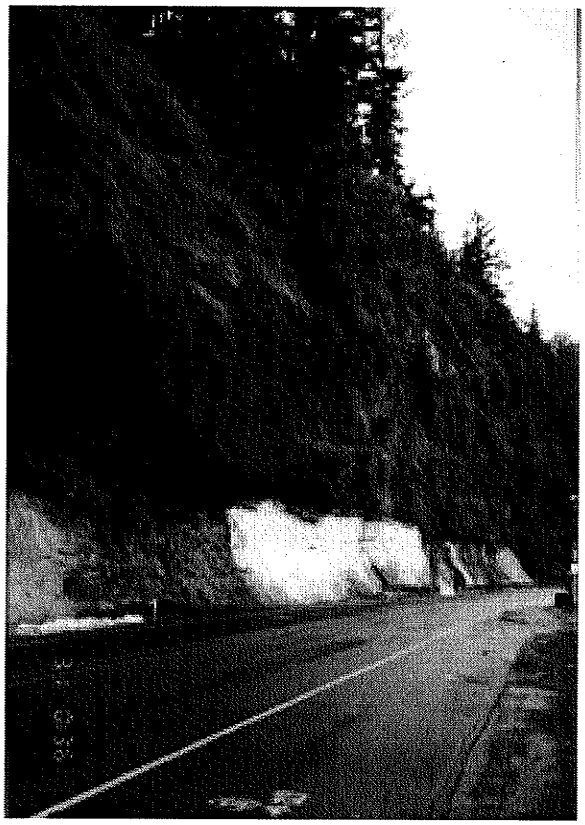

Figure 2. Various landslide control measures have been applied throughout the state. This photo shows the netting and shotcrete layer with drains on a road accessing the Columbia River Historic Highway, which experiences heavy traffic by tourists.

Background

Each year, many damaging landslides are triggered due to Oregon's geologic, topographic, climatic conditions and construction practices. Steep slopes and high rainfall lead to many slope failures in Oregon with a high concentration in western Oregon's coast, Coast Range, Willamette Valley and Cascade Range. In a typical year, Oregon receives over 80 inches of rain in places along the coast, 40 to 45 inches in the Willamette valley and about 60 inches in the Cascades. See Figures 1 and 2.

Rainfall patterns vary each year and storm events can concentrate rainfall levels and cause serious landslide damage. During early 1996, the Portland metropolitan area received 8 inches in four days (Burns, 1998). Rainfall patterns in 1996, 1997 and 1999 significantly concentrated rains and also resulted with higher than average rainfalls than typically experienced in Oregon. See Figures 3 and 4, which show rainfall variability.

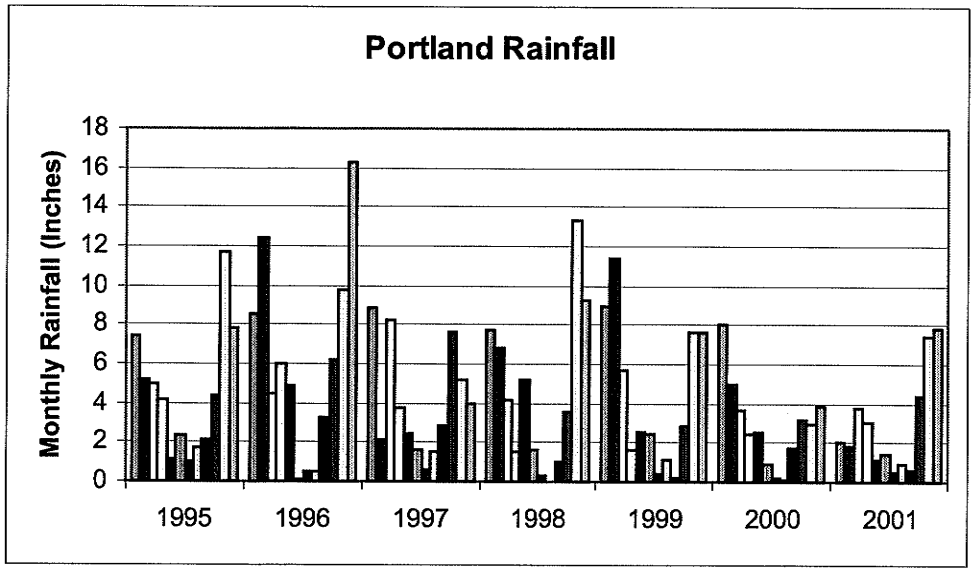

Figure 3. Seven years of monthly rainfall data in Portland, Oregon. This graph shows the variability in rainfall pattern, which directly affects landslide occurrences.

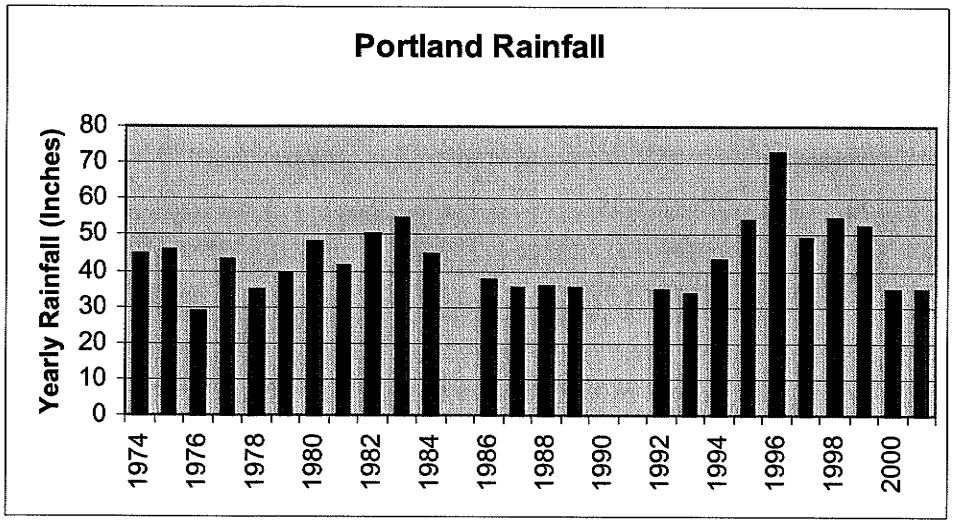

Figure 4. Rainfall data from 1974 to 2001 in Portland, Oregon. This graph shows that rainfall varies from <30 to >70 inches/year.

Poor construction practices, inadequate geotechnical investigations and development oversight can cause slope failures. For example, slope failures can result from the disturbance of old landslide sites, over-loading unstable slopes, detrimental changes the site hydrology, and more. In Oregon, many landslides have been reactivated by increased driving forces from construction activities or by removal of the toe of slides resulting in a decrease of resisting forces. In addition, poor storm water control and improper drainage have caused slope instability.

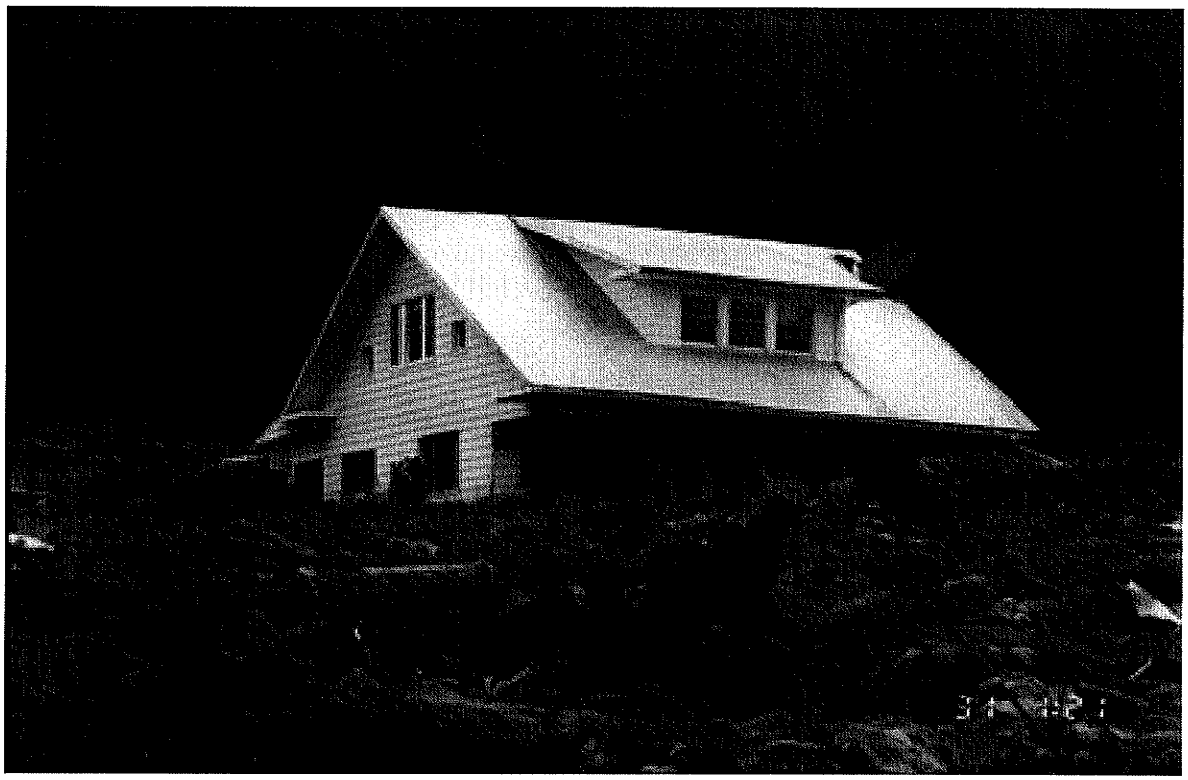

Figure 5. A debris flow destroyed this 2-story residence in Dodson, Oregon in the February 1996 FEMA-OR-1099-OR disaster.

