2007 Landslide Symposium:

New tools and techniques for developing regional hazard maps and future risk management practices

Presented by DOGAMI/USGS/ASCE/AEG

Landslide Symposium Program - Bios and Abstracts

Thursday April 26, 2007, 8:00 AM to 5:00 PM - Portland State Office Building
800 NE Oregon Street, Portland Oregon, 97232

Morning focus: DOGAMI/USGS partnership, state of practice/art methods, DOGAMI/USGS research, including bringing USGS Seattle-based research findings to Western Oregon - Moderator: Tova Peltz (GRI)

8:00AM - 8:10AM Welcome: Yumei Wang and Peter Lyttle (DOGAMI Geohazards Section Leader, USGS Landslide Hazard Program Coordinator)

8:10 AM - 8:30 AM Yumei Wang (DOGAMI) "DOGAMI/USGS partnership on landslide risk reduction: DOGAMI's Landslide Efforts"

BIOGRAPHY

Yumei Wang's expertise is in science, engineering, and technology policy; natural-hazard analyses and risk reduction, and sustainable engineering practices. Since 1994, Ms. Wang has worked as a geotechnical engineer at the Oregon Department of Geology and Mineral Industries (DOGAMI) where she leads the Geohazards Section, and focuses on lowering risks from earthquakes and landslides.

Ms. Wang has been influential in enacting public policies in her expertise areas, including in 2000, co-developing earthquake safety laws as chairperson of the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) that were enacted in 2001. Later, in 2004, she led a diverse task force that culminated into complementary earthquake safety laws in August 2005 that focus on statewide earthquake risk management. She co-led an engineering investigation on the 2004 Sumatra earthquake and tsunami and participated in two subsequent BBC science documentaries. She is a commentator in "Megaquake," which has aired on the Discovery Channel (2005), and "Earthquake Alert" that has aired on the National Geographic channel (2006). In 2007, she was appointed as one of 15 national advisors to the National Earthquake Hazards Reduction Program. In 2006, she was awarded Government Engineer of the Year by the American Society of Civil Engineers (ASCE) Oregon Section. In 2000,

Yumei served a one-year term as a Congressional Fellow in the U.S. Senate in Washington DC. The ASCE-funded fellowship was hosted by the American Association for the Advancement of Science (AAAS). She has over three-dozen technical publications, serves on local and national advisory commissions and committees, and is a frequent speaker at events. She is adjunct faculty at the Portland State University Civil and Environmental Engineering Department. Before coming to Portland in 1994, she had a geotechnical consulting practice in Oakland, California. She obtained a master's degree in Civil Engineering at the University of California in Berkeley in 1988 and a bachelor's degree in Geological Sciences at the University of California at Santa Barbara in 1985.

ABSTRACT
Oregon is vulnerable to many geologic hazards, including flooding, landslides, and coastal erosion caused by heavy winter storms every year. Landslides cause tens-to-hundreds of millions of dollars of damage per year in Oregon, and current development practices and continued growth will only contribute to higher losses in the future. DOGAMI's landslide program, including its establishment, goals and selected publications surrounding various landslide issues is discussed. In 2005, the U.S. Geological Survey (USGS) funded DOGAMI to collaborate on the multi-year Western Oregon Landslide Project. This partnership between DOGAMI and the USGS has provided DOGAMI a major opportunity to make significant improvements to its landslide program. A brief description on how the Western Oregon Landslide Project was initiated is given. Last, an overview of DOGAMI's efforts as part of the DOGAMI-USGS partnership is provided.

DOGAMI Landslide Program
Oregon Department of Geology and Mineral Industries (DOGAMI) started the DOGAMI Landslide Program in 1999 as a result 1996-1997 storm damage and state directives. The program goal is to conduct targeted landslide risk reduction through landslide risk management as a means to protect communities from unnecessary danger and property damage. Oregon's landslide risk management strategy includes five parts: 1) engaging stakeholders, 2) landslide hazard identification, 3) risk assessment, 4) risk management through prioritization of risks, and 5) mitigation. Figure 1 lists these five parts with examples of actions for each part—forming an "Oregon Landslide Workgroup" under "engaging stakeholders" is one example. It also depicts how these five parts are being integrated. Some of the activities of the program include: increasing awareness through education, brochures, field trips, existing landslide and landslide hazard maps; assisting local jurisdictions with technical expertise on sustainable policies and ordinances; and, supporting a statewide landslide warning system. For many years, the activities were sporadic and minimal due to funding limitations.

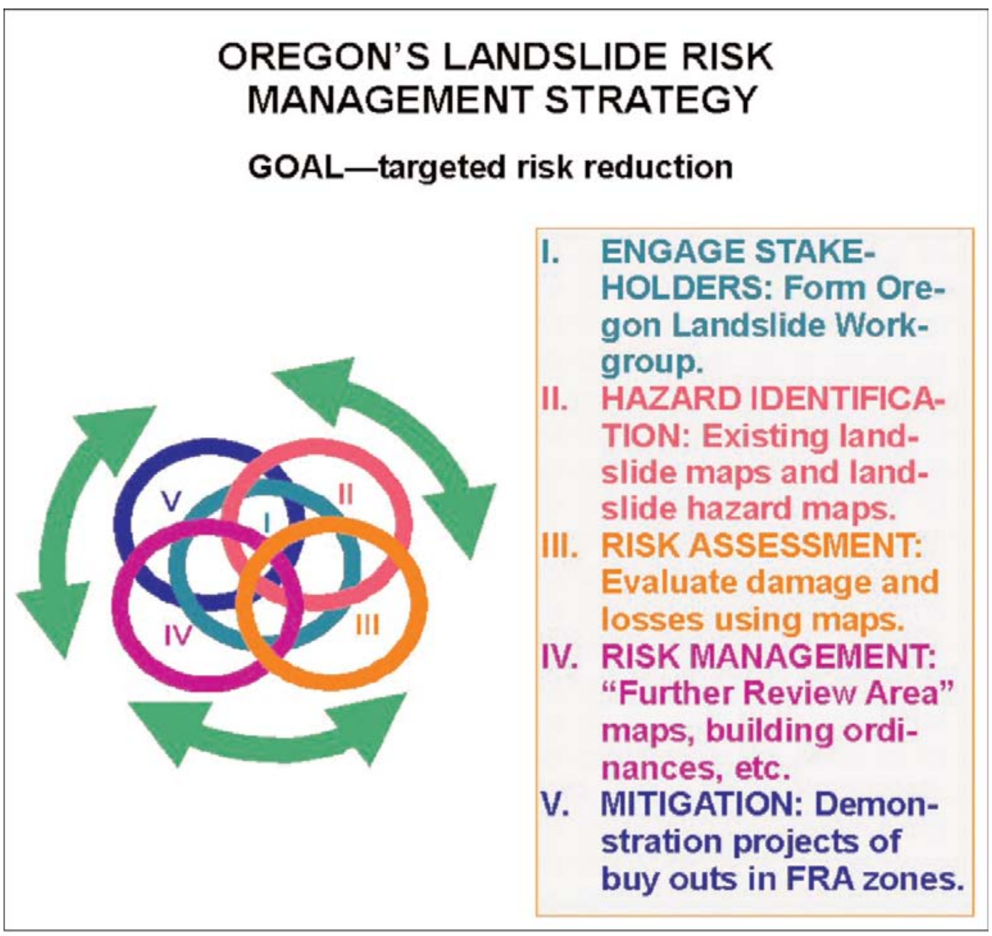

Figure 1

8:30 AM - 8:50 AM **Jeff Coe** (USGS) "Overview of USGS Landslide Research in Oregon"

By Jeffrey A. Coe (jcoe@usgs.gov), Rex L. Baum, William L. Ellis, Jonathan W. Godt, Edwin L. Harp, Lynn M. Highland, Jonathan P. McKenna, and William H. Schulz, U.S. Geological Survey, Denver, Colorado, and Mark E. Reid, U.S. Geological Survey, Menlo Park, California

ABSTRACT
In late 2004, the Landslide Hazards Program of the USGS began a multi-year, collaborative research program on landslides in Oregon. Collaborating organizations include the Oregon Departments of Geology and Mineral Industries, Forestry, and Transportation; the US Forest Service and Bureau of Land Management, Portland State University, and the USGS Cascades Volcano Observatory.

