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LANDSLIDE INDIRECT LOSSES:

METHODS AND CASE STUDIES FROM OREGON

By

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Landslide Indirect Losses: Methods and Case Studies from Oregon

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Executive Summary

Indirect costs from landslides, such as relocation costs and loss-of-use of infrastructure, are frequently overlooked components of the total loss resulting from landslides, yet recording and/or calculating indirect costs is important for decision making. This document is intended to provide general information on how indirect costs can be estimated based on readily available information from landslide occurrences (e.g., physical impacts, time period of interruption), and support the efforts of the AASG/USGS Landslide Loss Pilot by providing resources to aid in indirect loss estimation.

This report presents an overview of three sets of indirect loss methodologies applicable to landslides: 1) unit cost estimation, 2) probability-based estimations, and 3) survey data collection. It also includes examples of these methods as applied to case studies in Oregon in order to demonstrate the feasibility of using simplified means of approximation based on readily available information.

Background on Indirect Costs

The overall costs of landslides include both *direct* and *indirect* costs. Direct costs typically include property damage and clean up costs specifically associated with the physical impacts of landslide events. Indirect costs, on the other hand, are the additional economic factors beyond the physical damage resulting from a landslide event and include losses and costs such as:

- The loss of use of infrastructure
- Emergency response costs
- Engineering evaluations
- Litigation
- Environmental impacts
- Loss of recreation use
- Loss of tourism revenue (by damages to land, facilities, or transportation)

- Reduced real estate value
- Loss of tax revenue from properties devalued by slides
- Loss of industrial, agricultural, and forest productivity
- Loss of human or domestic animal productivity (due to injury, death, or trauma)

(From Turner and Schuster, 1996)

Indirect losses from landslides can be significant – in some cases even greater than the direct costs – but they are not commonly tracked. A few reasons for this are:

- Indirect costs tend to add up over time and, as property owners and other impacted parties move or transfer interests, it is difficult to track and compile total costs.
- For public sector incidences, multiple agencies may be involved making it difficult to collect information from all jurisdictions. In addition, there may be little authority or incentive for public agencies to compile and disseminate this information (Highland, 2003).
- Private loss information is often not collected due to perceived or real privacy concerns. Losses may be underestimated (if published at all) in order to minimize negative publicity for various parties involved (Turner and Schuster, 1996).
- In the case of lawsuits, court documents may be sealed in some instances, and it may be difficult to gather information related to cases settled out of court.
- In times of emergency or shock associated with a landslide event, indirect costs may not be recorded in the ensuing chaos, and later not even remembered.
- In cases where costs are well documented, some parties combine landslide costs with other costs. For example, FEMA currently groups landslide impacts with flood and earthquake damage data following significant events. While individual damage reports generally specify landslide losses, compilation requires wading through printed reports often dispersed amongst multiple state and local government agencies (Highland, 2003).
- In the transportation sector, the cost of clearing slides or repairing infrastructure (roads or bridges) is often merged with of the cost of general maintenance activities, like grading and clearing, in annual budget reports. Thus, damage to infrastructure resulting from landslides may be difficult to determine. Costs of traffic disruption and delays may be reported for indirect loss estimation, but are rarely included in cost summaries of landslide impacts. In addition, slides that occur on *private* roads can be significant, but this information is rarely reported in loss consolidation data.
- Unlike other natural hazards such as floods and hurricanes, insurance is rarely offered for landslides, thus eliminating a significant incentive to accurately track loss data.

As a result of these and other factors, the reported cost of landslides in the U.S. significantly underestimates the true costs (Turner and Schuster, 1996). In the U.S., direct damages from landslides are commonly reported at between $1 to $2 billion annually, with an average of 25 to 50 lives lost each year (Spiker and Gori, 2000). Indirect costs are not currently estimated at a national level but are known to be substantial. **Table 1** provides a comparison of direct and indirect costs for a select group of landslide incidents to give an idea of the magnitude of some indirect costs. Clearly, the indirect costs from landslides can be as large, and in some cases, significantly more than the commonly reported direct damage figures.