Following seven fatalities and high landslide losses in severe storms in 1996 and 1997, DOGAMI has implemented a debris-flow hazard mapping program in western Oregon. See Figures 5 and 6, showing damaged residences. Digital maps were released in 2002, which will help identify the hazard zones that will be used by local communities to screen new development and mandate site-specific studies in high risk, life-threatening areas (Hofmeister and others, 2002). Although these efforts help increase life safety, the public and private sectors are still at risk from significant landslide losses. Oregonians are subject to life safety concerns as well as significant property losses due to landslides, including many types of landslides not included in the debris-flow mapping effort.

Using socioeconomic loss data, DOGAMI is contributing to federal policy development to increase resources for landslide identification, hazard mapping, sustainable practices and mitigation efforts to reduce overall landslide risks.

Figure 6. A debris flow destroyed this residence in Scottsburg, Oregon, in late 1996.

Study Methodology

In general, we followed a "top-down" approach, targeting larger agencies and groups with significant landslide information first. With these larger sources, we established a good base from which to tailor additional efforts and expand the information collection. Given the plethora of potentially useful breakdowns of cost data (by geography, nature of slide, type of infrastructure, and so on), decisions were made regarding logical breakdowns of information for developing survey forms and targeting specific data sources. Using the survey form (included in the Appendix), interviews were conducted with the following agencies to determine the available data on landslide losses and to discuss current methods of damage and tracking associated with landslides: Small Business Administration, U.S. Forest Service, Oregon Department of Transportation, Bureau of Land Management, Clackamas County, Douglas County, City of Portland (Office of Planning, Development Review and the Bureau of Water Works), Portland General Electric, Northwest Natural Gas, Bonneville Power Administration, Rail Road System, and Weyerhaeuser.

Contacted Organizations

The federal, state and local government, and private organizations and individuals contacted in this study are listed below. The survey results are provided in the Appendix.

Table 1. Contacted Organizations

Federal government

Federal Emergency Management Association (FEMA)

- Lori Miller
- Ron Langhelm

Federal Highway Administration (FWHA)

- John Gernhauser
- Annette Earl

US Forest Service (USFS)
-Courtney Cloyd

Small Business Administration (SBA)
- no staff was identified

Bureau of Land Management (BLM)
- Doug Baird
- Ken Gardner

Bonneville Power Administration (BPA)
- Mark Newbill

State and local government

Oregon Emergency Management (OEM)
- Dennis Sigrist
- Julie Slevin

Oregon Department of Transportation (ODOT)
- Mike Long
- Amy Pfeiffer
- Steve Leep

Clackamas County
- Darrel Burnum
- Bill Garity
- Cindy Kolomechuk
- Todd Namp

Douglas County
- Jim Alberding

City of Portland
- Eric Peterson
- Stan Vandaberg
- Calvin Lee
- Bill Freeman

Private organizations

Portland General Electric (PGE)
- Robert Hall

Northwest Natural
- Bruce Pasket

Weyerhaeuser
- Chuck Volt
- Ted Turner
- Mike McDowell

Loss Data Obtained from Contacted Organizations

The following are summaries of findings for each contacted organization. The summary describes only the finding of the entity being discussed; consequently, there is no overlap of data. The organizations are presented in the following categories: federal government, state and local government, and private organizations.

Selected landslide costs were obtained from FEMA, FHWA, and OEM damage reports, including some costs for Oregon storms in 1995, 1996 and 1997. Unfortunately, most of the reports show no distinction between landslide damage verses other storm-related damages. Therefore, we made assumptions to get an estimated figure on how much of the total amount was allocated to landslides. These costs were estimated either by professionals in the DOGAMI office or staff within the agency we contacted. Through collaboration with these agencies, more efficient methods for identifying landslide damages may be developed in the future.

Federal Government

FEMA

The Federal Emergency Management Agency (FEMA) maintains a detailed database on losses during disaster events; the location, description of damage, cost estimates for damage repair and allocated federal funds are included. In 1995, 1996 and 1997, four separate disaster events were announced, FEMA-DR-1107-OR, FEMA-DR-1099-OR, FEMA-DR-1149-OR, and FEMA-DR-1160-OR. The incident periods for the events were:

12/10/95 to 12/12/95 for 1107
02/04/96 to 02/21/96 for 1099
11/17/96 to 12/11/96 for 1149
12/25/96 to 1/6/97 for 1160

It should be noted that the dates for the declared disasters are political and may not correspond to the actual dates of the impacts.

DOGAMI estimated funds allocated to landslide repair from available data on disasters 1107 and 1099. Approximately $4 million in landslide damages was incurred during the 1099 disaster and $21 thousand during disaster 1107, for a total of $4.021 million for Western Oregon. Disaster 1099 included 27 counties and included flooding, landslides and stream erosion damage. Disaster 1107 was primarily a windstorm with windstorm-related damage rather than landslides. The Figure 7 shows locations of landslides that occurred during 1995 and 1996 from these two disasters where FEMA assistance was provided. This report does not include direct loss figures for disasters 1149 and 1160, both which had significant landslide damage. Disasters 1149 and 1160 involved three and 14 counties, respectively.

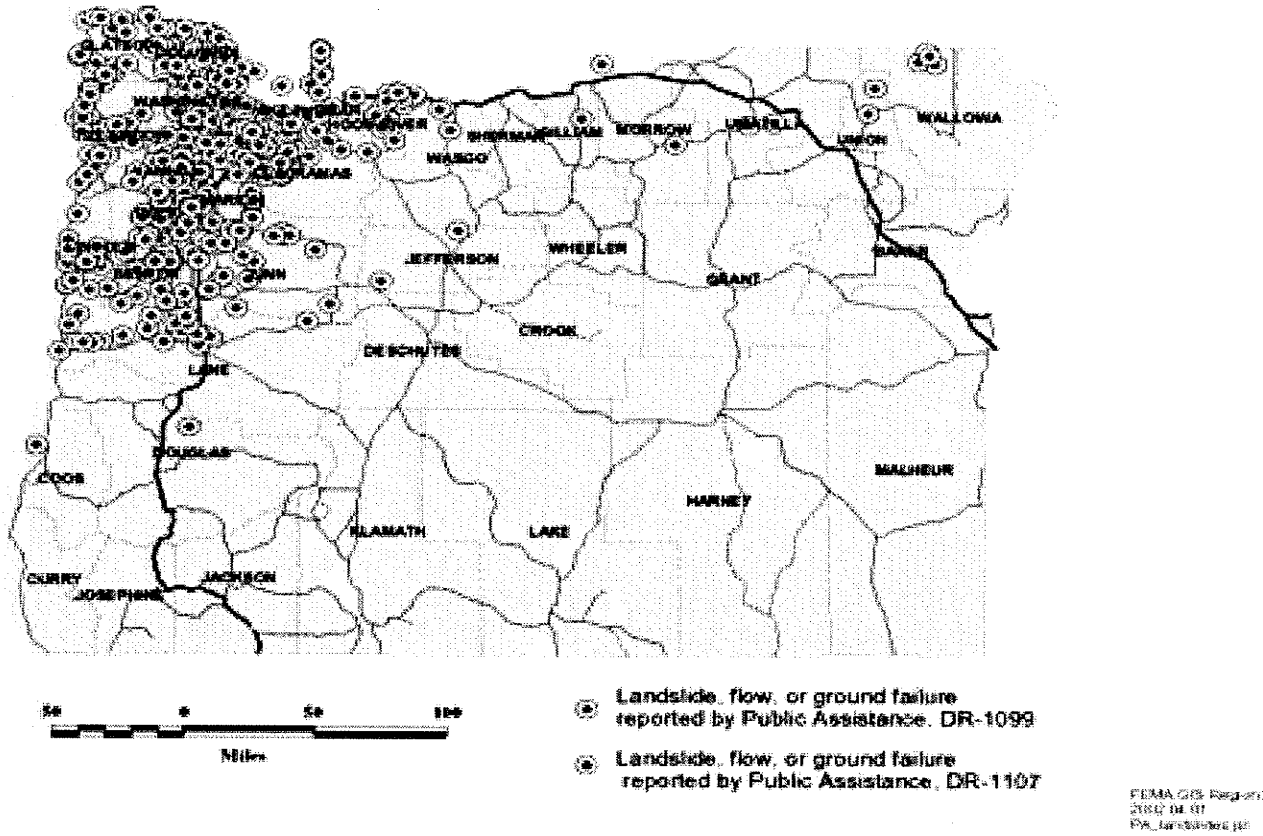

Figure 7. FEMA map showing probable landslides from two declared disasters, FEMA-DR-1107-OR and FEMA-DR-1099-OR. Source: FEMA

FHWA

The Federal Highway Administration (FHWA) works directly with the Oregon Department of Transportation (ODOT) when disaster funds are distributed. ODOT then issues the funds to the appropriate projects and to local government for disaster recovery efforts. In many states FHWA funds are solely used for the state's department of transportation. However, the state of Oregon has opted to share their federal funds, through FHWA, with smaller government entities. A formula based upon population, risk and other factors determines where the money is distributed. The values shown below in Table 2 represent estimates of federal funding ODOT received during the disaster events of 1996, 1997, 1999 and 2000 for landslide damages. In these figures, it is estimated that 70% of the total expenditures were associated with landslide losses. The values include all flood damage

.