Several collaborative research topics have been identified so far, most of which are in the early stages of data collection. These topics include (1) the study of sediment entrainment by rapidly moving landslides (i.e., debris flows), (2) an examination of how hillslope hydrology affects landslide occurrence and reactivation, and (3) landslide hazard assessments of selected urban areas and transportation corridors in western Oregon. Study areas include coastal, Coast Range, and inland settings.

The study of sediment entrainment will utilize detailed sediment budgets determined from field and photogrammetric measurements of natural channels, as well as from experiments at the USGS debris-flow flume near Eugene. The hydrologic studies can be further subdivided into research on (1) rainfall intensity and antecedent soil wetness for the occurrence of landslides and (2) the relationship between rainfall, pore-pressure rise, and movement of landslides. The hydrologic research relies on a combination of instrumental monitoring, laboratory experiments, numerical modeling, and statistical analysis. The hazard assessment work will utilize airborne LiDAR data acquired during the winter and spring of 2007 and will incorporate results from our other research.

Our collaborative research seeks to develop landslide-hazard information and hazard assessment tools that are applicable to Oregon and transferable to other areas of the United States to reduce the loss of life and damage caused by landslides.

8:50 AM - 9:20 AM **Steve Dickenson** (OSU) "State of practice and state of the art predictive tools, and future direction"

Stephen Dickenson, Associate Professor, Department of Civil, Construction, and Environmental Engineering, Oregon State University

BIOGRAPHY
Professor Dickenson has been active in geotechnical education, research, and consulting for almost 20 years. His areas of research specialization have focused primarily on ground failures and soil-structure interaction, with an emphasis on seismically-induced soil deformations. He has greatly enjoyed working with talented students and geo-professionals on a variety of slope stability projects including; the performance of earth dams and native slopes during rapid drawdown conditions, stability of Columbia River levees during flood and earthquake events, landslide initiation in shallow forest slopes of the Oregon Coast Range, mechanics of slope deformation for coastal landslides, the initiation of submarine landslides, and the seismic performance of waterfront slopes and rubble mound breakwaters at ports.

Dr. Dickenson and his students have employed a variety of numerical tools for modeling the static and dynamic performance of slopes. The results of this applied research have culminated in numerous technical papers, reports, and design guidelines for engineers. A notable example is the ASCE-TCLEE monograph "Instrumentation for Monitoring the Performance of Port and Coastal Infrastructure," which includes guidance on integrated instrumentation programs for monitoring of waterfront slopes during daily operations and extreme events. Prof. Dickenson served as co-author and editor of this book, which is scheduled for publication by ASCE during the summer of 2007.

ABSTRACT
The increasing adoption of reliability analysis and performance-based design concepts by organizations that manage and maintain transportation systems requires the quantification of uncertainties associated with current procedures for simulating the performance of earth structures, excavated slopes, and natural slopes. Specific applications include the development of LRFD methods for geotechnical aspects of surface transportation projects, and the application of performance-based design standards by numerous ports and agencies within the maritime transportation system. In both cases the predictive capabilities of widely-used models for evaluating slope stability and permanent ground deformations, the latter of which is more important in most cases involving soil-structure interaction, is widely varying. This presentation will focus on the application of numerical models for several projects in the Pacific Northwest and address the strengths and limitations of these tools.

Attempts to gauge the directions for applied research are made in response to perceived limitations of the current tools for simulating the field performance of slopes and earth structures. The presenter believes that while incremental enhancement to existing predictive tools can be made with improvements to constitutive models, 3D modeling procedures, and methods of visualization, more broad ranging improvements in slope modeling can be made by developing methods for the direct integration of field data (survey, geophysics, and geotechnical) into the numerical models. Advances in the use of surveying techniques such as LIDAR represent a worthwhile step in this direction. The development of methods for inputting geo-spatial data directly into 3D numerical models is a goal that has been expressed by several agencies. The latter portion of the presentation will address recommendations for integrated site characterization and monitoring with the goal of increasing the reliability of numerical modeling efforts.

9:20 AM - 9:40 AM George Priest, DOGAMI "Research Investigations at the Johnson Creek Landslide, a Cooperative Effort of Private, State, and Federal Partners"

George R. Priest and Jonathan Allan, Oregon Department of Geology and Mineral Industries (e-mail: george.priest@dogami.state.or.us)

BIOGRAPHY
George R. Priest has a doctorate in geology from Oregon State University and has worked for the Oregon Department of Geology and Mineral Industries (DOGAMI) since 1979 managing at various times geothermal, earthquake and coastal research programs. Prior to the DOGAMI position he worked as an assistant professor at Portland State University and as an exploration geologist in the mineral and geothermal industries. He currently works part time in the DOGAMI Coastal Field Office in Newport.

ABSTRACT
The Johnson Creek Landslide is a large translational slide in seaward-dipping Astoria Formation that cuts the coastal bluff 6 km north of Newport, Oregon. The slide is the subject of a five-year research project started in the fall of 2002 and supported by the Oregon Department of Transportation (ODOT) Research Program, utilizing a Federal Highway Administration (FHWA) grant. The project aimed to find out what makes this and similar slides move and determine the most cost effective means of slowing or stopping movement. In 2002, a line of six borings with piezometers and inclinometers were completed east-west across the west-directed slide. Later, manual extensometers were installed in the inclinometer borings when slide movement made it impossible to conduct inclinometer surveys through the

basal slip zone. A raingauge was also installed. Raingauge and piezometer data were recorded hourly by individual dataloggers, but the extensometers were measured manually and at irregular intervals. Precise correlation of rainfall, pore pressure, and landslide movement was therefore not possible because the extensometer data was not recorded simultaneously with the other hourly data.

In November 2004 the U.S. Geological Survey (USGS) Landslide Hazards Program installed new dataloggers at the site and connected electronic transducers to the extensometer cables so that all of the instruments could be recorded concurrently. The dataloggers were later equipped with cell-phone telemetry such that data could be collected remotely and at regular and more frequent intervals. In the fall of 2006 additional piezometers were installed to better characterize the hydrology of the slide. This paper summarizes data and interpretations compiled before the 2004 installation of USGS instruments and draws heavily from Priest and others (2006). The companion paper by Ellis and others (2007) summarizes the later data.

