

DOGAMI-USGS Partnership on Landslide Risk Reduction: DOGAMI's Landslide Efforts

Yumei Wang, PE, Geohazards Section Leader, Oregon Department of Geology and Mineral Industries (DOGAMI)

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.

1996-1997 Storms and State Directives. Severe storms in Oregon in 1996 and 1997 triggered on the order of 10,000 landslides and caused over \$100 million in damage (DOGAMI Publication SP-34, Hofmeister, 2000; O-02-05, Wang and others, 2002). The November 1996 storm resulted in five fatalities (refer to government report on www.oregon.gov/LCD/HAZ/docs/landslides/sb12body.PDF). In response to these devastating storms, the Oregon Legislature passed Senate Bill (SB) 1211 (1997) and later SB 12 (1999) as a means to reduce future landslide losses. These legislation resulted in Oregon Revised Statute (ORS) 195.250-275, which requires selected state agencies and other responsible parties work together to reduce landslide risks. It requires the state to operate a statewide landslide warning system as a means to protect its citizenry. Furthermore, it requires DOGAMI to issue “Further Review Area” (FRA) maps which are to indicate areas that are potentially susceptible to rapidly moving landslides, such as debris

flows. Oregon Administrative Rule 632-007-0020, enacted in 2003, stipulates how DOGAMI is to issue these FRA maps.