Table 2: Total Expenditures on Emergency Response Projects by Disaster Date

Total Expenditures on Emergency Response Projects by Disaster Date					
1996-1 $1000s	**1996-2 $1000s**	**1997-1 $1000s**	**1997-2 $1000s**	**1999-1 $1000s**	**2000-1 $1000s**
7,608	70,603	8,727	21,784	1,985	7,166

John Gernhauser, engineer at FHWA, Oregon Division, stated the majority of the funds distributed during disaster events went to land movement repairs. It was estimated by DOGAMI that approximately 70% of the total expenditures were used for landslide losses. Table 3 shows the estimated values.

Table 3: Estimated Total Amount Used on Landslide Losses by Disaster

Estimated Total Amount used on Landslide Losses by Disaster					
1996-1 $1000s	**1996-2 $1000s**	**1997-1 $1000s**	**1997-2 $1000s**	**1999-1 $1000s**	**2000-1 $1000s**
5,326	49,422	6,109	15,248	1,389	5,016

Small Business Administration

The Small Business Administration (SBA) distributes low interest loans during disaster events, such as storm events during 1996-1997. The total amount lent was $7.2 million, which includes all storm damage. This value is the accumulation of money borrowed by 252 homeowners, renters, and businesses. SBA staff projected that about 50% of the total amount lent was used for landslide repairs, which comes to an estimated $3.6 million. The 50% value was determined by comparing total flood damage verses the amount of damage occurred by landslides in surrounding areas (City of Portland, US Forest Service, BLM, and Douglas County).

USDA Forest Service

U.S.D.A. Forest Service (USFS) estimates were drawn from a summary of the Emergency Relief-Federal Ownership (ERFO) fund allocated by Congress to repair forest service roads and infrastructure damage during the storm events in 1995, 1996, 1997, 1999 and 2000. Costs are only for western Oregon National Forests affected by each storm event, and are estimated at $50 million for these five years. Table 4 shows the total ERFO funds allocated to different National Forests in western Oregon for repair of damage due to storms occurring between 1995 and 2000. Estimated values for landslide repair are shown in the second column. Courtney Cloyd, Regional Engineering Geologist, estimated the 50% value based upon his personal experience in the USFS.

Table 4: ERFO expenditures (source: USFS)

ERFO OREGON NATIONAL DISASTER NO. (Year)	FOREST (USDA)	Cost to repair damage caused by landslides (50% of total repair costs) $1000s	Total repair costs: storm-related damage $1000s
OR 95-1 FS (1995)	Rogue River	43	86
	Siskiyou	332	665
	Umpqua	290	581
	Willamette	625	1,251
OR 96-1 FS (1996)	Mt. Hood	1,668	3,337
	Siskiyou	107	215
	Umpqua	900	1,800
	Willamette	4,863	9,727
OR 96-2 FS (1996)	Mt. Hood	4,069	8,139
	Siuslaw	1,887	3,774
	Willamette	1,190	2,380
OR 97-1 FS (1997)	Mt. Hood	913	1,825
	Siskiyou	4,294	8,588
	Siuslaw	198	395
	Umpqua	1,537	3,074
	Willamette	5,970	11,940
OR 97-2 FS (1997)	Mt. Hood	2	4
	Rogue River	2,996	5,991
	Siskiyou	831	1,662
	Siuslaw	282	564
	Umpqua	1,709	3,418
	Willamette	6,048	12,097
OR 1999-1 FS (1999)	Mt Hood	323	645
	Rogue River	164	328
	Siskiyou	1,919	3,839
	Siuslaw	2,125	4,250
	Umpqua	660	1,320
	Wilamette	2,515	5,029
OR 2000-1 FS (2000)	Mt Hood	626	1,251
	Siuslaw	98	196
	Wilamette	1,224	2,448
Total Cost		50,409	100,818

Figure 8. Multnomah Falls rock catchment net on footpath. This was installed by the USDA Forest Service as a result of a severe injury from a rockfall (modified from Wang and others, 2002)

Bureau of Land Management

Five BLM districts were included in the landslide loss study, as follows: Coos Bay, Medford, Eugene, Salem and Roseburg. Landslide impact to BLM land is not tracked directly. Typically, damages due to storm events are lumped together and monitored through the maintenance department. The amount allocated to landslides was determined from two sources, the Emergency Relief-Federal Ownership (ERFO) fund and a special appropriation. It was determined that the ERFO program has accounted for $18.7 million to BLM over the last 7 years and the special appropriation came to $30 million. The special appropriation was a one-time event, and is being used over a 10-year period. The recent average annual amount spent on landslides was estimated to be approximately 50% of the total funds, which comes to about $2.84 million per year. Doug Baird, engineer for BLM, conducted the estimation. The estimate does not include annual maintenance costs incurred due to landslide losses.

Bonneville Power Administration

Bonneville Power Administration has recently instituted a 5-10 year maintenance project to address slope stability-related issues with their road network. The road maintenance budget is nearly $150,000 per year for western Oregon. In 2001, the BPA spent about $500,000 to rectify damages caused in 1996-1997. During 2002, BPA was funded $450,000. All maintenance costs are addressed through the BPA. No federal funding was reported following disaster events.

State and Local Government

Oregon Emergency Management

Oregon Emergency Management (OEM) is the liaison between the counties and FEMA for distributing disaster funds. OEM staff indicated that OEM does not keep a detailed record on the allocation of money during disaster events. Instead, DOGAMI was referred by several OEM staff to FEMA to determine the amounts appropriated to different agencies.

Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) is the largest entity in the state having significant losses due to landslides. ODOT does not have a designated landslide tracking system. Currently, landslides are tracked through the finance department, with activity codes assigned to certain types of jobs. However, when slide repairs are federally funded, there is a special form that needs to be filled out, which makes slide tracking easier during disaster events. There are plans to improve the landslide tracking using a management system that would inventory, prioritize, and collect data on slope failures. A successful pilot program was implemented in Region 3, which covers southwest Oregon (see Figure 9). Due to the lack of funding, however, the project has not yet been implemented in the remainder of the state.

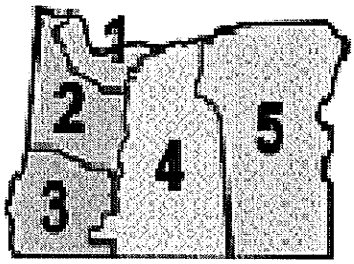

Figure 9. Map of ODOT regions

Figure 9 shows the ODOT region (accessed on 4/29/02, www.odot.state.or.us). Due to the steep topography, the focus for this study is Regions 1, 2 and 3. These three regions are the most highly affected by land movement. Table 5 shows the estimated annual repair cost for Regions 1, 2, and 3. Table 6 shows the total repair cost of all landslides ODOT is presently managing. This does not include future slope failures. ODOT has spent over $25 million on Highway 101 alone over the last 8 years—approximately $3,125,000 spent per year, most of which is used to repair the damage caused by slope failures and debris flows.

Figure 10. Cape Foulweather landslide. The downslope lanes of coastal US Highway 101 was damaged from a fill slope failure in December 1999. Repair work lasted about one month. (ODOT photo)

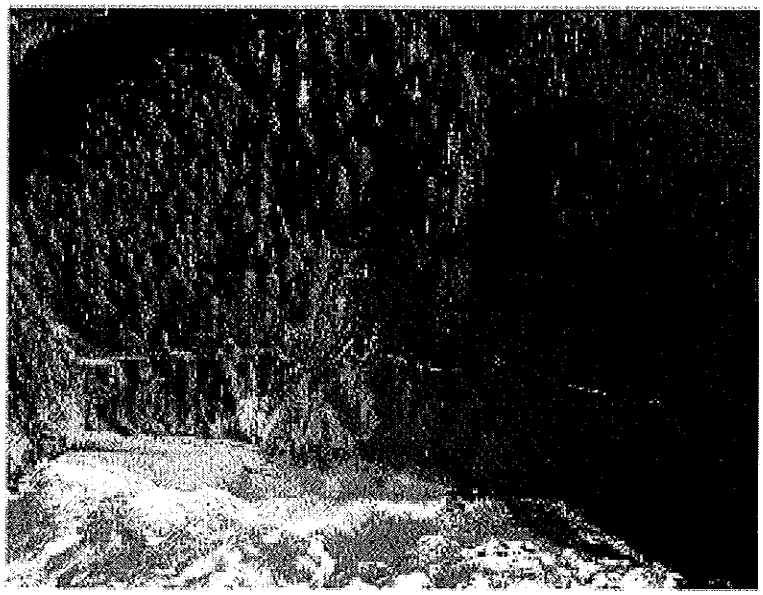

Figure 11. Cape Cove Landslide. A damaging landslide interrupted traffic in both directions of US Highway 101 in January 2000. Repair work forced an approximate three-month road closure. (ODOT photo)

Table 5: Estimated annual direct loss for Regions 1, 2 and 3 (source: ODOT)

Estimated annual direct loss for Regions 1, 2, and 3			
Region1 $1000s	**Region2 $1000s**	**Region3 $1000s**	**Total Average Annual Cost $1000s**
2,290	710	1,480	4,480

Table 6: Total cost to date for all existing landslides in Regions 1, 2 and 3 (source: ODOT)

	TOTAL COST TO DATE FOR ALL EXISTING LANDSLIDES IN REGIONS 1, 2 and 3			
	LANDSLIDES (Severe Cost or Hazard) **$1000s**	LANDSLIDES (Medium to Low Hazard) **$1000s**	ROCKFALLS A RATED **$1000s**	ROCKFALLS B RATED **$1000s**
Region 1	38,100	28,500	40,600	105,600
Region 2	5,100	26,690	7,730	4,550
Region 3	47,000	45,000	75,000	100,000
TOTAL	90,200	100,190	123,330	210,150

The values above are only for state highways and road right-of-ways. There exists a significant hazard for many of the landslide sites, since oftentimes, only minimal clean up work was conducted. Frequently, all ODOT can do is clean up the damage and repeat the process the following year. Most slides are not repaired due to lack of funding.