Table 1: Comparison of Estimated Direct and Indirect Costs

Date	Location	Direct Cost	Indirect Cost	Source of Indirect Cost	Reference
1968-1969	Nine counties in the Bay Area affected	$44 to $60 million	$39 million	Mostly reduced market value	Taylor and Brabb, 1972.
1983	Thistle, Utah (Figure 9)	$300 to $480 million	$150 million lost by one railroad company alone	Closure of highway and railroads (used by coal, uranium, and petroleum industries), reduced production, increased unemployment, and reduced income	University of Utah, 1984
1983	Closure of US Highway 50 west (in California) and east (in Nevada) to Lake Tahoe	$5.7 million	$111 million from losing access for 2 ½ months	Loss of tourism revenue	Walkinshaw, 1992 (San Francisco Chronicle, 1983)
1997	Closure of US 50, in California	$5.3 million	Over $59 million	Detour costs and lack of access for 4 weeks	Reid and LaHusen, 1998

For both direct and indirect losses, it is helpful to distinguish between public and private impacts. Public costs are those incurred or reimbursed by government agencies. Typical public costs include rebuilding or repairing highways and railroads, buildings, dams and reservoirs, canals, harbor and port facilities, communications and electric power systems (Turner and Schuster, 1996). Indirect public costs can include loss of tax revenue, reduced capacity or capabilities of infrastructure systems, reduced productivity of government forests, and the impact on quality of recreational fisheries (National Research Council, 2004). Private losses are often the result of damage to real estate and structures such as homes or industrial facilities (Turner and Schuster, 1996). Private losses from landslides are typically borne by individual property owners, making such an event particularly devastating (National Research Council, 2004). And as one would imagine, it can be particularly difficult to obtain data on dispersed private losses.

Methods for Estimating Indirect Costs

Indirect loss assessments can and should be estimated, and there are a number of applicable approaches. The appropriateness of selected estimation methods depends on a number of factors such as the type of impact, the amount of information available, local conditions, and the time and resources available to the estimator. Given the tight time and budget constraints for most landslide researchers and practitioners, it is useful to have a range of estimation tools to draw on. The three methods presented in this report for estimating indirect costs are organized by level of detail and time required for the methodology. The three methods described are:

1. Unit cost estimation (as applied to road outages primarily),
2. Empirical, probability-based risk assessments, and
3. Survey data collection from personal accounts.

Discussions of each of these methods are supplemented with examples of national and Oregon-specific applications. This coverage of the topic is intended to generate additional thoughts on how indirect costs may be tracked and recorded for other significant landslide events.

Unit Cost Estimation

When estimating costs, it can be useful to break the overall impact into cause-and-effect estimations using unit costs. The general idea is to use unit cost breakdowns to estimate losses based on readily-available information. Here, we use road closure costs as a primary example, but the basic framework is applicable to a wide range of landslide impacts such as estimating relocation costs, water outage effects, and costs from utility line disruptions. More generally, this method is applicable whenever a unit variable is known (e.g., days an area is affected) and the associated unit cost (e.g., dollars lost per day) can be determined.

Road Closure Cost Estimation

Landslides can be particularly costly for agencies responsible for maintaining state and national highway transportation routes. The average national cost of maintenance and repair for federal and state highways alone was estimated at $143 million in 1992 (Walkinshaw, 1992) and this estimate did not include county, city, private, US Forest Service, Bureau of Land Management, or National Park Service roads (Turner and Schuster, 1996). In Oregon, the budgeted annual repair fund for landslide mitigation just for state highways is on the order of $4 million, but emergency repair costs just along coastal Highway 101 were over $22 million for the last recorded five year cycle from 1995-2000 (ODOT, 2002).