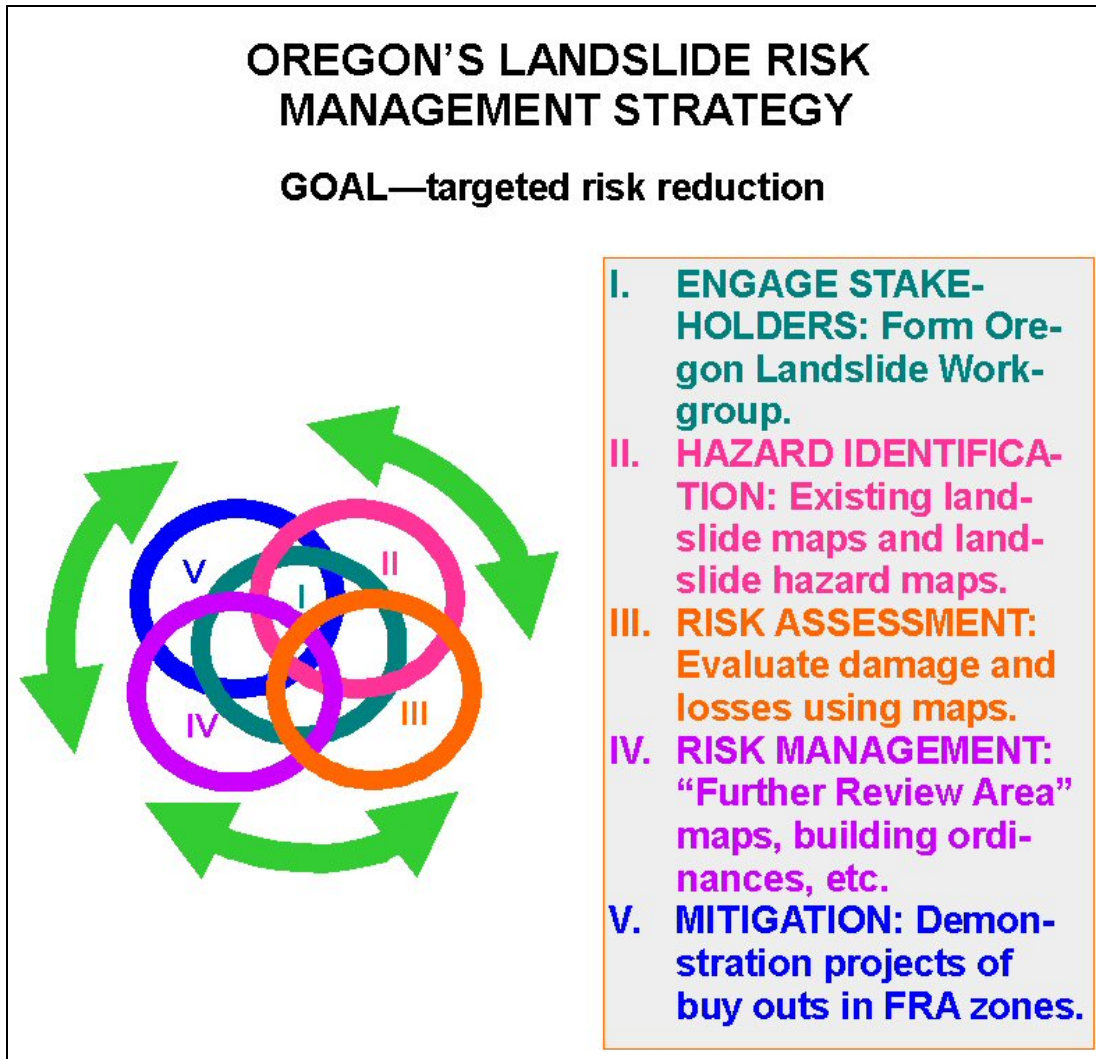


Figure 1. The five parts of Oregon's Landslide Risk Management Strategy

By late 1999, DOGAMI began to map debris flow hazards throughout western Oregon in response to these state directives. In 2002, DOGAMI, in partnership with the Oregon Department of Forestry and the Department of Land Conservation and Development, issued preliminary FRA maps (DOGAMI publication IMS 22, Hofmeister and others, 2002). The IMS 22 product includes digital maps that identify potentially hazardous zones and can be used by local communities to screen new development and mandate site-specific studies in potentially high risk and life-threatening areas. Several jurisdictions have voluntarily adopted IMS 22 in their local ordinances, such as the city of Salem and Marion County. Official FRA maps will be forthcoming as funds become available, and as the USGS and DOGAMI develop acceptable FRA mapping techniques. Pilot studies on FRA mapping techniques involve using light detection and ranging data, commonly referred to as LiDAR.

As a result of the 1996-97 storms, DOGAMI increased its effort on promoting landslide awareness, identifying landslide hazards and promoting risk reduction. Below are a few examples of selected efforts and related publications (which are referenced using the DOGAMI publication number).

DOGAMI developed an inventory of landslides that were triggered from the 1996-97 storms as well as estimated the direct losses from the storms.

- SP-34. Slope Failures in OR—GIS Inventory for Three 1996/97 Storm Events, by R.J. Hofmeister, 2000, 20 p. & CD.
- O-02-05, Wang, Y., Summers, R.D., and Hofmeister, J., 2002, Landslide losses in Oregon, 46 pp.

DOGAMI worked with local governments and others to improve geotechnical reports and adopting landslide risk reduction ordinances.

- O-00-04. Guidelines for engineering geologic reports & site-specific seismic hazards reports, developed & adopted by OR Bd. of Geologist Examiners, 2000, 8 p.
- SP-31. Mitigating geologic hazards in OR: A technical reference manual, by J.D. Beaulieu & D.L. Olmstead, 2000, 60 p.

DOGAMI improved mapping methods for identification of earthquake-triggered landslide hazards, developed landslide hazard maps and mapped existing landslides.

- SP-30. EQ-induced slope instability: Methodology of relative hazard mapping, W. portion of Salem Hills, Marion Co., OR, by R.J. Hofmeister, Y. Wang & D.K. Keefer, 2000, 73 p.
- IMS-17 and IMS-18. EQ-induced slope instability: Relative hazard map, W. portion of Salem Hills, Marion Co., OR, R.J. Hofmeister, Y. Wang & D.K. Keefer, 2000, and E portion of Eola Hills, Polk Co., by R.J. Hofmeister and Y. Wang, 2000, 1:24,000.
- IMS-5 and IMS-6. Water-induced landslide hazards, Eola Hills and Salem Hills, OR, by A. Harvey & G. Peterson, 1998, 1:24,000.
- O-01-05. Prelim. EQ hazard & risk assessment & water-induced landslide hazard in Benton Co., OR, by Z. Wang, G.B. Graham & I.P. Madin.
- O-03-9 and O-03-10. Earthquake and Landslide Hazard maps in Clackamas County, Oregon, by R. J. Hofmeister, C.S. Hasenberg, I.P. Madin & Y. Wang 2003 paper map and CD.