During notable storm events, the annual cost soars. Federal funding is distributed to different regions depending on the severity of the damage. Table 7 shows the cost break down during the storm-events of 1996-1997 and 1999. The estimated repair cost is the total amount spent to repair damages during the storm events. The Federal Highway Administration (FHWA) distributes federal funds to ODOT

during disaster events. The amounts shown below indicate how much each region received during an event. It should be noted that ODOT personnel determined the total overall amount of FHWA funds for the three regions during the 1996-1997 storm-event without regional breakdowns.

Table 7 Highway Repair Costs (source: ODOT)

	1996-1997 Storm Event		1999 Storm Event	
	Estimated Repair Cost $1000s	FHWA $1000s	Estimated Repair Cost $1000s	FHWA $1000s
Region 1	31,810	8,540	500	0
Region 2	5,000	1,300	11,000	6,420
Region3	9,400	3,050	2,000	300
Total	46,210	12,890	13,500	6,720

The breakdown for Regions 1, 2, and 3 was estimated by DOGAMI personnel and are approximated partly based on the break down for the 1999 storm event. Also, the figures for FHWA show where federal funds are allocated within ODOT, and are only a fraction of the total values given in Table 8. The total amount of federal funding ODOT received in 1999 exceeds the amount the FHWA declared they funded for the year. This is a significant discrepancy, which could not be investigated further at this time. Due to the extensive amount of work that ODOT has done on landslide and rock fall mitigation, the loss values from ODOT are considered to have high reliability. Figures 12 and 13 shows the repairs cost in each region and how much federal funding was granted during the 1996, 1997 and 1999 storm events.

Table 8: Total cost in regions 1, 2 and 3

	TOTAL COST PER REGION		
	REGION 1 $1000s	REGION 2 $1000s	REGION 3 $1000s
COST	212,800	44,070	267,000

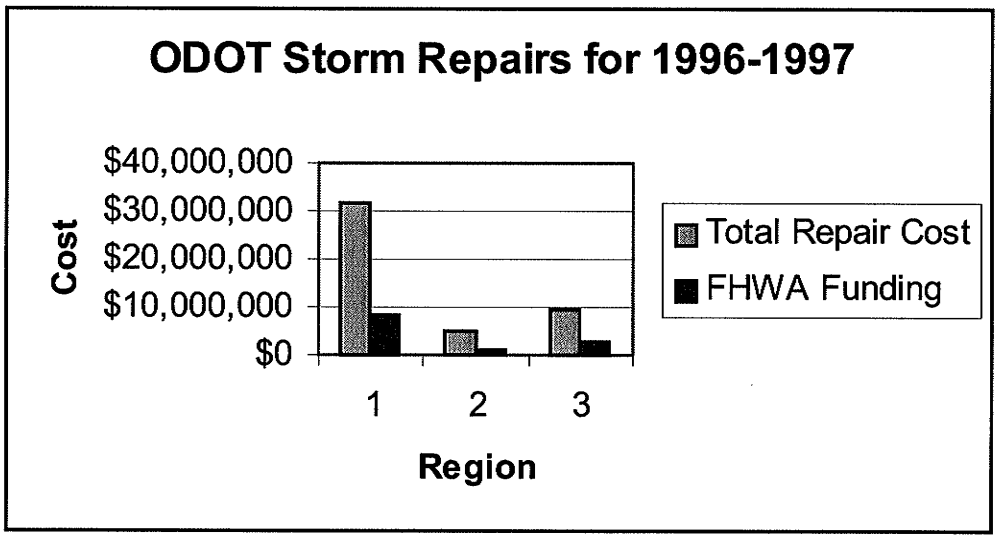

Figure 12. ODOT storm repair costs and FHWA funding in 1996 and 1997. Source: ODOT.

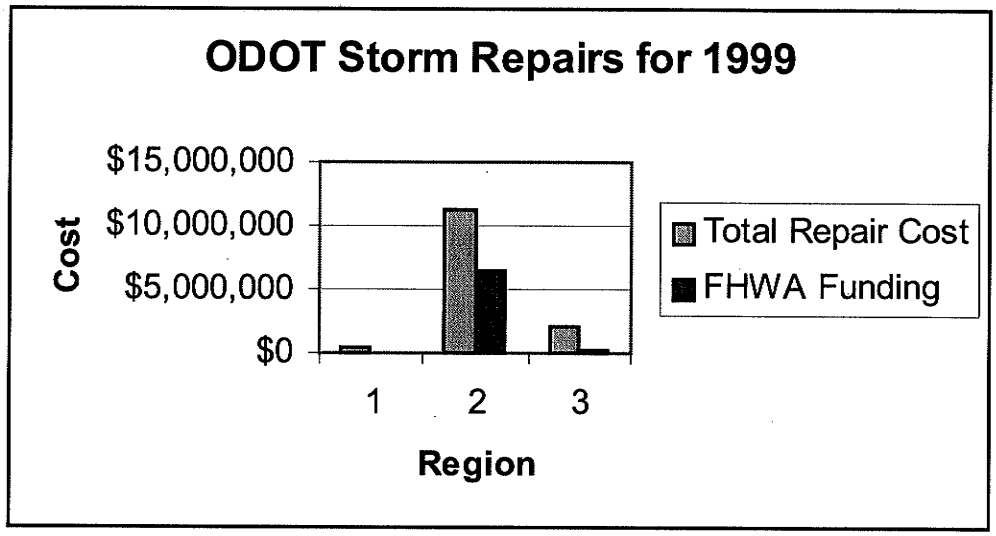

Figure 13. ODOT storm repair costs and FHWA funding in 1999. Source: ODOT.

Clackamas County

During the 1996 storm, an assessment on flood damage was conducted, which included landslides. Table 9 below shows the estimated average repair costs per year and the total cost during the 1996-1997 storm event.

Table 9 Clackamas County Expenditures

	Monitoring $1000s	Sewer $1000s	Water $1000s	Transportation $1000s	FHWA $1000s	Total Cost Subtract FHWA $1000s
Avg. Annual Cost	1	0	0.5	100	0	0
1996-97 Storm Event	1	0	0.5	3,000	1,168	1,834

The Clackamas County water system has not experienced catastrophic failures due to fast moving landslides. Instead, slow slope movements have caused the majority of the damage. Creeping slopes pull water lines apart causing pipes to leak. Typically, these damages are repaired before a complete breach in the water line occurs. Two different pipelines have had damage in the last ten years. Hillside Drive caused $600 in damage. Oatfield Road South of Jennings Road caused $2,000 in damage. The Oatfield Road slope movement disconnected a 24-inch diameter main line. The County recently allocated $40,000 dollars to monitor this slow moving landslide.

Douglas County

Douglas County tracks its landslide losses through their accounting system. Landslides are categorized by job type and road number. During an average year, approximately $175,000-$200,000 is spent to repair landslide damage to the road infrastructure. During the large storm events in 1996-1997, the costs rose to $750,000-$800,000. Approximately $650,000 from FEMA was used to assist with the repairs. During the 1996-1997 storm events, seven people died in debris flows, and landslides caused at least $532,000 in direct damage to private property within the County.

City of Portland

The City of Portland currently relies on the maintenance department to keep track of their landslides. Landslides have the most impact on the transportation department. Table 10 shows the break down between different departments during an average year and the storm years of 1996 and 1997.

Table 10. City of Portland Expenditures

	Avg. Annual Cost $1000s	1996-1997 Storm Event $1000s
Sewer/Water	75-100	1,500
Private	N/O	1,850
Park and Recreation	N/O	90
Monitoring	50	50
Transportation	250-400	20,700
FEMA	0	500*

*NOTE: The amount FEMA contributed during 1996-1997 is only for the transportation department.
N/O – Not Obtained

The actual losses for the private sector is higher than the amount listed in Table 10. In many cases, losses in the private sector are not reported or tracked since private owners have no motivation to report losses unless there is a possibility for financial assistance.

Private Organizations

Utility organizations appear to adopt a wide range of approaches in addressing landslides. Some appear proactive in preventing damage before it occurs while others appear reactive to landslides as they occur.