The Oregon Department of Transportation (ODOT) is responsible for providing a safe and efficient transportation system that supports economic opportunity and livable communities for Oregonians. When landslides occur, delays caused by road closures are of significant concern. Cost estimates for these delays help measure the impact landslides and other incidents impose on transportation system users. The method ODOT uses to calculate such estimates depends on the availability of data, but essentially one simple method is followed: estimate the value of the time and vehicle operating costs to travelers going from point A to point B before and after a road closure.

When a road is closed, detours are marked for travelers to follow. Because detours typically take longer and/or require greater travel distance to reach the destination, the indirect cost of a road closure is the additional time and distance required. Costs of outages can be estimated by the impact of the detour on road users. For example, if a vehicle will be traveling at a certain speed, one can estimate the amount of time it will take to traverse an alternative route in the event of a road blockage, and a cost per hour can be calculated based on the value of traveler's time and additional vehicle usage. A general equation for the approach is the cost of the detour time added to the cost of the fuel used in the detour (ODOT, 2001) as follows:

Detour cost = [Detour time*Operating costs + Extra fuel used*Fuel price]*Number of travelers affected

In logistical applications, ODOT uses average daily traffic (ADT) data to estimate the number of travelers forced to detour around a closed road location and the total detour cost is varied by the vehicle type – such as cars, light trucks, and heavy trucks.[1]

The implemented approach can be as simple or as complex as the situation dictates. In cases of limited traffic and vehicle type data, it can be appropriate to use a simple, weighted average vehicle cost value such as $15/hr or some other value appropriate for the local area to

[1] Since vehicle type determines the operating costs and fuel efficiency, the number of travelers affected must be broken down into vehicle types. Detour cost is computed for each type then costs are summed for a total detour cost (ODOT, 2001).

get a “ballpark” estimate. In cases where time and sufficient data are available, a number of refinements may be warranted to improve the level of detail of the loss estimation. For example, monthly averages for weekday traffic can vary substantially throughout the year and may vary widely between weekday and weekend (or holiday) traffic (Knudson, 7/19/04). This in turn can have a large impact on the magnitude to which travelers may be affected by a detour. Ideally, accurate estimates of traffic would be performed at or near the time of the highway closure (ODOT, 2001) and, whenever indirect costs are estimated, it is important to list all the assumptions included in the estimation methodology.

Oregon Highway 101 Road Closure Case History

Landslides and rock falls have caused notable road closures in Oregon in recent years, particularly along coastal Highway 101. Two particularly significant events were the 1999 Cape Foulweather landslide (north of Newport, Oregon) and the 2000 Cape Cove landslide (between Yachats and Florence shown in **Figures 1 and 2**). These events closed Highway 101 for 5 days and 12 weeks respectively. The direct costs of clean up and repairs for these events were similar at $2.5 million and $2.3 million (Doug Tindall, 6/30/04), but the indirect impacts of the road closure were clearly significant and different.

Fig 1: US 101 Cape Cove Landslide.

Closures of these sections of Highway101 forced significant detours, and the associated costs for motorists were estimated by ODOT in a study performed in 2001. To calculate the cost of these detours, ODOT examined traffic patterns along the coast and used the unit cost estimation method described above. For example, the Cape Cove landslide forced a 123.3 mile detour (2.47 hours at 50 mph) with an average daily traffic (ADT) estimated at 2,000 vehicles (1,836 cars, 67 light trucks, and 97 heavy. trucks). Examining just cars (with an operating cost of $13.95/hr and a fuel efficiency of 20 mpg) results in a cost of approximately $80,000 per day, and the total detour cost is estimated at just over $90,000 per day as follows:

Detour cost = Detour time*Operating costs (per hour)*ADT +
Extra fuel (in gallons)*fuel price (in gallons)*ADT

Detour cost $_{\text{(cars)}}$ = (2.47 hours)($13.95)(1,836) +
(6.2 gallons)($1.40/gallon)(1,836) = $79,199