In addition, DOGAMI addresses various landslide-related issues as special needs arise, such as:

- Landslide warning press releases in coordination with the Oregon Department of Forestry, Oregon Emergency Management, and Oregon Department of Transportation (ODOT). These press releases were issued to warn the public of rapidly moving landslide hazards and are a result of the directives from the 1996-97 storms.
- O-04-05. Geotechnical Investigation Johnson Creek Landslide, Lincoln County, Oregon, by Landslide Technology, 115 p., 2004 CD only. This originated as a ODOT-funded DOGAMI research project along U.S. Highway 101, and recently expanded to include USGS collaboration.
- O-00-03. Memo: Cape Cove landslide, findings from field visit, February 10 & March 10, 2000, by G. R. Priest, 2000, 14 p. This was an emergency situation with the state's request for DOGAMI's technical assistance.
- O-04-08. Geologic Hazard Study for the Columbia River Transportation Corridor, by Y. Wang & A. Chaker, 2004 CD only. This included a preliminary assessment of the economic importance of this critically important multimodal transportation corridor.
- Oregon City LiDAR landslide map O-06-27. Map of Landslide Geomorphology of Oregon City, Oregon, and vicinity interpreted from LiDAR Imagery and Aerial photographs, Clackamas County, OR, by I.P. Madin & W.J. Burns, 2006, CD. This map includes existing landslides and is a product of the DOGAMI-USGS partnership on the Western Oregon Landslide Project.

Although progress had been made on several fronts, which is supported by the above publications, much needed improvements are necessary in order to curb future losses. In late 2004, DOGAMI and the USGS began a partnership which led to a marked increase in DOGAMI's efforts on landslide issues. This will be discussed in the next sections "Western Oregon Landslide Project" and "Current DOGAMI-USGS Efforts."

Western Oregon Landslide Project

Since 1995, DOGAMI has been collaborating with the USGS to improve the understanding of earthquake triggered landslide hazards. In 2001, the USGS funded DOGAMI to collect information on landslide losses. These collaborative efforts led to DOGAMI hosting a National Academies meeting in Portland Oregon in late 2001. At that time, the National Research Council (NRC), which is part of the National Academies, was conducting a study to determine how the USGS could improve its landslide hazards program. DOGAMI explained that state geologic surveys need more support from the USGS in order to better understand and manage landslide risk, and stronger partnerships are necessary. The NRC agreed that more partnerships are needed for effective risk reduction. In 2004, they published a landmark report with their complete findings.

Armed with the NRC’s findings, DOGAMI and the USGS sought ways to improve its partnership. It was agreed that a stronger partnership would include collaborative research projects that would benefit the landslide professional community and geologic state surveys-at-large. DOGAMI worked with the U.S. Congress to increase funding for the USGS Landslide Hazard Program in fiscal year 2005 (FY05). When Congress increased the FY05 funding to the USGS’s Landslide Hazard Program, the USGS began to fund DOGAMI for a multi-year project, called the “Western Oregon Landslide Project”. A portion of DOGAMI’s proposal to the USGS of the “Western Oregon Landslide Project” is shown in **Figure 2**. Since this time, DOGAMI and the USGS have developed a strong collaborative partnership on a number of research projects.

Western Oregon Landslide Project

“The National Landslide Hazard Mitigation Program must play a vital role in evaluating methods, setting standards and advancing procedures and guidelines for landslide hazard maps and assessments.”

Taken from “National Research Council’s Partnerships for Reducing Landslide Risk: Assessment of the National Landslide Hazards Mitigation Strategy” (2004)

The NRC recently recommended “that the USGS—in close partnership with other relevant agencies—produce the implementation and management plans that will provide the practical basis for an effective national strategy that can be applied at the local level.” In accordance with this and other NRC recommendations, the Oregon Department of Geology and Mineral Industries (DOGAMI) proposes that the USGS launch its first concentrated landslide efforts in a collaborative “Western Oregon Landslide Project.” The proposed Project Scope, Funding and Schedule, Location and Background, Available Data, Contacts and Potential Partners are outlined.