Portland General Electric

PGE does not directly track landslide losses although they are aware that landslides have affected the system. PGE finds that storm water causes the greatest damage to their system, and haa addressed problems on a case-by-case basis. PGE has incurred losses but their loss values were not available. They often rely on geotechnical consultants to meet their landslide mitigation needs.

Northwest Natural

Northwest Natural appears to have an effective system for monitoring landslides. They conduct a thorough analysis of known landslide areas that directly impact their pipeline system. Surveying, monitoring, and geotechnical evaluations are conducted to determine movement and possible hazards. If the possibility for land damage is significant, they will generally relocate their pipelines before slope failure occurs. NW Natural spends on the order of $1-2 million per year on landslide investigations and mitigation. They incur minimal losses due to landslides because they take a proactive approach to areas with landslide potential. NW Natural has not received federal assistance.

Weyerhaeuser

Weyerhaeuser is proactive at addressing landslide hazards through analyses and a land-movement monitoring program. For example, the company conducted a comprehensive hydrologic analysis from 1994 to 1998, which included monitoring and measuring landslides. They noted dimensions and locations through global positioning systems (GPS) and geographic information systems (GIS). The cause of slope failure was recorded (e.g., storm event, human, and fire). Aerial photographs were taken of timber areas after major rainfall events to track landslide losses. The monitoring system will be in effect for 10 years. After the 10-year period, a review session will be conducted to see if any improvements can be made. Weyerhaeuser does not expect any major changes to their current system.

Their landslide losses primarily affect their road system. For a typical year, the cost for repairs can range from nominal to $2,000. Repairs generally consist of rebuilding roads, culverts, bridges and installing gabion walls. Weyerhaeuser does not track tree losses due to landslides, because landslides

to date have not destroyed a large enough area to cause any significant loss. During notable loss events, which occur every 10-15 years, approximately $500,000 worth of damage has been incurred. The landslides mainly affect Weyerhaeuser, but they can also affect the USDA Forest Service and Bureau of Land Management, which access some of the same logging roads. During the 1996 floods, 15 landslides affected one of the jointly owned roads with the Forest Service. Weyerhaeuser did the repairs on the road, and the Forest Service reimbursed Weyerhaeuser for $135,105.

Summary of Losses

Table 11 provides a summary of the total costs occurred in the organizations mentioned above, average annual cost, selected storm events in 1995, 1996, 1997 and 1999. The total annual cost during an average year for Oregon is on the order of $10's million, which does not include federal disaster assistance. During the storm events in 1996 and 1997, total losses came to about $100 million, with $58.7 million coming from federal assistance. The 1999 storm event caused $21.3 million in damage, with FHWA funding $1.4 million. At the time of this study, the amount FEMA funds were not available for the late 1996, 1997, and 1999 storms.

These losses presented herein are general estimates and are considered to be on a lower range estimate. At this time, loss information is often not specifically recorded. Few agencies track both damage and dollar losses. It is difficult to determine private landowners losses because no established method for keeping track of their losses exists, except during disaster events when federal funds and low interest loans are distributed.

Table 11. Summary of losses for a typical year, and selected storms of 1995, 1996, 1997, and 1999.

Agency	Average Annual Losses ($1000s)	1996-1997 Storm Events ($1000s)	1999 Storm Event ($1000s)
Federal Emergency Management Fund (FEMA)	0	4,000#	N/O
Federal Highway Administration (FHWA)	0	76,100	2,000
U.S. Forest Administration (USFS)	INA	18,000	2,500
Small Business Administration (SBA)	0	3,600	INA
Bureau of Land Management (BLM)	2,840	2,840	2,840*
Bonneville Power Administration (BPA)	150	650	150*
Oregon Emergency Management (OEM)	INA	INA	INA
Oregon Department of Transportation (ODOT)	4,480	46,210	13,500
Clackamas County	102	3,002	102*
Douglas County	184	1,250	184*
City of Portland	500	24,190	500*
Portland General Electric (PGE)	INA	INA	INA
Northwest Natural Gas	1,500	1,500	1,500
Weyerhaeuser	2	500	2*
Total Cost	**9,758**	**98,142**	**21,278**
Total Federal Assistance	0	80,100	2,000

Only the storm losses in the early 1996 storm were included

* The amount was not determined, or the entity was unaffected by the 1999 disaster, average annual cost was inserted.

INA - Information not available **N/O** - Not Obtained

Discussion

The loss data presented in this report indicate that Oregon suffers significant landslide losses. The average loss per year is substantial, yet large storm impacts are orders of magnitude larger. The systems in place to track landslide losses vary substantially. Most agencies and companies currently do not track landslide losses specifically within their budgets, yet several are amenable to future modifications to their systems. Some larger entities, such as the City of Portland, have well-developed permit tracking systems that could be modified in the future to more specifically track landslide costs. Other large sources, including the Oregon Department of Transportation (ODOT) also recognize the value of tracking landslide damages more specifically. ODOT has implemented a test project to monitor and prioritize landslide repairs in southwest Oregon.

Weyerhaeuser and Northwest Natural provide examples of proactive landslide mitigation programs. Weyerhaeuser's extensive hydrologic study, mapping, and aerial photographs after large storm events have proven to be a useful and effective way of tracking and monitoring landslides. Northwest Natural monitors and assesses risk of land movement and mitigates landslide hazards.

Many areas could benefit from further research to determine an accurate estimate of losses to Oregon. Federal funding is typically made available after a disaster occurs, but many landslide areas could be identified and losses reduced with reasonable pre-disaster mapping and planning. The high cost of landslide damage supports the importance of better understanding and reducing future risk. To better estimate the impact of landslides in Oregon, a more global tracking system should be implemented.

The City of Portland and the greater Portland Metropolitan area was the focus of an extensive post-storm inventory of landslide locations conducted by Portland State University (Burns and others, 1998). As part of this data collection project, landslide locations were mapped and repair costs were summarized where possible. Many of the damage sites were not repaired at the time of the inventory, but the location data provides an excellent resource for later collection of loss data. Such geographically referenced inventory efforts are extremely valuable for loss estimation, as well as a number of other landslide-related projects.

Although it is difficult to predict when landslides will occur, likely areas of high hazard can often be identified. Such hazard mapping can lead to planning and mitigation efforts that can save lives and substantially reduce damages. One example effort that was initiated from Oregon state legislation because of seven fatalities implement a debris-flow hazard mapping program in western Oregon (Discussion section).

Recommendations for further studies

We recommend that additional landslide-related work be conducted to assess the losses from landslides, to identify landslide hazards, to increase public awareness for citizen safety, to mitigate landslides, and to improve common construction practices. We recommend that landslide cost programs be implemented (as stated in the discussion section) and that a state database on existing landslides be developed.

Figure 14. The 1993 Klamath Falls earthquake triggered a fatal rockfall on US I-97.

Also, a better understanding of landslide processes and detailed maps of high-risk areas for landslides are needed. To effectively reduce risk, mitigation needs to be applied and institutionalize in appropriate ways. As one example, rainfall patterns need to be investigated to discern how wet cycles affect landslide occurrences and to obtain an accurate account of the rainfall intensity during storm events. Landslides are highly dependent upon weather conditions and patterns. Earthquake-triggered landslides need to be investigated (see Figure 14).

In future surveys, the remaining 34 counties and organizations in the private sector would be contacted. For example, the railroad system and PGE, which are known to have landslide losses, would be further researched.

Limitations

The estimates provided in this study are from general data obtained from a number of disparate sources. The figures have varying degrees of uncertainty and are appropriate only as general approximations as there may be inconsistencies and/or errors.

Funding Statement
This project was made possible by the efforts on landslide risk reduction by the Association of American State Geologists and by the USGS. The USGS provided $7,000 in funding. State matching funds were also provided.

Acknowledgements
We appreciate the assistance from the many Oregonians and others whom we contacted to collect landslide data to help with this study. We are saddened by the tragic fatalities suffered from landslides that occurred in the 1996 and 1997 storms in Oregon and hope that this work will help reduce future risks.

We thank Dr. John Beaulieu and Dennis Olmstead of DOGAMI for their project support and astute reviews. We thank Paula Gori of the U.S. Geological Survey and Jim Davis of the California Geological Survey for their coordination efforts. Klaus Neuendorf and Geneva Beck of DOGAMI assisted with preparing this publication.

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Appendix

Appendix

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	Date: April 09, 2002	
Organization:	Federal Emergency Management Association		
Name	**Title**	**Phone Number**	**Email**
Ron Langhelm	FEMA Region 10	(425) 487-4642	Ron.Langhelm@fema.gov
Lori Miller	FEMA Region 10	(425) 487-4716	

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?)
FEMA keeps a detailed database on losses during disaster events; the location, description of damage, cost estimates for damage repair and allocated federal funds are included.

Is there any plan for improving tracking system or any suggestions on how it should be improved?
Currently, there are no plans for improvement.

Estimated amount of funding during the 1996-1997 disaster event?
It was determined, approximately $4 million during the 1099 disaster and $21 thousand during the 1107, resulting in a total of $4.021 million. The 1099 and 1107 were the two separate disaster events declared in 1996-1997. The incident periods for the events are 12/10/95 to 12/12/95 for 1107 and 02/04/96 to 02/21/96 for 1099. It should be noted, the dates for the declared disasters are politically motivated and don't necessarily represent the actual dates of the disaster.