Detour cost $_{\text{(total)}}$ = $79,199 $_{\text{(cars)}}$ + $3,765 $_{\text{(light trucks)}}$ + $7,568 $_{\text{(heavy tucks)}}$ = $90,532

Given the 12-week closure for the Cape Cove Landslide, the indirect cost of the detour was well over $5 million, or more than twice the direct repair cost for the landslide. While clearly significant, this is still a low estimate in that it does not include other business ramifications from loss of access to local resources and an associated loss of business at local shops, restaurants, tourist sites, and hotels. Estimates compiled by the Oregon Department of Emergency Management set minimum local business impact estimates in the range of several

Figure 2: US 101 Cape Cove Landslide.

thousands of dollars (OEM, 2000; Joseph Murray, 6/30/04). As evidenced by this and related scenarios, ignoring indirect costs can lead to significant underestimation of overall impacts and can, in turn, affect policy decisions.

This example of the indirect cost of the detour illustrates a relatively straightforward application of the unit cost method for road impacts in Oregon, but the approach lends itself readily to the estimation of impact cost in other locations. Essentially, whenever there is some record of traffic patterns, the number and type of impacted vehicles and the time period, this method can be used to provide a reasonable estimate of the unit cost of a detour.

<u>Probability-Based Risk Assessments</u>

In situations where there are large numbers of geographically dispersed landslide impacts, such as from a region-wide storm or large earthquake events, it is generally not practical or feasible to collect reliable data for every impact location. In these instances, or in situations where one would like to estimate in advance what impacts may be for various regional events, probability-based risk assessments can be particularly valuable.

FEMA's HAZUS Damage and Loss Modeling Software

The Federal Emergency Management Agency (FEMA) and various partners – including the National Institute of Building Sciences (NIBS) and Risk Management Solutions (RMS) – have developed a GIS-based model program for estimating potential loss due to earthquakes, floods, and wind hazards (USGS, 1999). This HAZUS methodology combines information on the nature of hazards with information on the built environment (**Figure 3**). Built-environment information includes infrastructure locations and characteristics for residential and commercial buildings, transportation lines (including highway, railway, light rail, bus, port, ferry, and airport systems) and utility systems (including potable water, wastewater, oil, natural gas, electric power, and communication systems). Within the HAZUS program, economic losses are estimated by assessing the probable damage caused by a given hazard event (expressed as a probability) and converting the percent damage information into an estimation of dollar loss.

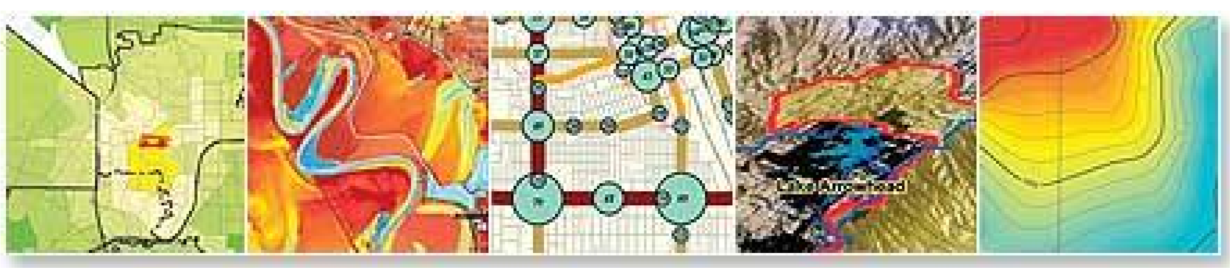

Figure 3. Schematics showing various HAZUS GIS layers (from www.fema.gov/hazus)

For indirect losses, the method is extended to include information about the community and its business links. HAZUS defines indirect losses as interruptions in businesses connections: all businesses rely either on regional customers to purchase their output, or rely on regional suppliers to provide their inputs. In this way a ripple effect is produced when one sector is affected. The magnitude of indirect loss depends on factors like the availability of alternate sources of supply and markets for products, the length of the production disturbance, and the deferability of production (USGS, 1999). Much more information on HAZUS is available online at http://www.fema.gov/hazus.