Project Scope: Areas of Comprehensive Study

- Improve field and aerial mapping techniques, especially beneath densely forested areas
- Advance characterization of landslide types (life threatening, property damage, reactivation of large slide complexes, hydrogeologic characterization, forest lands, storm-induced, earthquake-triggered, fire-related, weather-related and future climate trends)
- Integrate remote sensing, climatological and hydrological analyses into landslide studies
- Conduct state of the art analytical research and improve procedures; piggyback on Johnson Creek Landslide Research Project (DOGAMI has a secure budget of \$500,000)
- Advance landslide monitoring and warning systems by upgrading existing instrumented landslides
- Improve hazard identification and hazard mapping
- Research active soil creep rates into salmon bearing streams and sustainability of spawning beds
- Advance identification of landslide-induced turbidity events into rivers and public water supply
- Quantify loss, investigative, and mitigation costs and integrate into improved tracking and benefit-cost analyses
- Improve guidelines, standards, risk analyses, risk reduction, and mitigation
- Provide sound public policy options on risk and loss reduction
- Launch public education campaign
- Co-organize and co-sponsor advance landslide workshop in Fall 2005 (see attachment)

Figure 2. A portion of the “Western Oregon Landslide Project” proposal

Current DOGAMI-USGS Efforts

As part of the Western Oregon Landslide Project, DOGAMI is currently collaborating with the USGS on several projects and efforts. Both DOGAMI and the USGS also have agency-specific projects and efforts in which each agency has a lead role. For these projects, there is a varying amount of collaboration. In general, the USGS research projects are largely aimed to benefit DOGAMI's goals and, in turn, the DOGAMI projects are largely aimed to reduce risk to the public. As an example, one of the USGS projects is to better characterize debris flow entrainment behavior. Modeling of entrainment is needed for the forthcoming DOGAMI FRA maps. For a summary of the current USGS efforts, please refer directly to the USGS Landslide Hazard Program.

The current projects that DOGAMI has taken the lead role and have substantial USGS support focus on:

- Educating and increasing awareness, including:
 - DOGAMI and USGS co-organized the April 26-28, 2007 symposium with co-sponsorship from the American Society of Civil Engineers and the Association of Engineering Geologists. DOGAMI and USGS researchers are sharing information on current Western Oregon Landslide Project research and are facilitating an exchange of technological advancements with landslide experts including geotechnical consultants.
 - DOGAMI organized a landslide forum in 2006 that was a 10-yr commemoration of the 1996-97 storms. USGS personnel provided talks at this forum, which included a broad audience.
- Engaging stakeholders. DOGAMI is forming the Oregon Landslide Workgroup (OLW), which will include a broad spectrum of stakeholders, including technical landslide experts. The primary goals are to promote collaborative efforts to reduce damage and losses with both private and public sector partners. The USGS, geotechnical consultants and others will be represented on OLW.
- Evaluating mapping techniques, including multiple types of remote sensing data
- Improving mapping techniques using LiDAR
- Developing risk management strategies that involve sustainable practices
- Mapping existing landslides using LiDAR in the Portland Hills area
- Developing landslide susceptibility and hazard maps using LiDAR, including in Oregon City and FRA maps
- Developing a Statewide Landslide database, called "SLIDO" (statewide landslide information database of Oregon)

Future efforts may involve:

- Co-organizing landslide sessions at Geological Society of America (GSA) conference in Portland 2009 to further share information on DOGAMI and USGS research projects and facilitate an exchange in technological advancements with landslide experts including local geotechnical consultants
- Conducting technology transfer to cities and counties (e.g., understanding landslide triggers, hazard maps, policies, guidelines, ordinances)
- Sharing and exchanging technological knowledge with other state geology surveys (e.g., seek collaborative research, mapping with LiDAR, developing stakeholder

workgroups, promoting risk reduction involving sustainable practices, creating web-based landslide databases)

- Producing risk assessment studies
- Establishing an interactive landslide website
- Improving the statewide landslide warning system (and possibly involve the National Weather Service)
- Conducting landslide mitigation projects, such as buying out high risk structures (including homes) in high frequency debris flow areas

Since 1996-97, some landslide risk reduction progress has been made but clearly not enough to reduce future damage in a significant manner. Similar storms will trigger landslides and future damage and losses will continue to occur. As the population increases and assuming current land use and construction practices, losses are expected to increase both in developed areas and in the areas of new development. This includes vulnerable hill slopes, and near stream banks and ocean bluffs.