NOTE: In Appendix B, there are two maps showing the locations of landslides during the disaster events of 1099 and 1107 which FEMA had helped in funding.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	**Date:** March 13, 2002	
Organization:	Federal Highway Administration		
Name	**Title**	**Phone Number**	**Email**
John H. Gernhauser	P.E. FHWA, Oregon Division	(503) 399-5749 ext.309	John.Gernhauser@fhwa.dot.gov
Annette E. Earl	Federal-aid Assistant	(503) 587-4729	Annette.Earl@fhwa.dot.gov

Landslide Loss Information

The Federal Highway Administration currently does not keep track of how federal funds are allocated to different agencies. It works directly with the Oregon Department of Transportation (ODOT) when disaster funds are distributed. ODOT then issues the funds to the appropriate projects and to local government, disaster recovery efforts. In many states FHWA funds are solely used for the state's department of transportation. However, the state of Oregon has opted to share their federal funds through FHWA, with smaller government entities. A formula based upon population, risk and other factors determine where the money is distributed. The values shown below in Table1 represent the total amount of federal funding ODOT received during the disaster events of 1996, 1997, 1999 and 2000. The values include are dollar figure for the whole state and include all damage.

Total Expenditures on Emergency Response Projects by Disaster Date					
1996-1 ($1,000s)	1996-2 ($1,000s)	1997-1 ($1,000s)	1997-2 ($1,000s)	1999-1 ($1,000s)	2000-1 ($1,000s)
7,608	70,603	8,727	21,784	1,985	7,166

Table1

The majority of the funds distributed during disaster events went to land movement repairs. It was estimated by DOGAMI personnel, approximately 70% of the total expenditures were used for landslide repairs in western Oregon. Table 2 shows the estimated values.

An Estimated Total amount used on Landslide losses by Disaster					
1996-1 ($1,000s)	1996-2 ($1,000s)	1997-1 ($1,000s)	1997-2 ($1,000s)	1999-1 ($1,000s)	2000-1 ($1,000s)
5,325	49,422	6,109	15,248	1,389	5,016

Table 2

Method of tracking landslide losses (How do you know the losses are caused by a landslide?) FHWA doesn't keep track of where funds are allocated within the Oregon Department of Transportation.

Is there any plan for improving tracking system or any suggestions on how it should be improved? There are no plans for improving the monitoring system of funds.

What is included in the notable loss events? (E.g., 1996 storms, roads, sewer, water, power, rail road, private property, community, businesses, residents) The FHWA is a federal agency that distributes money during disaster events. The funds go directly to the Oregon Department of Transportation where it will be distributed to the appropriate jobs.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller: Renee Summer		Date: January 19, 2002	
Organization: U.S. Forest Service			
Name	**Title**	**Phone Number**	**Email**
Courtney Cloyd	Regional Engineering Geologist	(503) 808-2705	jcloyd@fs.fed.us

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?) All damages due to storm events are lumped into one category; landslide losses are not directly tracked.

Is there any plan for improving tracking system or any suggestions on how it should be improved? There are currently no plans for improving landslide monitoring.

Estimated annual indirect loss or impact: No dollar value is available.

Impacts of slide(s): Slides impact the USFS road system.

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?) Do not keep track of possible future losses caused landslides.

Whom does the landslide effect? (E.g. property owners, railway, agencies, commuters) Landslides primarily affect the USFS road system. Landslides can also affect the BLM and large logging companies that would have access to the roads

Who pays for the repairs? (If more than one party, break down how much is paid by each party) (E.g. FEMA, SBA, OEM) All of the funds for determining landslide repair were determined from Emergency Relief-Federal Ownership (ERFO) funds.

What is included in the estimated annual direct loss to the road system?

ERFO OREGON DISASTER NO. (year)	NATIONAL FOREST (USDA)	Cost to repair damage caused by landslides (50% of total repair costs)	Total repair costs: storm-related damage
OR 95-1 FS (1995)	Rogue River	$42,908	$85,815
	Siskiyou	$332,422	$664,843
	Umpqua	$290,362	$580,723
	Willamette	$625,310	$1,250,619
OR 96-1 FS (1996)	Mt. Hood	$1,668,461	$3,336,921
	Siskiyou	$107,450	$214,900
	Umpqua	$899,918	$1,799,835
	Willamette	$4,863,311	$9,726,621
OR 96-2 FS (1996)	Mt. Hood	$4,069,384	$8,138,768
	Siuslaw	$1,887,012	$3,774,023
	Willamette	$1,189,977	$2,379,954
OR 97-1 FS (1997)	Mt. Hood	$912,643	$1,825,286
	Siskiyou	$4,294,118	$8,588,236
	Siuslaw	$197,738	$395,475
	Umpqua	$1,537,144	$3,074,288
	Willamette	$5,969,759	$11,939,518
OR 97-2 FS (1997)	Mt. Hood	$1,550	$3,100
	Rogue River	$2,995,639	$5,991,277
	Siskiyou	$831,127	$1,662,254
	Siuslaw	$281,836	$563,671
	Umpqua	$1,709,048	$3,418,095
	Willamette	$6,048,296	$12,096,591
OR 1999-1 FS (1999)	Mt Hood	$322,650	$645,299
	Rogue River	$164,075	$328,150
	Siskiyou	$1,919,496	$3,838,991
	Siuslaw	$2,124,955	$4,249,910
	Umpqua	$660,030	$1,320,060
	Wilamette	$2,514,612	$5,029,223
OR 2000-1 FS (2000)	Mt Hood	$625,737	$1,251,474
	Siuslaw	$97,818	$195,636
	Wilamette	$1,224,085	$2,448,169
		$50,408,863	$100,817,725

Summary of ERFO funds spent on National Forest lands in western Oregon for repair of damage due to storms occurring between 1995 and 2000.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	**Date:**	March 21, 2002
Organization:	Bureau of Land Management		
Name	**Title**	**Phone Number**	**Email**
Doug Baird	Manager for BLM in WA and OR	(503) 808-6099	dbaird@or.blm.gov

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?) Landslides are monitored through BLM's maintenance department.

Is there any plan for improving tracking system or any suggestions on how it should be improved? No current plans for improvement.

Estimated annual direct loss? $2.84 million (recent annual amount spent, last 7 years)

What is included in the estimated annual direct loss? (e.g. roads, sewer, water, power, railroad, private property)
Transportation – All losses affect the transportation system.

Estimated annual indirect loss or impact: - Unable to determine a dollar value for indirect loss.

Impacts of slide(s): Landslides impact BLM's road system. BLM currently owns and maintains 19,000miles of road in western Oregon.

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?) Large landslide hazards are rectified; smaller landslides receive minimal repair (clean up). BLM does not set money aside directly for future landslides, but has received a large amount of federal money to emend the deteriorating road system.

What is included in the notable loss events? (E.g., 1996 storms, roads, sewer, water, power, rail road, private property, community, businesses, residents) BLM was affected by the 1996/1997-storm event and is still in the process of repairing and up grading the road system. BLM spent a total of 3.68 million dollars in 1996 and 1997. The total dollar amount due to storm damage was not determined.

Whom does the landslide effect? The landslide primarily affect BLM, but landslides can also impact the Oregon Forest Department and logging companies that have access to BLM roads.

Who pays for the repairs? (If more than one party, break down how much is paid by each party) (e.g. FEMA, SBA, OEM). Federal funds pay for landslide repairs. The amount allocated to landslides was determined from two sources, Emergency Relief-Federal Ownership (ERFO) fund

and a special appropriation. It was determined that ERFO has given BLM $18.7 million over the last 7 years and the special appropriation came to $30 million. The special appropriation was a one-time event, and is being used over a 10-year period. The recent average annual amount spent on landslides was determined to be approximately 50% of the total funds, which comes to $2.84 million per year. Doug Baird, P.E. for BLM, conducted the estimation. This figure does not include annual maintenance costs incurred due to landslide losses. Such data is not easily accessible and will not be investigated for this project.

Additional Information: Five BLM districts were included in the landslide loss study, as follows: Coos Bay, Medford, Eugene, Salem and Roseburg.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers		Date: March 25, 2002
Organization:	Bonneville Power Administration		
Name	**Title**	**Phone Number**	**Email**
Mark Newbill	Maintenance Department	(541) 915-4622	manewbill@bpa.gov

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?) Landslides are not directly monitored, losses from land movement is grouped into a general category associated with other erosion and flooding repairs.

Is there any plan for improving tracking system or any suggestions on how it should be improved? Currently, there are no plans to improve the monitoring system for landslides.

Estimated annual direct loss? For the last 5-10 years the average maintenance budget has been $150,000 for Western Oregon. DOGAMI personnel estimated approximately half of the budget went to landslide repair. This number is based upon other agency estimates of landslide repair cost verses the total annual maintenance cost. The estimated annual direct loss from landslides came to $75,000.

What is included in the estimated annual direct loss? All damages affect the BPA access roads.

Estimated annual indirect loss or impact: No dollar amount was determined.

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?) There are remaining hazards for landslides where only the debris was removed. BPA doesn't anticipate future losses from landslide; landslide damage repair is included into the annual maintenance budget.

What is included in the notable loss events? In 2001, the BPA spent about $500,000 to rectify damages caused in 1996-1997. During 2002, BPA was funded $450,000. It is estimated 50% of the total funds were allocated to landslide repair (estimated by DOGAMI personnel), approximately $425,000 for landslide repair due to 1996-1997 disaster event.