A Probabilistic Risk Assessment Case Study: The City of Portland Water Bureau

Following a similar framework as employed by HAZUS, the City of Portland has developed a probabilistic loss estimate for the Portland water network considering risks posed by landslides. The Portland Water Bureau is a medium-sized water utility that supplies water to over 840,000 customers in Portland, Oregon (Chang, 2003). The majority of the corridor that transports Portland's water supply is characterized by historic or active landslide terrain and landsliding has been a significant source of damage. Landslides have caused both direct damage to the system (conduits or bridges) and increased turbidity to a point that necessitated shutting down the surface water supply to Portland (forcing the Water Bureau to rely only on emergency groundwater supplies). One event, the Headworks Landslide in 1995, damaged two main conduits accounting for approximately 67% of the total capacity of Portland's main surface water supply. The mitigation cost for damage to the structure alone was estimated at $3 million dollars, but the conduits were also out of service for a period of six weeks (Portland Water Bureau, 2000).

In light of this and several other significant landslide events, the Portland Water Bureau has initiated risk assessments of its water supply system and components (Portland Water Bureau, 2000). In these studies, the Bureau has outlined performance levels for 100-year and 500-year interval events (the recurrence intervals for major storms and large earthquakes) and determined the reliability of individual components of the water supply system based on impact of the loss of distribution (Portland Water Bureau, 2000). Similar to HAZUS, these risk assessments rely on empirically-based assumptions regarding the impact of various scenarios and associated states of damage to infrastructure. The expected reliability level of water delivery is thus associated with certain hazards.

In looking at potential damage and probability information, reliability curves were developed that show the probability of damage as a function of hazard intensity (based on empirical data, testing, analysis, and engineering judgments). Based on bureau repairs, historic repair records and engineering judgments, restoration curves were also developed to estimate the time to repair components and get them back on line (Portland Water Bureau, 2000).

Both the estimated direct and indirect losses from a system failure are significant. In addition to the cost of direct landslide damage (the conduits cost about $200 million), the agency estimates $150,000 a day is lost in fee revenues when water delivery is interrupted. In addition to Water Bureau losses in fee revenues, other potentially-significant ramifications to outages include limited fire fighting capabilities, compromised hospital care, telecommunications disruptions, and a shutdown of industries using water for cooling or other processes (with daily losses up to $1 million estimated for some large water users). In addition, many restaurants, hotels, office buildings, and residences would of course be significantly impacted by the inaccessibility of the existing potable water supply (Portland Water Bureau, 2000).

In a complementary study conducted by Chang in 2003, the Portland water system was evaluated using an updated probabilistic hazard assessment using life-cycle cost analysis applied in a disaster context. Life-cycle cost analysis is closely related to cost-benefit analysis (in the use of probability techniques) and demonstrates the importance of considering changes over time, such as infrastructure deterioration, future management costs, and urban growth. The study also emphasizes societal impacts, and Chang estimates that, for the Portland Water Bureau, *societal losses from service disruption are likely to outweigh agency losses by 100 times* (Chang, 2003). While about half of municipal organizations use life cycle cost analysis, only half of these consider societal/hidden costs like environmental, business, and government impacts. The main reason cited for excluding these was the difficulty in determining them (Chang, 2003). Clearly, addressing or neglecting to address these impacts can seriously affect overall loss estimates.