The central part of the landslide has a total displacement of ~28 m horizontal and 6 m vertical based on a ba anced cross section. Offset of the Old Coast Highway since its abandonment in 1943 until 2004 is 3.35 0.6 m horizontal and 0.91 0.05 m vertical, indicating a mean movement rate of 5.4 1 cm/yr horizontal and ~1.5 0.08 cm/yr vertical. The slide plane dips seaward, cutting though weak siltstone units and generally deflecting along the top of more competent sandstone and zeolitized tuff beds. In the northern 85 percent of the slide, the slide plane reaches below sea level and then curves upward at the toe of the slide, rotating the westernmost slide block backward and overriding slide talus on the beach. In the southern 15 percent of the slide, the slide plane at the toe is relatively flat but still has a back-rotated slide block at the sea cliff. Six slide movements were recorded by inclinometers or extensometers between 2002 and spring of 2004, all correlating with intense rainfall events that trigger large increases in piezometric head.

The largest single slide movement so far observed occurred at the end of January 2003. At the latitude of the boreholes the slide moved a maximum of ~24 cm during this event. Only minor offset of the Highway 101 occurred at the northern slide margin during the January event, but a resurvey in April 2003 of marker pins emplaced October 2002 revealed that movement increased toward the southwest to values as large as ~130 cm at the toe of the slide. The slide at the southwest toe is flat rather than forming an east-inclined buttress as it does to the north.

Extensometer and resurvey data revealed that interior blocks within the slide moved at different rates during the January 2003 event, creating areas of extension, compression, and lateral movement within the slide. Later events in 2003-2004 were all slow creeping movements each of <4 centimeters lateral (<1 cm vertical) that caused only minor highway damage. Marker nails monitored around the slide perimeter and data from extensometers in the center of the slide during the slow movement event in March 2003 revealed that the slide moved approximately equal amounts in the center and at the north, south and east margins.

These data indicate two distinctive styles of slide movement, slow and fast, with differential offset within the slide occurring principally during the fast movements. Only 1.5-2.7 m of head separates slow versus fast slide movement, so lowering of piezometric head by ~3 m would probably eliminate the most dangerous, highly damaging slide movements.

Piezometric elevation head in a sand pack 3-6 m below the slide plane is 4-6 m lower than head at the slide plane, illustrating the lack of hydraulic communication into relatively unfractured Astoria Formation at these depths below. Installation in 2006 of piezometers ~1 m below the slide plane allowed water pressure closer to the slide plane to be measured (see companion paper by Ellis and others, 2007, for results). Hourly piezometer data from above the slide plane reveals that spikes in pressure head occur progressively from east to west (down the hydraulic gradient) over a period of 30-44 hours in response to large rainfall events.

About 90 mm of hourly head rise occurs for each millimeter of hourly rainfall at a piezometer located in marine terrace sand near the head of the slide. Intergranular void space in the terrace sand is~40 percent, but the large rise in piezometric head (90 times the rainfall) can be accommodated only if the voids being filled comprise ~1.1 percent of the terrace sand. Field estimates of fracture voids in a structural position within the slide identical to this drill site were also ~1.1 percent. These data and field observations of the slide fracture system are consistent with pressure head "spikes" at the head of the slide being caused by downward percolation of rain into ~1 percent fractures spaced ~0.3 m apart in the slide mass.

Since movement is triggered by rainfall and correlative water pressure increases, dewatering should be an effective remediation option. A significant amount of the water in the slide is from direct rainfall percolating into well-connected, fractures that appear to effectively drain groundwater after each rainfall event, so dewatering schemes should be efficient. Modeling of slide forces revealed that dewatering and slowing or eliminating toe erosion is important in achieving an increase in the factor of safety (Landslide Technology, 2004). Erosion has been monitored since May 2004 through ground based LIDAR surveys, one in October 2006 and another in April 2007. Other remediation options such as buttressing, tied-back shear pile wall, or draining the upper part of the slide with perforated pipes were also examined by Landslide Technology (2004) but were found to be too high in cost relative to maintenance of the road.

References Cited: Landslide Technology, 2004, Geotechnical investigation Johnson Creek Landslide, Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-04-05, 115 p, published on CD. Priest, G.R., Allan, J., Niem, A., Christie, S.R., and Dickenson, S.E., 2006, Interim report: Johnson Creek landslide project, Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-06-02, 65 p, 10 appendices. Ellis, W.L., Schulz, W.H., Baum, R.L., and Priest, G.R., 2007, Hydrogeologic Investigations at the Johnson Creek Landslide – Recent Data, Results and Future Plans: Extended abstract submitted to the Landslide Symposium, Portland, Oregon.

9:40 AM - 10:00 AM Bill Ellis, Bill Schulz, Rex Baum and George Priest (DOGAMI and USGS) "Hydrogeologic Investigations of the Johnson Creek Landslide - Recent Data, Results and Future Plans" (2 of 2)

William L. Ellis,1 William H. Schulz,2 Rex L.Baum,3 and George R. Priest4
1U.S. Geological Survey, Denver Colorado, ellis@usgs.gov 2U.S. Geological Survey, Denver, Colorado, wschulz@usgs.gov 3U.S. Geological Survey, Denver, Colorado, baum@usgs.gov 4Oregon Department of Geology and Mineral Industries, george.priest@dogami.state.or.us

ABSTRACT
Near real-time monitoring of the Johnson Creek landslide, located on the Oregon coast about 7 km north of Newport, has provided detailed data on the geohydrology and movement behavior of the landslide. In November, 2004, new data acquisition systems were installed to monitor existing instrumentation at the site and new instrumentation was added that allowed, for the first time, the simultaneous recording of precipitation, groundwater pressure, and landslide movement. In early 2006, cellular modems were incorporated into the data acquisition systems so that the data could be accessed remotely and more frequently. In November, 2006, fourteen additional piezometers were installed in four new boreholes. Two vertical arrays of six piezometers each were installed using the grout-in method in two boreholes, and single piezometers were installed inside slotted casing near the bottom of two additional boreholes. The vertical-array piezometers were installed to determine groundwater pressures at different levels within, and just below, the landslide. The single-piezometer installations are for monitoring water levels and may be used for future hydrologic testing. Shallow soil-moisture sensors were also installed at two locations near the data acquisition systems on the landslide.

Between March, 2003 and December, 2005, a period that corresponded to unusually dry climatic conditions for the region, no measured movement of the landslide occurred. With the return of more characteristic rainfall conditions

in the winter of 2005-2006, several episodes of landslide movement totaling a few centimeters occurred that yielded detailed data on the relationship between precipitation, groundwater pressure, and the onset of movement on time intervals as short as fifteen minutes. Although an approximate groundwater-pressure threshold for landslide movement could be identified for each movement episode, the threshold was not always consistent between episodes and sometimes decreased with later episodes. Additionally, the timing and variation of groundwater-pressure response to rainfall between three locations on the landslide was found to vary temporally, even when there was no measurable landslide movement. In the winter of 2006-2007, intense rainfall events again produced several episodes of minor movement. The groundwater pressure thresholds at which these movements occurred were similar to those of the previous year, but the peak groundwater pressures were less than recorded in the previous winter. The total landslide movement in 2006-2007 was also less than in 2005-2006, although the total yearly rainfall amounts were similar.