Whom does the landslide effect? Landslides affect both property owners and BPA. The BPA doesn't own the property the power lines are on, they only hold an easement that allows them to access private property.

Who pays for the repairs? All maintenance costs are address through the BPA; no federal funding was received during disaster events.

Additional Information: Bonneville Power Administration has recently had to address the issue of slope stability and landslide repair to their access roads. Poorly designed roads built 40 years ago, during power line construction, have now hit a critical point and need immediate attention. BPA is aware of the lack of maintenance and is in the process of rectifying the situation. Recent problems with the maintenance roads have occurred after clear cutting of surrounding lands. Culverts are unable to deal with the increased amount of storm water clear cutting induce causing road to be washed out.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	Date:	January 19, 2002
Organization:	Oregon Emergency Management		
Name	**Title**	**Phone Number**	**Email**
Denis Sigrist Julie Slevin		(503) 378-2911 ext. 247 (503) 378-2911 ext. 235	

Landslide Loss Information:

Oregon Emergency Management is the liaison between the counties and FEMA for distributing disaster funds. OEM doesn't keep a detailed record on the allocation of money during disaster events. DOGAMI was referred by several different sources to FEMA to determine the amounts appropriated to different agencies.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller: Renee Summers		**Date:** February 18, 2002	
Organization: ODOT			
Name	**Title**	**Phone Number**	**Email**
Mike Long	Regional Director of Geology	(503) 986-3374	Mike.T.Long@state.or.us
Amy Pfeiffer	Region 1 Geologist	(503) 731-8302	Amy.L.Pfeiffer@state.or.us
Bill Burns	Region 2 Geologist	(503) 986-2646	
Rick Kobernik	Region 3 Geologist	(541) 957-3595	Rick.M.Kobernik@odot.state.or.us

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?)
Landslides are tracked by the finical system. There are activity codes that are associated with the type of activity being preformed. Federally funded projects have more extensive documentation. There are special forms that need to be filled out for disaster funds that goes into a lot more description on what the disaster is.

Is there any plan for improving tracking system or any suggestions on how it should be improved?
There was a purposed management program for landslides that would inventory, prioritize and collect data on landslide. A pilot program was implemented in Region three but due to lack of funding, it is not being implemented in all regions.

Estimated annual direct loss?
Transportation system (estimated annual)

Region 1 – $2,290,000
Region 2 – $710,000
Region 3 – $1,480,000

	TOTAL COST TO DATE FOR ALL EXSITING LANDSLIDES IN REGIONS 1, 2 & 3				
	LANDSLIDES (severe cost or hazard)	**ROCKFALLS** "A" RATED	LANDSLIDES (medium to low hazard)	**ROCKFALLS** "B" RATED	**TOTAL COST**
Region1	$98,000,000		Unknown		$98,000,000
Region2	$5,100,000	$7,730,000	$26,690,000	$4,550,000	$44,070,000
Region3	$47,000,000	$75,000,000	$45,000,000	$100,000,000	$267,000,000

NOTE: $25 million have been spent on hwy 101 alone over the last 8 years (~$3,125,000 per year).

Estimated annual indirect loss or impact:
Loss of commerce, no dollar value has been calculated or estimated.

Impacts of slide(s):
The slides effect state roads and right of way.

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?)
Many slides are still in the process of being repaired and do have potential of moving until properly contained. There are other less critical slides that have not been properly contained or minimal work has been done, such as clean up, there is a chance of reactivation of these slides under rainy conditions.

What is included in the notable loss events?

Cost Break Down

Transportation - 1996

	Estimated Cost Repair	Federal Funding
Region 1 –	$31,810,000	$
Region 2 –	$5,000,000	$
Region 3 –	$9,400,000	$

Transportation – 1999

	Estimated Cost Repair	Federal Funding
Region 1 –	$310,000	$0
Region 2 –	$11,310,000	$6,420,000
Region 3 –	$2,030,000	N/A

Whom does the landslide effect? (E.g. property owners, railway, agencies, commuters)
Slides generally effect commerce, do not work on private property but can effect property owner's ability to get in and out of property.

Who pays for the repairs? (If more than one party, break down how much is paid by each party) (E.g. FEMA, SBA, OEM)
Federal agencies do assist in years of chronic landslides such as 1996 and 1997 or when one landslide causes mass destruction as can be found on hwy 101.

NOTE: THIS ONLY NEEDS TO BE FILLED OUT FOR REALLY SIGNIFICANT SLIDES.
(CAUSED MAJOR DAMAGE OR DEATH)

Landslide Characteristics

Landslide ID (entity's system)	Landslide Name (if available)	Location	Date of Slide

Repair Cost for Slide:

Contributing to slide (check all that apply)

- ☐ Heavy Rains
- ☐ Poor Drainage System
- ☐ Poor Grading
- ☐ Stream Erosion
- ☐ Fire
- ☐ Pre-Existing Slide
- ☐ Construction Activities
- ☐ Road
- ☐ Other

Dimensions of Slide

Length (ft)	
Width (ft)	
Depth (ft)	
Volume (ft^3)	

Predominate type of Material

- ☐ Rock
- ☐ Debris (coarse soil)
- ☐ Earth (fine soil)
- ☐ Fill
- ☐ Vegetation

Predominate type of Movement

- ☐ Fast (F) or Slow (S)
- ☐ Cut (C) or Fill slope (F)
- ☐ Slump
- ☐ Rock Fall/Topple
- ☐ Debris Flow
- ☐ Rotational (R) vs. Translational (T) Slide
- ☐ Spread

Slide occurred in (check all that apply)

- ☐ Forested area
- ☐ Harvested area
- ☐ Rural area
- ☐ Urban area
- ☐ Next to stream or creek
- ☐ Next to ocean or lake

Approximate slope of ground before slide (in degrees) ☐

Comments:

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	**Date:**	March 2,2001
Organization:	Clackamas County		
Name	**Title**	**Phone Number**	**Email**
Darrel Burnum	Transportation & Development	(503) 650-3210	
Bill Garity	Roads & Engineering	(503) 353-4674	BillG@co.clackamas.or.us
Cindy Kolomechuk	Natural Hazards Mitigation	(503) 723-4848	CindyKol@co.clackamas.or.us
Todd Namp	Oak Lodge Water Manager	(503) 654-7765	

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?)
In 1996 a damage assessment on flood damage, slides were included in the study. After the landslides are repaired, the survey department checks the landslides for movement over a 2-3 year period.

Is there any plan for improving tracking system or any suggestions on how it should be improved?
There are no future plans for improvements; there is not enough land movement to warrant any change in the system.

Estimated annual direct loss?
Transportation - $100,000 generally 5-6, 50 cubic yard mudflows a year, usually cleaned up in 24 hours.
Monitoring - >$1,000 per year
Sewer – no losses recorded due to landslides, most damages due to erosion and flooding
Water – Two separate events:
Hillside Drive – slow movement – 3" in last several years, service was pulled - $600
Oatfield Rd. South of Jennings Rd.– Service pull – have a 24" main – total cost for repair $2,000 so far. There is $40,000 allocated for monitoring the Oatfield Rd. landslide.

Estimated annual indirect loss or impact:
There was a 3-ton weight limit put upon a road after a major slide had made the ground unstable. It restricts buses and garbage trucks from using the route, has caused an inconvenience for the residents around the road, no cost value is known.

Impacts of slide(s):
Transportation – Impacts traffic flow and local residents.
Water – Pulls apart pipes, causes short term losses of water service while water line is being repaired

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?)
There are currently 12 active slides that are in the process of being repaired.

What is included in the notable loss events? (E.g., 1996 storms, roads, sewer, water, power, rail road, private property, community, businesses, residents)

Transportation – for 1996/97 event $3,000,000 total cost, FHWA paid for $1,168,000. There was one major slide on Forsythe road costing one million dollars in repairs.

Water – There was no notable losses that occurred during the 1996 – 1997 flood.

Public -

Whom does the landslide effect? (E.g. property owners, railway, agencies, commuters)

Transportation – commuters and road right of way.

Water - no water service while repairs are made to the system.

Who pays for the repairs? (If more than one party, break down how much is paid by each party) (E.g. FEMA, SBA, OEM)

Cost break down is noted above in the 'notable loss event' section.

NOTE: THIS ONLY NEEDS TO BE FILLED OUT FOR REALLY SIGNIFICANT SLIDES.
(CAUSED MAJOR DAMAGE OR DEATH)

Landslide Characteristics

Landslide ID (entity's system)	Landslide Name (if available)	Location	Date of Slide
Source # Metro Source ID 689	G-20	Intersection of Forsythe Road and Thurman, Oregon City	February 1996

Repair Cost for Slide: Total Cost - $1,000,425, FHWA assistance – $223,584

Contributing to slide (check all that apply)

X	Heavy Rains
	Poor Drainage System
	Poor Grading
	Stream Erosion
	Fire
X	Pre-Existing Slide
	Construction Activities
	Road
	Other

Dimensions of Slide

Length (ft)	300
Width (ft)	900
Depth (ft)	
Volume (ft^3)	1500

Predominate type of Material

	Rock
	Debris (coarse soil)
X	Earth (fine soil)
	Fill
	Vegetation

Predominate type of Movement

	Fast (F) or Slow (S)
	Cut (C) or Fill slope (F)
X	Slump
	Rock Fall/Topple
X	Debris Flow
	Rotational (R) vs. Translational (T) Slide
	Spread

Slide occurred in (check all that apply)

	Forested area
	Harvested area
X	Rural area
	Urban area
X	Next to stream, creek or river
	Next to ocean or lake

Approximate slope of ground before slide (in degrees) 40

Comments: A key trench was used to stabilize the slope, the slope kept moving while construction was going on, during construction blew out a 8-12" hole in the side of the slope, drained constantly for about a week. The water came from an underground lake.