In the study, societal costs associated with lifeline outage are limited to direct economic losses or business interruptions, although this technique could be expanded to include the financial costs associated with traffic delays, dispersed households, and other indirect economic impacts. Loss then would depend on the total outage level and how the outage is distributed spatially relative to economic activity (Chang, 2003). Based on the current methodology, it is estimated that, if no mitigation or maintenance is undertaken, over 90% of the total cost of a natural disaster like the Headworks landslide event ($339.2 million) would be borne by Portland Water Bureau customers.

Acting on these probabilistic results, the Portland Water Bureau is taking specific actions to mitigate landslide and other hazards along the public water system. Their strategy includes a proactive landslide monitoring and mitigation system program, including pipe leakage and surface drainage evaluation, with continued engineered channel mitigations (Portland Water Bureau, 2000). The Portland Water Bureau has also implemented a geologic study of aerial photos for potential slide locations, drainage studies to evaluate initiation sites, and identification of particularly vulnerable locations to mitigate or monitor (looking at slope indicators and pipe strains). These Portland Water Bureau efforts demonstrate the application of probabilistic techniques to both direct and indirect loss estimation and are indicative of the significant role indirect losses can play.

<u>Survey Data Collection from Personal Accounts</u>

When large landslide events (such as those resulting from earthquakes or severe storm events) occur, it is also relatively common for the impacts to be inventoried, along with some estimation of the direct damage costs. Much of this loss estimation can be done through surveys or interviews. For example, interviews were conducted in the California San Francisco Bay Area following the El Nino rainstorms of 1997-98 (Ellen and Wieczorek, 1998). In this and most other cases, interviewers were interested primarily in direct private damages. Through informal interviews with private property owners, businesses, construction contractors, and others, the losses as a result of mitigation efforts and other costs were collected (Ellen and Wieczorek, 1998). Similarly in Oregon, after large storms in 1996 and early 1997, there was widespread inventorying and data cataloging of landslide impact locations with some landslide loss data collection (Burns et al., 1998; Hofmeister, 2000).

One particularly valuable surveying approach for landslides is time-sequenced interviews for known damage locations. Interviews can be conducted at or very near the time of initial impact and then again some months (or years) after the event to arrive at estimates for indirect losses. These sequenced interviews can provide data to compare the validity of original estimates (contractor estimates, for example) versus actual dollar amounts spent. It is also valuable to compare estimates of probable damage to the actual damage recorded for various magnitudes and types of landslide events in order to evaluate the reliability of predictive estimations for future scenarios.

Portland, Oregon Inventory Case Study

The Pacific Northwest experienced much higher than normal amounts of precipitation in the winter of 1995-96. Heavy precipitation from February 6-9, 1996 triggered landslides all over Oregon in what was regarded as a 100-year landslide event (Burns et al., 1998). Damage was particularly widespread in the western half of Oregon (Hofmeister, 2000) and particularly in the Portland Metro area where landslides damaged infrastructure, residential buildings and property resulting in significant losses (FEMA, 1996; Burns et al., 1998).

Following these impacts, Portland State University students, led by Professor Scott Burns, conducted an extensive field investigation to develop an inventory of landslides in the Portland Metro area (Burns et al., 1998). Over 20 weeks, they collected information on 710 landslides in a roughly 500 square mile area. Information was obtained about each slide regarding the type of failure, size, and impacts. For a subset of slides with available information, direct damage information was also collected.

To better assess indirect losses for these slides, a follow-up survey was conducted this year (2004) to obtain information on costs incurred from relocations, lawsuits and court costs, housing value impacts, and other indirect costs. The survey involved returning to the original sites where direct damage estimates were collected and interviewing the parties involved. Some of the basic data targeted in the interviews is outlined in **Appendix A**, but the intent was to gather as much recall information as possible from impacted parties.

While the host of limitations regarding "recall interviews" are duly noted, a number of interesting and useful observations came out of this student-interview effort. Of particular interest was the collection of specific information on the magnitude of litigation costs for several of the damage cases. As has been reported in previous studies, the costs of urban landslide impacts can be high (see Table 2 for a summary of a few California sites). For several of the Portland area sites, litigation costs were also significant and in some cases exceeded the total value of the direct damages. Clearly it is important to consider this factor when gathering information for regional landslide loss estimations.