Data from the vertical piezometer arrays installed in late 2006 indicate approximately slide-base parallel groundwater flow and a very weak vertical hydraulic gradient, even across the basal shear zone. This observation contradicts previous observations in 2003 that indicated groundwater pressure beneath the basal shear was significantly less than groundwater pressures just above the shear zone. The vertical piezometer arrays also indicate that groundwater-pressure increases occur almost simultaneously at all elevations within the saturated zone following significant rainfall events, verifying previous interpretations of a high effective hydraulic conductivity within the landslide mass. Although the piezometers in the unsaturated zone detect some apparent surface infiltration, the timing of the pressure increases suggest that vertical infiltration is not the primary cause of groundwater pressure increases where the water table is relatively deep. Instead, infiltration near the head of the slide, where the water table is near the surface, appears to produce lateral pressure transmission and groundwater flow that is the primary cause of groundwater pressure increases throughout the landslide. The groundwater flow gradient is also observed to be greatest between two locations in the central part of the landslide where previous geologic interpretations indicated the possible presence of a near-vertical fault.

Based on recent observations of minor movement, the following sequence of events typically occurs. Significant rainfall causes a rapid increase of the groundwater pressure near the head of the landslide, which is followed by a progressively more gradual and delayed increase in groundwater pressures at locations farther down the landslide. This is consistent with earlier observations that groundwater pressure increases travel from east to west (headscarp toward the toe). When the basal shear-zone groundwater pressure near the center of the landslide reaches an approximate threshold value, the landslide begins to creep almost uniformly. Groundwater pressures near the center of the landslide therefore seem to be the critical factor in controlling landslide movement.

Potential future work includes continued monitoring of the landslide and further interpretation and analysis of the data. Ideally a rapid landslide movement event could be captured in future monitoring efforts to determine groundwater pressures at the onset of rapid movement. Hydrologic testing may be conducted during the summer months using the existing boreholes and instrumentation to help quantify the hydrologic properties of the landslide mass. The potential influence of toe erosion on triggering landslide movement is also an area of needed future research, as is the degree of similarity between behavior of the Johnson Creek landslide and other coastal landslides.

10:00 AM - 10:20 AM Break - Coffee Service, breakfast goodies

10:20 AM - 10:40 AM Mark Reid (USGS) "Assessing regional instability using 3-D groundwater flow and 3-D slope-stability analyses"

Mark E. Reid and Dianne L. Brien, U.S. Geological Survey, 345 Middlefield Road, MS 910, Menlo Park, CA 94025 USA, 650-329-4891 mreid@usgs.gov

ABSTRACT
Deep-seated, large landslides are driven by the interplay between gravitational stresses induced by complex topography and the three-dimensional (3-D) subsurface distribution of soil or rock shear strength. In addition, saturated groundwater flow patterns in hillslopes commonly produce 3-D distributions of pore-fluid pressure and locally elevated positive pore pressures are typically destabilizing. One-dimensional methods are inadequate to fully capture all of these effects. We have developed a 3-D slope-stability model, SCOOPS, that allows us to search a digital elevation model (DEM) and determine the least-stable areas. We use a 3-D version of Bishop's simplified limit-equilibrium analysis that incorporates 3-D arcuate potential failure surfaces, 3-D variations in material properties, 3-D pore-fluid pressures, and pseudo-static earthquake shaking effects to determine regions of minimum stability. By computing the stability of millions of potential failure surfaces, we can map the relative stability of all regions of a landscape. Moreover, unlike 1-D or 2-D analyses, our 3-D model can calculate the volume of potential failures, making it particularly useful for quantitative hazard analyses.

We successfully applied this approach to volcano edifices prone to massive flank collapse and to coastal bluff landslides affected by regional 3-D groundwater flow. For the Mount St. Helens volcano edifice with relatively uniform material properties, a 3-D analysis using topography alone provides a good post-failure assessment of the location and volume of the catastrophic 1980 collapse. At Mount Rainier volcano, both topography and a 3-D distribution of weaker, hydrothermally altered rocks are needed to adequately identify regions of past instability. In Seattle, Washington, we analyzed the 3-D slope stability of coastal bluffs using pore pressures from a 3-D groundwater flow model, constructed using MODFLOW, combined with 3-D heterogeneous strength properties. Groundwater flow patterns were calibrated using observed water level data. Here, groundwater flow is 3-D, resulting in a perched shallow groundwater table and groundwater convergence in coastal re-entrants; both effects create regions of lower stability. In all these cases, the 3-D effects of topography, strength, and pore pressure determine the location and size of potential landslides.

10:40 AM - 11:00 AM Rex Baum (USGS) "Modeling transient rainfall-induced pore pressure and slope instability"

Rex L. Baum, Jonathan W. Godt, and William Z. Savage, U.S. Geological Survey, Box 25046, M.S. 966, Denver, CO 80225-0046, baum@usgs.gov

ABSTRACT
Precipitation is one of the most common external factors in the occurrence of landslides and debris flows in western Oregon and throughout the U.S. Seasonal and long-term precipitation raise soil moisture and groundwater levels and thereby contribute to landslide occurrence or reactivation, but intense precipitation induces (or triggers) most shallow and many deep landslides. Predicting the timing of rainfall-induced landslide movement is an important aspect of landslide hazard assessment. Understanding and predicting the magnitude and timing of rainfall-induced pore pressure changes in landslides and steep slopes can be aided by real-time monitoring and by mathematical models that represent the physical processes of rainfall infiltration and pore-pressure transmission below the water table.

The transient effects of rainfall can be represented by vertical flow superimposed on the initial flow field. We modeled the infiltration process using a two-layer system that consists of an unsaturated zone above a saturated zone, and

then implemented this model in a GIS framework. The model joins analytical solutions for transient, unsaturated, vertical infiltration above the water table to pressure-diffusion solutions for pressure changes below the water table. Pore pressure rise that occurs as water accumulates at the base of the unsaturated zone drives pressure diffusion below the initial water table. This scheme, though limited to simplified soil-water characteristics and moist initial conditions, greatly improves computational efficiency over numerical models in spatially distributed modeling applications. Pore pressures computed by these models are subsequently used in slope-stability computations to estimate the timing and locations of slope failures.

Preliminary model results indicate that the unsaturated layer attenuates and delays the rainfall-induced pore-pressure response at depth when compared with results of linear models for suction-saturated initial conditions, consistent with observations at instrumented hillsides. For shallow landslides, the attenuation reduces the area of false-positive predictions of slope instability in distributed application of the model over an area. Modeling indicates that initial wetness of the hillside materials affects the intensity and duration of rainfall required to induce shallow landslides and, consequently, the timing of their occurrence, a result that is consistent with observations of landslide occurrence in the Seattle area. Beyond aiding our understanding of the mechanisms and timing of shallow landslides, the model can be applied to forecasting landslide occurrence using real-time precipitation data and quantitative precipitation forecasts. The model also can be used for deterministic modeling of rainfall thresholds based on topography, mechanical and hydraulic properties of hillside materials, and rainfall patterns. Preliminary results also indicate that a similar modeling approach can explain the timing of rainfall-induced pore-pressure rise in certain deep landslides.