Increasingly, Oregon is employing sustainable practices geared toward minimizing geohazard-related disasters. For example, building of essential facilities requires site-specific seismic hazard studies to ensure that appropriate design and construction are employed (i.e., mandated by ORS 455.447). Also, construction of these facilities within mapped tsunami inundation zones is restricted (ORS 455.446). Landslide-, earthquake-, and tsunami- hazard maps can be integrated into local government comprehensive plans. DOGAMI has been assisting counties and cities with maps, risk studies and developing disaster recovery plans; however, a much stronger effort targeted towards landslide risk reduction is needed.

In order to effectively manage landslide risks, the geotechnical landslide community needs to become more proactive to help increase landslide awareness, landslide identification, hazard mapping in landslide prone areas, risk assessments, sustainable practices in risk reduction and mitigation efforts. The geotechnical landslide community needs to engage other stakeholders, including local government planners, building officials, realtors, decision makers and many others. Only then will there be a significant reduction in landslide risks to Oregonians.



**DOGAMI-USGS partnership
on Landslide Risk Reduction:
DOGAMI's Landslide Program**

Yumei Wang, PE
Oregon Department of Geology & Mineral Industries

Photo from ODF, J Seward

Talk Overview

- I DOGAMI Landslide Program
(started after 1996-7 storms in 1999)
- II Western Oregon Landslide Project:
DOGAMI-USGS multi-year partnership
(started in FY05)
- III Current DOGAMI-USGS efforts

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I. DOGAMI Landslide Program

- ◆ Established in 1999 as outcome of 1996-97 storms
- ◆ Goal: save lives & \$\$\$ (targeted risk reduction)
- ◆ Oregon's risk management strategy (starting Oregon Landslide Workgroup to engage stakeholders, incl. geotechs)
- ◆ Promote risk management strategies; reasonable & sustainable practices (can't avoid all landslide prone areas)
- ◆ Serious Limitation: minimal staff & state funds

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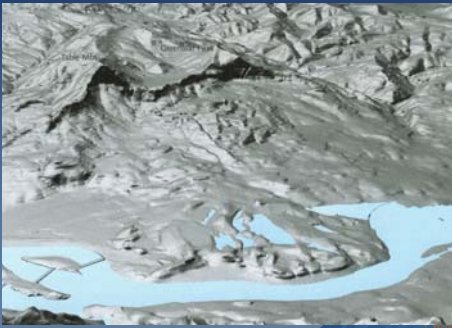
ARE ALL LANDSLIDES BAD?



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Bonneville Landslide, Cascade Locks, OR (Bridge of the Gods Legend)

Bonneville Landslide "stable" & Corps of Engineers' Hydroelectric Complex



Probably
Earthquake
Triggered
Landslide
that
Blocked
Columbia
River

Source: Oregon Atlas

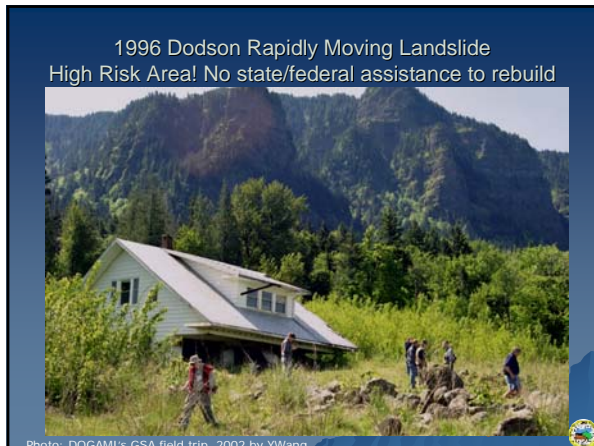
© Wang, 2010/06/10/11

Sometimes "Need" to build slide-prone areas
Cape Cove Highway 101: closed for 3 months
(DOGAMI assisted ODOT & others)