Table 2: Select U.S. Landslides with Significant Legal Costs

Date	Location/Event	Estimated Direct Damages	Estimated Lawsuit Cost	Source
1956-59	Portuguese Bend landslide (Palos Verdes Hills in Southern California)	$54 million to roads, homes, and other structures	County of Los Angeles an additional $50 million, as litigants claimed that road construction was responsible for initiating the failure	Vonder Linden, 1989
January 1982	Earthquake in San Francisco	Killed 30, 6500 homes and 1000 businesses were destroyed, total direct costs over $109 million	930 lawsuits against city and county agencies totaled over $489 million	Creasey, 1988
1983	San Clemente, California	$71.5 million	Litigation involved about $48 million	Taylor and Brabb, 1986
1983-84	Big Rock Mesa landslide, along the Malibu coast west of Los Angeles	Condemned 13 homes and threatened 300 more, which ranged in value from over $600,000 to $1.5 million	Cost of lawsuits filed against the County of Los Angeles was over $762 million	Association of Engineering Geologist 1984

Another significant item of information revealed in the sequential interviewing was specific documentation on assessed property devaluation for select sites. In some cases, not only did the assessed property value of the impact site plummet but neighboring sites also saw substantial drops, in some cases by over 50%. As a follow-on study, we are considering a more comprehensive evaluation of this important factor to obtain quantitative information for additional residential locations.

Overall, the sequential interviewing process provided corroboration of the importance of considering indirect costs in landslide loss estimation. Using just the minimum reported indirect impacts, the indirect dollar value loss was roughly equal to the direct damage value for the 54 sites with reported losses for both, indicating the importance of considering these associated costs.

Conclusion

Everyone involved in assessing indirect costs can attest to the difficulty of obtaining data and achieving a complete and accurate estimate, yet indirect loss estimation is vital for a more complete picture of overall landslide losses. As evidenced by examples in this report, indirect costs often exceed (and sometimes greatly exceed) direct costs.

The three methods presented in this paper provide some options for selecting loss estimation techniques. These methods include simple unit cost calculations (such as the road outage detour time example), probability-based risk assessments (such as those used by HAZUS and the City of Portland Water Bureau), and personal account surveys using inventories, interviews, and other records of economic impact (such as those used for the Portland Metro area).

When data is incomplete and/or resources are inadequate, some may question whether it's worthwhile to attempt estimating indirect losses. In establishing the indirect component of landslide cost, there is always some trade-off between the practicalities of loss assessment and the adequacy of details provided. However, the effort is still a worthwhile one. Representative loss estimation provides a basis for more informed decision making. As evidenced by positive steps taken by ODOT to proactively prioritize and plan for road impact detours and the City of

Portland Water Bureau to implement mitigation actions to better protect the water system from landslide impacts, more comprehensive loss estimation has led to on-the-ground actions to better plan for and protect our citizens from inevitable landslide impacts. With ongoing data collection and refinements in our loss estimation strategies, we can expect to see many more improvements in assessing indirect costs in the future.

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Appendix A: Portland Inventory Survey Data Collected

Slide ID number
Date of original investigation
Original investigator(s)
Date of second investigation
Second investigator(s)

Descriptive location of slide
County
Property owner/manager/contact

Slide description
- Process
- Geology/parent material
- Date of first movement
- Approximate volume
- Slope angle

Description of slope/property damage repair measures

Repair Costs
- Estimated repair costs
- Actual repair costs
- Who paid for the repairs

Indirect costs
- Relocation costs (rent, hotel, transportation)
- Loss of business (including rental income)
- Litigation
- Reduced real estate value
- Medical costs
- Environmental impacts
- Others

General description of overall impact from personal interviews