Contact Information

DOGAMI Caller:	Renee Summers	**Date:**	January 17, 2002
Organization:	Douglas County		
Name	**Title**	**Phone Number**	**Email**
Jim Alberding	O&M Manager	(541)440-4268	jjalberd@co.douglas.or.us

Landslide Loss Information

Method of tracking landslide losses: Cost accounting system tracks job type to road number.

Improvements to tracking system: No plans for improvement

Estimated annual direct loss (get details, such as main costs):
Transportation: $175,000-$200,000

Estimated annual indirect loss or impact:
Commerce: $100,000

Impacts of slide(s): Time and repair materials costs, occasional property purchase for right of way needs.

Remaining hazards or anticipated future losses: N/A

Notable loss events (e.g., 1996):
Transportation: $750,000 - $800,000
Private: $532,000
Who pays for the repairs? Generally Douglas County, in disaster events, FEMA assists with costs (approximately $650,000 in 1996)

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller:	Renee Summers	**Date:**	March 10, 2002
Organization:	City of Portland		
Name	**Title**	**Phone Number**	**Email**
Eric Peterson	Environmental Bureau	(503) 823-5746	
Stan Vandaberg	Water Bureau	(503) 823-7476	
Calvin Lee	Building Bureau	(503) 823-7063	

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?)
RIFE – Keeps track of landslide losses

Is there any plan for improving tracking system or any suggestions on how it should be improved?
There are no plans at this point in time to improve tracking system.

Estimated annual direct loss?
Monitoring - $50,000
Water/Sewer - $75,0000-$1,000,000
Transportation - $250,000-$400,000

Estimated annual indirect loss or impact:
Water/Sewer – There is minimal indirect loss for water and sewer facilities, no dollar amount is determined.
Transportation -$100,000 due to loss in commerce

Impacts of slide(s):
Water/Sewer – Impacts service of utilities
Transportation – Impacts commerce and residents
Public – Effect land values and living conditions

Remaining hazards or anticipated future losses? (Has the slide been properly contained, or is there a chance the slide will reactivate?)
The city doesn't plan for future losses due to landslides, the funds for landslide emergencies comes out of contingency fund.

What is included in the notable loss events? (E.g., 1996 storms, roads, sewer, water, power, rail road, private property, community, businesses, residents)

Transportation - $20,700,000 (Est. repair costs for 96 floods, City PDX BTE)
Sewer and Water - $1,500,000 (No federal assistance was provided)
Private - $1,850,000 (FEMA, reporting costs for private property, e.g. 96', 93 properties included in report)
Other – (Parks and Recreation) $90,000 (Damage assessment report, flood 96')

Whom does the landslide effect? (E.g. property owners, railway, agencies, commuters)
The landslides reported have affected the water bureau, transportation bureau, commerce, and property owners.

Who pays for the repairs? (If more than one party, break down how much is paid by each party) (E.g. FEMA, SBA, OEM)
For private property owners and business the SBA supplied low interest loans to help with repair costs during the storm event of 1996 -1997
For the city bureaus (water, sewer, transportation) FEMA assisted during the disaster event of 1996 and 1997.

NOTE: City of Portland is not responsible for any landslides on private land even if it is due to neglect on the city maintenance or partially caused by bad decisions made by the city.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller: Renee Summers		Date: February 21, 2002	
Organization: Portland General Electric			
Name	**Title**	**Phone Number**	**Email**
Robert Hall	Risk Management	(503) 228-6322	

Landslide Loss Information

Method of tracking landslide losses?
PGE currently doesn't keep track of landslide losses; water damage causes the greatest amount of damage to their system

Is there any plan for improving tracking system or any suggestions on how it should be improved? There are no future plans for improving the tracking system. Damage caused by landslides is minimal in comparison to water damage.

Estimated annual direct loss? PGE does admit landslides have affected the system, but no dollar value was not given.

NOTE: Further investigation is currently being conducted with an engineering firm that has worked for PGE on landslide repair at Deck Comforth Reservoir.

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller: Renee Summers		**Date:** March 19, 2002	
Organization: Northwest Natural Gas			
Name	**Title**	**Phone Number**	**Email**
Bruce Pasket	Engineering Department	(503) 226-4211 ext. 4300	blt@nwnatural.com

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?) Northwest Natural Gas, keeps track of landslides through analysis and monitoring of know landslides and potential landslide risk areas. They keep track of creep in know slide sites by periodic survey and geotechnical evaluation.

Is there any plan for improving tracking system or any suggestions on how it should be improved? There are no plans for improving the current system; it is very affective in preventing landslide damage to gas lines.

Estimated annual direct loss? NW Natural, doesn't occur any losses due to landslides. They are proactive in preventing damages to gas lines from land movement. If significant movement is detected, NW Natural will relocate gas lines to prevent a potential failure in the system.

Estimated Annual Cost of Landslide Prevention? NW Natural currently pays on an order of $1-$2 million a year in landslide prevention. They currently do not receive any federal assistance in landslide mitigation all costs are paid by the company.

NOTE: THIS ONLY NEEDS TO BE FILLED OUT FOR REALLY SIGNIFICANT SLIDES. (CAUSED MAJOR DAMAGE OR DEATH)

Landslide Characteristics

Landslide ID (entity's system)	Landslide Name (if available)	Location	Date of Slide

Contributing to slide (check all that apply)

- ☐ Heavy Rains
- ☐ Poor Drainage System
- ☐ Poor Grading
- ☐ Stream Erosion
- ☐ Fire
- ☐ Pre-Existing Slide

Dimensions of Slide

Length (ft)	
Width (ft)	
Depth (ft)	
Volume (ft^3)	

- [ ] Construction Activities
- [ ] Road
- [ ] Other

Predominate type of Material

- [ ] Rock
- [ ] Debris (coarse soil)
- [ ] Earth (fine soil)
- [ ] Fill
- [ ] Vegetation

Predominate type of Movement

- [ ] Fast (F) or Slow (S)
- [ ] Cut (C) or Fill slope (F)
- [ ] Slump
- [ ] Rock Fall/Topple
- [ ] Debris Flow
- [ ] Rotational (R) vs. Translational (T) Slide
- [ ] Spread

Slide occurred in (check all that apply)

- [ ] Forested area
- [ ] Harvested area
- [ ] Rural area
- [ ] Urban area
- [ ] Next to stream or creek
- [ ] Next to ocean or lake

Approximate slope of ground before slide (in degrees) [ ]

Comments:

Landslide Loss Assessment Project
Contact Information

DOGAMI Caller: Renee Summers		**Date:** March 5, 2002	
Organization: Weyerhaeuser			
Name	**Title**	**Phone Number**	**Email**
* Chuck Volt	Area Engineer for Springfield	(541) 741-5205	chuck.volt@weyerhaeuser.com
Ted Turner	Geologist (Springfield)	(541) 741-5597	ted.turner@weyerhaeuser.com
Mike McDowell	Forest Area Team Leader	(541) 741-5727	mike.mcdowell@weyerhaeuser.com

Landslide Loss Information

Method of tracking landslide losses (How do you know the losses are caused by a landslide?)
Water flow analysis from 1994 – 1998, would monitor and measure slides when analyzing water characteristics. Would take dimensions of the slide and also how it was caused (cut/fill road, drainage, etc.) The timber area is photographed (areal) after any major rainfall event to track losses. Use GPS and GIS.

Is there any plan for improving tracking system or any suggestions on how it should be improved?
After monitoring system has been in effect for 10yrs there will be a review to see if anything changes are needed. Do not expect any major changes to the system.

Estimated annual direct loss?
Transportation: Average year $0 - $2,000

What is included in the estimated annual direct loss?
Losses are general transportation related, rebuilding of roads, retainment walls, rebuilding culverts and bridges. Do not keep track of tree losses due to landslides; do not take out a large enough area to cause any significant loss to tree harvesting.

Estimated annual indirect loss or impact:
Minor losses, do not keep track. Landslides can cause delays to harvesting areas. Harvesting another area or taking an alternative route to the site easily rectifies the problem.

Remaining hazards or anticipated future losses?
Do not anticipate future slides. Take care of the slides as they come up, some times if there is a large quantity of slides (like 1996-97) Weyerhaeuser will repair remaining slides the following year.

What is included in the notable loss events?
Transportation - $500,000 about every 10-15 years for large storm events. (96-97, 64, early 70's, late 80's)

Whom does the landslide effect?
Effects mainly Weyerhaeuser, and can effect the forestry department and BLM , since they access some of the logging roads.

Who pays for the repairs?
Mainly Weyerhaeuser, but in the 1996 flood one of the jointly owned roads (Calapuya Road) with the forest service was affected, with a total of 15 slides. Weyerhaeuser did the repairs on the road and the forestry department reimbursed Weyerhaeuser $135,105 for their share of the repair costs.