Photo: ODOT

© Wang, 2010/06/10/11



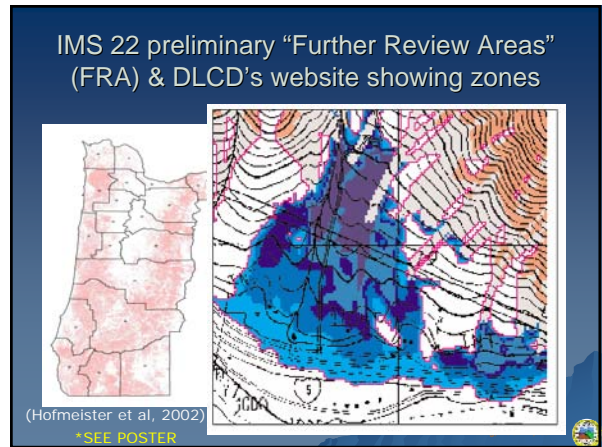
Oregon's Landslide Risk Management Strategy

OREGON'S LANDSLIDE RISK MANAGEMENT STRATEGY
GOAL—targeted risk reduction

- I. ENGAGE STAKEHOLDERS: Form Oregon Landslide Workgroup. ←see poster
- II. HAZARD IDENTIFICATION: Existing landslide maps and landslide hazard maps. ←see posters
- III. RISK ASSESSMENT: Evaluate damage and losses using maps.
- IV. RISK MANAGEMENT: "Further Review Area" maps, building ordinances, etc.
- V. MITIGATION: Demonstration projects of buy outs in FRA zones.

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- ### 1996-97 storms: damage & directives Legislation-Related History
- ◆ 1996-97 a wake up call for DOGAMI—
 - ◆ SB1211 (1997) Landslide warning system & SB12
 - ◆ SB12 (1999) ORS 195.250-275
 - "Each property owner, highway user, fed/local/state gov't share in responsibility for making sound landslide decision..." Also, requires DOGAMI to develop & issue "Further Review Area" maps
 - ◆ IMS 22 maps w/DLCD, ODF & consultant (2002), preliminary FRA maps as screening tool
 - ◆ Salem/Marion Co adopted IMS 22 (voluntary)
 - ◆ DOGAMI has not issued "FRA" maps (OAR 632-007-0020 (2003))
- © Oregon Dept. of Geology and Mineral Industries



- ### 1996-97 storms: damage & directives DOGAMI Landslide Program- Mitigation
- Modest, piecemeal program
 - Awareness & risk reduction
 - 1996-97 landslide inventory
 - FEMA funded (pub: 2000 SP34)
 - Geologists/Engineers Board standard-of-practice guidelines (2000, pub: O-00-04)
 - Landslide loss study
 - USGS funded (pub: 2002, O-02-05)
 - Brochures, Field trips & Workshops
- © Oregon Dept. of Geology and Mineral Industries

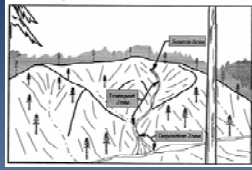
Lessons Learned in 1996-97

- ◆ About 10,000 slides recorded
- ◆ Direct Damages >\$100 million
- ◆ Similar future storms \$\$\$
- ◆ Indirect Losses can be \$\$\$\$\$

© Oregon Dept. of Geology and Mineral Industries

Indirect losses can be \$\$\$\$\$

1996 Dodson Debris Flow closed river traffic, rail traffic, I-84 traffic



USGS Fact Sheet 2007-3072-2004 Ken Cobble, <http://www.pgd.gov>

V. Wang, 02/20/2006, 2007



1996-97 storms: damage & directives Research & Efforts since 1996-97

- 1996 USGS landslide partnership: EQ-triggered landslide hazard map method using GIS
- Local partnerships: Salem/Marion Co. hazard maps & ordinances
- DOGAMI Maps: Salem, Springfield, Eugene, Counties—Klamath, Benton, Tillamook, Clackamas, Marion, Polk, Yamhill, Linn, Lane, & coastal studies
- 2002 Johnson Crk Landslide (Hi 101)

V. Wang, 02/20/2006, 2007



Johnson Creek Landslide Hi 101

Research 2002 w/ODOT & 2005 w/USGS



Johnson Creek Photo from Landslide Technology Change Point #1

02/20/2006, 2007



Need for improvements

- ◆ Limited partnerships with local governments, few ordinances, no "Further Review Area" maps
- ◆ New techniques and LiDAR data
- ◆ Limited statewide landslide warning system
- ◆ Increased Development & Land Modifications
 - Subdivision development, roads, & infrastructure (incl. storm-water) on hill slopes
 - Unstable ocean & view lots
 - Poor construction & planning practices
 - No grading codes in State Building Code