11:00 AM - 11:20 AM Bill Burns (DOGAMI) "Comparison of mapping techniques in the Portland hills pilot study area"

Bill Burns, Oregon Department of Geology and Mineral Industries, Portland, OR - bill.burns@dogami.state.or.us

BIOGRAPHY

Bill is a registered Professional Geologist (RPG) and Certified Engineering Geologist (CEG) in Oregon and Washington. He spent roughly 10 years consulting as an engineering geologist in Oregon and Washington before his current position as Landslide Geotechnical Specialist at the Oregon Department of Geology and Mineral Industries (DOGAMI). His areas of expertise include engineering geology, geomorphology, landslide hazards mapping, and landslide hazard susceptibility.

ABSTRACT

Many parts of Oregon are highly susceptible to landslides, particularly in the portions of the state with moderate to steep slopes and a wet climate; landslides pose significant threats to people and infrastructure. As population growth continues to expand and development into steeper terrain occurs, greater losses from landslides are likely to result.

DOGAMI is working on collaborative landslide research with the US Geological Survey (USGS) to identify and understand landslides in Oregon. In order to begin the extensive undertaking of mapping the existing landslides throughout Oregon, a pilot project area was selected to compare remote sensing data/images for effectiveness. In order to compare the remote sensing datasets, six individual mappers with landslide mapping experience participated in the study. One mapper used all five datasets and the five other mappers each used one dataset a piece to located landslides and provide some basic information (Table 1). The remote sensing datasets compared include:

1) 30 m digital elevation model (DEM) from the Shuttle Radar Topography Mission
2) 10 m DEM derived from the USGS topographic quadrangles
3) photogrammatic and ground based 5 ft interval contour data set
4) stereo aerial photographs from 1936 to 2000

5) light detection and ranging (LIDAR) with an average of 1 bare-earth data point per m2 and 15 cm vertical accuracy

Four preliminary key findings were: 1) the use of the LIDAR data resulted in the identification of between 3 to 200 times the number of landslides found with the other data sets, 2) the LIDAR data resulted in consistently finding small landslides, 3), the accuracy of the spatial extent of the landslides identified was greatly improved with the LIDAR data, and 3) the results varied with the individual mappers.

In general, the results strongly suggest the necessity of LIDAR data in order to even locate many of the smaller landslides and to accurately locate all landslides. However, LIDAR alone is not enough data to produce a quantitative and qualitative landslide map. Several strategies were found while working on this study which will aid in the development of a procedure for mapping landslides in Oregon and other places similar to Oregon including:

1) The compilation of all previously identified landslides from geologic maps, previous landslide studies, and other local sources is a critical starting point
2) The mapper should have experience identifying all types and ages of landslides within the area being studied
3) LIDAR data should be used to identify landslides and accurately locate the extents of the previously mapped landslides from step 1
4) An orthophoto of similar age to the LIDAR data should be used in combination to minimize the identification of man-made cuts and fills as landslides
5) The mapper should use at least one set of historic stereo-pair aerial photography to located landslides in the area being studied
6) Non-spatial data should also be collected at the time of the mapping so that a comprehensive database can be formed
7) A comprehensive check of the data including some field checks should be developed and implemented

These strategies are not alone enough to produce a quantitative and qualitative landslide map, but will aid in reaching this goal. DOGAMI is currently working on creating a landslide map of the study area and most of the Portland Hills using the above minimal requirements.

Table 1. Comparison of the general results of the landslides located using all data sets by a single mapper and each data set by individual mappers.

	Dataset	USGS 10 m DEM	City PDX Data	Stereo-Pair Aerial Photograph (1973)	LIDAR
Single Mapper	Time (hours)	6	10	21	37
	Smallest Landslide (m^2)	106,988	5,330	2,019	80
	Largest Landslide (m^2)	7,208,710	7,216,927	6,048,897	5,993,277
	Total Number of Landslides	**11**	**34**	**31**	**211**
Individual Mappers	Time (hours)	8	11	10	39
	Smallest Landslide (m^2)	34,693	1,694	8,111	28
	Largest Landslide (m^2)	309,185	3,050,746	959,016	92,640
	Total Number of Landslides	**6**	**69**	**18**	**151**

This project was funded through the USGS Landslide Hazard Program Partnership for the Western Oregon Landslide Project, with special thanks to Peter Lyttle, Paula Gori, and Rex Baum. The author is very grateful to the individual

mappers who provided valuable information along with the contribution of many hours of time identifying landslides in the study area.

11:20 AM - 11:40 AM Jeff Coe (USGS) "Use of landslide inventories for hazard and risk assessment, some recent examples from the western U.S."

Jeffrey A. Coe, U.S. Geological Survey, Denver Federal Center, MS 966, Denver, CO 80225 (jcoe@usgs.gov)

ABSTRACT
Regional landslide inventories are often the first product needed for landslide hazard and risk assessments because they provide ground truth data that can be used to calibrate and validate landslide prediction models. In the western U.S., numerous regional landslide inventories have been compiled; many by state agencies and the USGS. The type and quality of inventory data vary considerably as a function of the needs of the group, or groups, doing the compilation. The most useful inventories are usually those that were compiled with specific goals in mind before starting the inventory process, or those that were compiled or coordinated by single agencies, rather than by multiple agencies with different interests and agendas.

The spatial components of inventories are typically one-dimensional points or two-dimensional polygons. Point data have been used successfully in Seattle to estimate landslide initiation and probability, and in San Francisco to estimate future economic losses from landslides. Inventories composed of points are rarely useful for studies of landslide travel distances or volumes. Two-dimensional polygons offer an improvement over point data in that they account for both landslide initiation locations and total travel distances. The primary limitation of polygons is that the initiating landslide, transport paths, erosion and entrainment, and deposits are often lumped together, making studies of individual landslide components difficult. Two-dimensional data have been used successfully for landslide hazard studies in Colorado, California, Washington, and Oregon, but these studies often focus on landslide initiation, rather than travel distance or landslide volume.

Debris flows and deep-seated slides are the types of landslides that seem to cause most problems in Oregon. An extensive inventory of predominantly shallow slides and debris flows was compiled following extreme precipitation in Oregon in 1996 and 1997. This inventory was compiled by various government, academic, and private sources, and therefore covers a large area, but is somewhat inconsistent in the types of data that were recorded. This inventory formed a partial basis for the fast-moving landslide (debris flow) prediction maps that are currently available on the web. Currently, DOGAMI has a major ongoing effort to compile a state-wide, deep-seated landslide inventory map from existing geologic maps, as well as from newly acquired LiDAR data. Inventories of debris flows, however, are more difficult to compile (compared to inventories of deep-seated landslides) for several reasons. First, because debris flows tend to be relatively small, large-scale regional mapping is needed to adequately portray individual flows in the inventory. Second, an important feature of Oregon debris flows is that they often initiate as small slides that increase in volume (i.e., "bulk up") by eroding and entraining large amounts of hillslope and/or channel debris. Therefore, a typical two-dimensional polygonal portrayal of debris flows does not adequately capture locations of erosion and entrainment that seem essential for hazard analyses and assessments. Third, because volume bulking is a typical characteristic of Oregon debris flows, inventories should attempt to quantify bulking in the form of a volumetric sediment budget, wherever possible.

One of the objectives of the recently started USGS work in Oregon is to gain a better understanding of debris flows that grow by erosion and entrainment. The existing landslide database in Oregon is difficult to use for entrainment studies because it generally doesn't include volume estimates from erosion and entrainment locations. Our approach has 3 major components, 1) experimental entrainment studies at the USGS flume near Eugene; 2) two-dimensional inventory mapping which distinguishes between landslide source, erosion, transport, and deposition; and 3) three di-

mensional inventories (volumetric sediment budgets) of specific debris flows where erosion and entrainment have occurred.

The USGS is currently mapping a debris-flow inventory in the central Coast Range on both sides of Highway 38 between Reedsport and Elkton at a scale of 1:12,000. Mapping is being done using 1:12,000-scale, 1997 aerial photographs and a photogrammetric stereo plotter. The central Coast Range also provides an ideal location to attempt inventory and volumetric studies because 1) debris flows occur frequently and therefore provide many potential study sites, 2) 1:12,000 scale aerial photos are flown about every 5 years and therefore provide an excellent data source for pre- and post-flow measurements of topographic profiles and Digital Elevation Models (using an analytical stereo plotter) for estimating sediment budgets, and 3) large parts of the area are industrial forest and are routinely clear cut, making it easy to see the ground in pre- and post-flow aerial photos.

The critical importance of clear cuts for sediment budget work was impressed upon us when we attempted to use pre- and post-event aerial photographs to determine a sediment budget for the 1996 Dodson debris flow in the Columbia River Gorge. We were able to measure a post-flow DEM of the entire debris flow area, but were not able to measure a pre-flow DEM because trees prevented us from seeing portions of the ground. We were able, however, to measure pre- and post-flow topographic profiles along the debris flow path. Preliminary results from a comparison of the two profiles indicates that about 50% of the total debris-flow volume was generated through entrainment of channel sediment at and near the head of the debris fan. Average incision at the head of the fan was about 4.5 m and the maximum incision was about 6 m. Thus far, observations made during inventory mapping near Reedsport indicate that entrainment locations for debris flows in the Coast Range are not at the heads of fans, but rather in steep channel reaches between slide source areas and fan heads. This presentation will include a short summary of preliminary results from the Gorge and Coast Range studies.

11:40 AM - 12:00 N Bill Schulz (USGS) "Estimating landslide susceptibility on a regional basis using LIDAR imagery and historical landslide records"

William H. Schulz, U.S. Geological Survey, Box 25046, MS-966, Denver, CO 80225

ABSTRACT
Landslides have posed a significant hazard in Seattle, Washington since at least the late 1800s, in part because many landslide features are obscured by dense vegetation. LIDAR-derived imagery can reveal these features and was used to map Seattle landslides and landslide-related landforms. Imagery used for mapping included shaded relief maps with various sun orientations and vertical exaggeration, slope maps, curvature maps, and topographic contour maps. Vertical exaggeration was not useful for mapping, and shaded relief maps were best used in tandem because features on a given relief map that are washed out or heavily shaded should be revealed on a relief map with a different sun orientation. Topographic contour maps were the most useful for identifying landslide features. LIDAR aided in the identification of 173 landslides and associated headscarps, which is nearly four times the number identified by previous mapping efforts that used field and photogrammetric methods. Most of the LIDAR-mapped landslides and headscarps are complexes consisting of multiple smaller landslides. Mapped landslides are therefore referred to as the landslide deposit landform and mapped headscarps are referred to as the scarp landform. Many Seattle hillsides lack discernible landslide deposits but the LIDAR imagery shows evidence of landsliding; landslide deposits on these hillsides appear to have been eroded by wave action or streams. These hillsides were also mapped using LIDAR imagery and are referred to as the denuded slope landform. The area of Seattle outside of the landslide-related landforms is referred to as the glacial landform.

The locations of 93% of 1,308 cataloged historical landslides coincide with landslide-related landforms mapped using LIDAR imagery, and all of the historical landslides that occurred naturally were located on these landforms. The land-

slide-related landforms and historical landslides occur in locations where post-glacial erosion has been concentrated. Most of this erosion has been by wave action on Puget Sound and Lake Washington and stream incision. Manmade structures now prevent nearly all coastal erosion and stream incision, yet landslides are still common. The spatial distribution of historical landslides above former glacial-lake shorelines and along glacial melt-water channels suggests that thousands of years are required for Seattle hillsides to naturally stabilize in the absence of toe erosion.

The spatial distribution and size of historical landslides within landslide-related landforms mapped using LIDAR indicate that most of the landslides that created these landforms were prehistoric. Since both historical and prehistoric landslides are concentrated on the landslide-related landforms, future landslides will likely be concentrated on these landforms. Therefore, the spatial densities of historical landslides on the landforms (including the glacial landform) provide reasonable estimates of the relative susceptibilities of the landforms to future landslides. These densities and the mapped landform boundaries were used to create a relative landslide susceptibility map. Historical landslide characteristics and causes correlate with landform type so the susceptibility map provides relative susceptibilities to landslides with certain characteristics and causes. For example, the relative susceptibility of the scarp landform to shallow landslides is 3 to 237 times greater than on the other landforms, and the relative susceptibility of the glacial landform to human-caused landslides is 19 times greater than the susceptibility of this area to natural landslides. The map can be useful for regional planning and provides background data for site-specific investigations.

Lunch 12:00 N - 1:00 PM Please have ticket from registration

Afternoon focus: "Landslide mapping in Portland, reducing losses and managing risk, what's next." Moderator: Yumei Wang (DOGAMI)

1:10 PM - 1:30 PM Ian Madin (DOGAMI) "Lidar and landslides - New technology supports a new landslide hazard mapping program"

Ian Madin, Chief Scientist, Oregon Department of Geology and Mineral Industries -
ian.madin@dogami.state.or.us

BIOGRAPHY
Mr. Madin joined the Oregon Department of Geology and Mineral Industries in 1987 as the Seismic Hazard Geologist for the State of Oregon. In 1994 he transferred to the Baker City field office. After 4 years in Baker City making geologic maps, Mr. Madin returned to the Portland office of DOGAMI as the geologic mapping team leader, and in 2004 became Chief Scientist for the agency.

Ian's current research in the Portland Area includes geologic and geophysical investigations of potentially active faults, the development of detailed geologic models for improved hazard mapping, and the use of LIDAR data for mapping geology and geologic hazards.

ABSTRACT
Starting in 2004, high resolution bare-earth DEM's generated from high accuracy LIDAR data became available for parts of the Portland Metropolitan area as part of a USGS-funded program to search for active faults. These DEM's proved to be a powerful tool for mapping landslides in heavily urbanized and forested areas, and led DOGAMI to develop a new strategy to develop statewide landslide susceptibility maps. Sophisticated visualizations of the LIDAR DEM's make it possible to systematically map existing deep-seated and shallow landslides, and debris flow fans and

deposits with unprecedented precision and completeness.

As a result of this powerful new tool, DOGAMI is planning to systematically prepare landslide susceptibility maps for the inhabited parts of Western Oregon. We will develop a complete digital map and database of existing landslides from published maps and reports and interpretation of LIDAR data as it becomes available. With the complete database in hand we will then prepare and calibrate susceptibility maps using a standard set of analytical models that are being developed with pilot projects in the Portland METRO area as part of the DOGAMI-USGS landslide program. A key to this program will be working with local governments to develop appropriate regulations and policies as we develop the maps.