V. Wang, 02/20/2006, 2007



II. Western Oregon Landslide Project FY05 DOGAMI-USGS Multi-Year Partnership

PARTNERSHIPS FOR REDUCING LANDSLIDE RISK



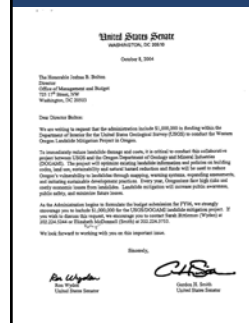
Partnership was created
2001 National Academies
Landmark Study

- Portland Meeting in 2001
- Report published in 2004

V. Wang, 02/20/2006, 2007



II. Western Oregon Landslide Project FY05 DOGAMI-USGS Multi-Year Partnership



DOGAMI met with
Congress in 2004

- Led to expanded USGS Landslide Hazards program in FY05
- Led to DOGAMI-USGS partnership

V. Wang, 02/20/2006, 2007



III. Current DOGAMI-USGS Efforts

- Collaborate with USGS researchers
 - DOGAMI staff are learning from USGS & their Seattle area landslide experience
- USGS research help w/DOGAMI goals
 - DOGAMI able to make better maps
 - Next: Jeff Coe overview USGS research
 - Today's talks by USGS & DOGAMI researchers on current projects (& by other experts)



III. Current DOGAMI-USGS Efforts

Since 1996-97, some risk reduction progress but not enough. Similar storms will happen again

- ◆ Improve mapping techniques w/LiDAR
 - Oregon City O-06-27 Landslide map *
- ◆ Need more landslide maps, hazard maps & "Further Review Area" maps
- ◆ Need risk management strategies, sustainable practices & risk studies
- ◆ Started "SLIDO" landslide database *

*SEE POSTERS



III. Current DOGAMI-USGS Efforts

- ◆ Forming Oregon Landslide Workgroup *
- ◆ Co-organize Landslide sessions at Geological Society of America (GSA) conference in Portland 2009
- ◆ Need interactive landslide website
- ◆ Need improved warning system
- ◆ Technology transfer to cities & counties (ordinances) & other state geology surveys

*SEE POSTER



USGS reviews DOGAMI's progress with LiDAR in Tryon Creek Watershed

Paula Gori (USGS), Ian Madin & Bill Burns (DOGAMI)

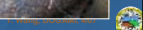


Photo: Wang (DOGAMI)



Portland West Hills, Johnson Creek & Elliot State Forest

Instrument Installation with USGS, Jan. 2006



2005 Debris Flows on Foster Rd Overlain on DOGAMI IMS-22 maps



Dec 2005 & Jan 2006
Landslides

Apartment Complex, Newell
Creek, Oregon City

PSU-METRO, 1998. Google Earth, 2006. www.KATU.com

2006 Landslides
in Portland

ONLY ON 8

TOP STORY
BLUFFSIDE SLIDES

Bill Burns w/Channel 8

PSU-METRO, 1998

2007 Astoria: landslide damage &
ancient slide on LiDAR

PSU-METRO, 1998

“Spring Break Slide” Highway 26
Oregonian Front Page on 3-29-07

Slides make mess of traffic

Roads | Three of S.S. 26's supplemental lanes will be open today for the morning commute, the state says.

In general terms:

A pair of accidents that killed seven people last week have again reminded us how close we are to the edge of disaster here. The Oregon Department of Transportation says the landslide area last slide hit west of the Third Bridge beyond the region's primary airport gateway. Seven fatalities and 21 injuries that have resulted from the slide and more than 200 cars for the highway's long weekend trip.

The state says because the slide was not a 100-year event, and that those of the highway's supplemental lanes remained. The area closed on the slide was a 100-year event with rock-rolling that hit it. It occurred in a more subtle, subtle, 100-year event.

Highwayway, according to a spokesman, about traffic back for the road and from on 3-29-07.

Conley | Three into the fall as a factor in the landslide, along with the area's wet weather and steep, rocky terrain.

By Tommie L. Hill

PSU-METRO, 1998

Got Questions?

PSU-METRO, 1998