Clearly, a critical element in this plan is to obtain LDAR data for the inhabited areas of western Oregon. To date there are about 500 square miles of public domain LIDAR data available in the Portland Hills, Oregon City and along the lower Columbia River. A survey currently underway will add 2200 square miles in a swath centered on the Portland METRO area and extending from Hood River County to the coast at Tillamook. DOGAMI is working to develop consortia to collect data for a further 10,000 square miles to provide complete coverage of the inhabited areas of western Oregon.

1:30 PM - 1:50 PM Jonathan Godt, Rex Baum and Jon McKenna (USGS) "Hydrologic conditions leading to shallow landslide occurrence on the Puget Sound bluffs near Edmonds, Washington"

Jonathan Godt*, Rex Baum, Jonathan McKenna, and Ed Harp, U.S. Geological Survey Geologic Hazards Team, MS966 Denver Federal Center, Denver, Colorado 80225, *jgodt@usgs.gov

ABSTRACT

In 2001, the USGS, in cooperation with BNSF and its consultant, Shannon and Wilson Inc., installed a system of instruments at two sites near Everett and Edmonds, Washington to monitor the hydrologic response of hillside materials to rainfall. The instrumentation supports USGS research on rainfall-induced landslide initiation and the applicability of field monitoring for anticipating landslide activity.

On January 14, 2006 a shallow translational landslide occurred at one instrumented site on an unstable coastal bluff near Edmonds, Washington. The landslide failed in colluvium on a 45 degree slope, about 24 long, 10 m wide, and less than 2 m thick. This landslide was one of several that occurred during the winter season of 2005-2006 along a section of the Burlington Northern Santa Fe Railway (BNSF) between Seattle and Everett, Washington. Shallow landslides are common in the deposits and colluvium that mantle many of the steep bluffs along the Puget Sound and are often triggered by heavy rainfall or rapidly-melting snow. The bluffs at the instrumented sites are underlain by subhorizontally bedded glacial and interglacial sediments, which include glacial outwash sand and glaciolacustrine silt deposits. The well-consolidated glacial deposits readily weather mechanically to form a loose, highly permeable, colluvium.

The instrument array at each site has varied over the monitoring period with equipment upgrades and replacements. The original systems consisted of rain gauges, water content reflectometers, soil temperature sensors, and shallow (1-2 m) open-tube piezometers. Positive head was never measured in the open-tube piezometers and they were thus abandoned. In 2003 two soil-water content profilers that provide measurements at eight depths to 2 m below the ground surface and two tensiometer nests of six instruments at similar depths were added to the Edmonds site. Data were collected and transmitted via commercial line-of-site networks and uploaded to the Internet, processed at USGS offices in Golden, CO, and finally made available in near real time on public USGS web pages.

Data collected during the five winter seasons the systems operated provide valuable insight into the hydrologic conditions associated with shallow landslide occurrence. Instrumental observations show that infiltration of rainwater was dominantly vertical and the pore-water response to rainfall at depths below about 1 m was highly dependent

on initial soil-moisture conditions. For example, record 24-hour rainfall on initially dry soils (~12% soil-water content at 0.8 m depth) in the fall of 2003 led to a small increase in pressure head and water content which peaked nearly six days after the storm. However, once initial water contents reached about 20% (typically between late October and early December) the response at depth was much greater and occurred within hours of the beginning of rainfall. About 200 mm of rain was recorded at the Edmonds field site between late December 2005 and the middle of January of 2006. By the New Year period soil-water contents at depths below 1 m exceeded 30%. In the following days, the BNSF rail corridor was closed several times because of landslide activity.

Preliminary slope stability analyses using laboratory measured shear strength parameters, observed pore pressure conditions, and field measured topographic profiles indicate that the landslide at the Edmonds site occurred under partially saturated or unsaturated conditions. Under the conditions of prolonged rainfall from late December 2005 through mid January 2006, overall wetness of the colluvium increased with depth. The progressive downward wetting apparently resulted in a gradual reduction of apparent cohesion and increased the weight of the soil, which in turn resulted in ground failure on the morning of January 14.

1:50 PM - 2:20 PM Scott Anderson (FHWA) "FHWA's efforts to raise the standard for analysis, mitigation and management of landslides"

Scott A. Anderson, Ph.D., P.E., Geotechnical Discipline Leader, Federal Lands Highway, Federal Highway Administration, Lakewood, Colorado.

BIOGRAPHY

Scott Anderson is a geotechnical engineer and geologist with more than 20 years experience in academia, consulting, and with the FHWA. He graduated in geology from the University of Colorado (B.A.) and Colorado State (M.S.), and in civil engineering from U.C. Berkeley (M.S., Ph.D.). He was assistant professor of civil engineering at the University of Hawaii after completing his Ph.D and was employed by Woodward-Clyde Consultants and URS Corporation through school and prior to joining the FHWA 5 years ago. The Federal Highway Administration (FHWA) strives to improve safety and mobility while minimizing expenditure and protecting the environment. It is in this context that the FHWA has interest in landslide analysis, mitigation and management. Responsibilities of the FHWA include research and development, technology deployment, technology transfer, stewardship, and oversight on roads ranging in size and daily traffic from interstate highways to single-lane, gravel-surfaced roads on federal lands - such as national parks and forests. The number of miles of highway and slopes traversed, natural and man-made, stable and unstable is tremendous.

ABSTRACT

Since at least the mid-1970's, the FHWA has sponsored technology deployment, hosted training, and implemented new technologies to raise the bar with respect to slope stability analysis and landslide mitigation and management. Recent activities in these areas are the subject of this presentation. Examples that address safety, mobility, asset management, and environmentally context-sensitive solutions are as follows:

Recent FHWA sponsored technology deployment

- LIDAR for mapping rock outcrops and safely designing safe rock cuts
- InSAR for monitoring slopes and landslide movement
- Risk-based framework for rock slope and rockfall mitigation design
- Hollow-Bar-Anchors; are these self-drilling anchors the next generation soil nail?

Current training on slopes and slope retention

- Interactive CD-based training on soil nail and ground anchor inspection

- Multimedia presentation of rockfall catchment design (w/Oregon DOT)
- Existing NHI offerings on soil slopes and embankments, reinforced soil slopes, and rock slopes, abbreviated offerings
- Update of Highway Slope Maintenance and Slide Restoration training course

Recent implementations with published findings

- Application of satellite borne InSAR for route selection and slide monitoring
- Patterned ground anchors for landslide stabilization
- Quantitative risk assessment of landslide mitigation strategies
- Retaining wall inventory and assessment

2:20 PM - 2:50 PM Mihail Popescu (Illinois Institute of Technology, Chicago) "Landslide Risk Assessment and Management Strategies: Some European and Japanese Experiences"

Mihail E. Popescu, Ph.D., P.E., Eur.Ing., Wang Engineering, Inc. / Illinois Institute of Technology

BIOGRAPHY

Dr. Mihail E. Popescu has more than 30 years of experience in geotechnical engineering research, consulting, and education.

Conducted fundamental and applied research on a variety of geotechnical topics. Main research interests: slope instability and stabilization, expansive and collapsible soils, soil – structure interaction, computer modeling, and geotechnical hazards compilation and assessment.

Responsible for geotechnical design and functional design criteria for a wide variety of engineering projects including the Danube – Black Sea Navigable Canal. Interfaced with major international consultants and contractors. Director of five landslide related workshops and short courses including the NATO Advanced Workshop on Prevention and Remediation of Landslide Related Hazards in the Black Sea Region, in 1998.

Professor and Visiting Professor at University of Civil Engineering, Bucharest, Romania, University of Edinburgh, U. K., University of Tokushima, Japan, University of Natal, Durban, South Africa, Norwegian University of Science and Technology, Trondheim, Norway, and Illinois Institute of Technology, Chicago, USA.

Leader of the Commissions on Landslide Causal Factors and Landslide Remediation of the UNESCO Working Party on World Landslide Inventory (1988-2000). Member of the ISSMGE-IAEG-ISRM Joint Technical Committee on Landslides (2001-present).

ABSTRACT

Landslides are frequently responsible for considerable losses of both money and lives. In view of above consideration, it is not surprising that slope instability phenomena are rapidly becoming the focus of major scientific research, engineering study and practices, and land-use policy throughout the world.

Despite the development of risk prevention, social structures seem paradoxically less prepared to face disasters and alleviate their effects. It is noted that the approaches developed have not managed to successfully reduce the impact of the natural hazards including landslides. This is due to the fact that risk management has remained for too long concentrated on the strict analysis of the physical processes and favors technical solutions and structural measures rather than more qualitative and more global solutions. It too often focuses on the short term and on the management of the crisis and dismisses local know-how. Risk management policies should adopt an integrated approach, involving all the stakeholders, from global to local, on the basis of a full diagnosis of the area, far beyond the problems of nat-

ural risks alone.

Landslide risk assessment and management strategies differ from country to country. The way how the society is organized, its economic strength and historical traditions, among other factors, determine the type of response to the threat caused by landslides. This might explain the difficulties in developing standard terminology and procedures for quantitative hazard and risk assessment and management.

After reviewing landslide risk assessment key elements and principles, the presentation discusses the acceptable risk strategies in different countries. The example of landslide management strategy adopted in Isle of Wight, U.K. for the largest urban landslide complex in north-western Europe is used to illustrate the tools and challenges of living with landslides in a reasonably safe way. Then the example of Jizukiyama Landslide in Nagano is presented in the context of the Japanese Landslide Prevention and Control Program. Finally, landslide management in Alpine countries is briefly discussed.

2:50 PM - 3:10 PM Break - Coffee service, snacks

3:10 PM - 3:40 PM **Albert T. Yeung** (University of Hong Kong) "Public awareness and participation in reduction of landslide risk—Hong Kong experience"

Albert T. Yeung, BSc(Eng)(Hon) MS PhD FICE MHKIE FASCE RPE (Civil, Environmental, Geotechnical) CEng PE

BIOGRAPHY
Dr. Albert T. Yeung is an Associate Professor at the Department of Civil Engineering, The University of Hong Kong. He received his BSc (Eng) degree in civil engineering with First Class Honours from The University of Hong Kong in 1982. He had worked for the former Binnie & Partners International (now Black & Veatch Hong Kong Limited) for two years before he pursued his graduate study on a Rotary Foundation International Graduate Scholarship 1984-1985 and an Earth Technology Corporation Fellowship 1987-1989 at the University of California, Berkeley. He received his MS and PhD degrees from UC-Berkeley in 1985 and 1990, respectively.

He was on the civil engineering faculty at Northeastern University in Boston, Massachusetts and Texas A&M University in College Station, Texas for a total of seven and a half years. Before his return to academia in 2003, he served as Chief Engineer of Black & Veatch Hong Kong Limited and Assistant Secretary for Financial Services and the Treasury of the Hong Kong Special Administrative Region Government. He is a Registered Professional Engineer (Civil, Environmental & Geotechnical) of Hong Kong, a Chartered Engineer of the United Kingdom, and a Registered Professional Engineer of Texas, U.S.A.

ABSTRACT
The total area of the Hong Kong Special Administrative Region (HKSAR), China is approximately 1,100 km2, accommodating a population of 6.9 million and one of the world's largest trading economies. However, most of the population is being housed in 215 km2 of urban development because of steep natural terrain and stringent planning controls. Over 400 km2 have been designated as protected areas including country parks, special areas, and conservation zonings. The concentration of population and economic activities in such a small area exert intense pressures on the demand of usable land.

Throughout the years, many cut or fill slopes have been constructed to cope with the rapid economic development of Hong Kong. There are more than 57,000 sizable man-made and natural slopes in Hong Kong. As many constructed

facilities are in close vicinity of man-made or natural slopes, the consequence of any major slope failures can be disastrous. In fact, large-scale landslides causing heavy casualties and severe damage of properties did happen in Hong Kong. There has been an on-going concerted effort of the Government and the public to prevent slope disasters in Hong Kong for decades.

The most important objective of any slope disaster management program is to reduce the loss of lives, casualties, and damage to properties in the event of any unpredictable landslides. Methodologies to achieve the objective can be broadly divided into three categories: (1) technological improvement of to increase slope stability or to mitigate the damage caused by debris flow in case of landslide; (2) routine maintenance to detect and repair any distress of slopes, and to maintain drainage paths functional; and (3) isolation of the public from landslides.

The theme of this presentation is on the Hong Kong experience on public awareness and participation to reduce landslide risk including: (1) systematic categorizing of more than 57,000 sizeable slopes in Hong Kong to provide the most updated slope information to the public and slope professionals through the internet; (2) delineation of slope maintenance responsibility between the Government and private parties to avoid unnecessary ambiguity; (3) provision of administrative and regulatory framework to enforce necessary slope maintenance; and (4) education of the public on how to maintain slopes within their properties, what they should or should not do so as not to deteriorate stability of slopes, how they can prepare themselves for landslides to minimize potential losses, how they can get the most updated information of landslides, and what they should and can do to protect themselves during landslides.

3:40 PM - 4:30 PM KEYNOTE: Derek Cornforth (Cornforth Consultants) "How we can improve landslide practice and management in Oregon: a practitioner's perspective"

BIOGRAPHY

Derek Cornforth has practiced as a geotechnical consulting engineer in the Pacific Northwest for almost 40 years. He was a principal with Shannon & Wilson, for 15 years before founding Cornforth Consultants, Inc. and its Landslide Technology division in 1983. In 2005, his textbook Landslides in Practice was published by Wiley. Derek has a Ph.D. from London University where he studied under Skempton and Bishop, two pioneers in slope stability and landslide analysis.

ABSTRACT

Three types of landslide hazard/risk maps have been produced in the Pacific Northwest over the past 40 years, namely: (1) conventional geological hazard maps; (2) landslide occurrence maps, and (3) perceived landslide risk maps. Each type of map will be illustrated, and their relative benefits and weaknesses for landslide reduction will be discussed.

The second part of the talk will focus on suggested ways to provide more useful information on such maps, and the need to obtain reports on landslide occurrences for future reference. The talk will conclude with specific procedures recommended for basic research on Oregon's widespread ancient landslide terrain.

4:30 PM - 4:50 PM Q & A for morning and afternoon sessions

4:50 PM - 5:00 PM Concluding Remarks (Bill Burns, DOGAMI) to include Oregon Landslide Workgroup (OLW) sign up sheet, questionnaire feedback forms