Urban landslide management in Seattle, Washington

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ABSTRACT
Landslides have occurred within the city limits of Seattle well before it was first developed and have been documented over the past 100 years. The combination of Quaternary geology, steep terrain and a winter rainfall pattern make the area particularly susceptible to landslides. The winter storms of 1996-97 were particularly devastating to public and private property. These storms triggered over 300 landslides and resulted in about US $30 million in damage to public infrastructure. Public concern over these damages prompted the City of Seattle to review its responsibilities and liabilities for landslide damage and mitigation. This review resulted in a recommended landslide risk management policy that was adopted by City council. The landslide policy can be loosely grouped as identification of the problem, education of property owners in landslide prone areas, emergency preparedness and mitigation of hazards that impact public facilities. This talk will focus on two areas. First I will focus on the studies and tools that were developed to identify the landslide hazards and risks. Second I will focus on how the City is working to reduce the risk of damage to its infrastructure by continuing to execute a landslide mitigation program.

Seattle Public Utilities commissioned several studies to identify the landslide problem. This includes the “Surface Drainage Needs Assessment” (Black and Veatch, 1999), “Seattle Landslide Study” and “Seattle Landslide Study Prioritization report” (Shannon & Wilson, 2000). The “Surface Drainage Needs Assessment” identified drainage problem areas in landslide prone areas (LPAs) and recommendations for solutions. The Seattle Landslide Study documented landslide locations, identified landslide causes, types and potential project areas. The prioritization report ranked potential slide projects.

Coincident with the previously noted studies Seattle was identified as a Project Impact city by the Federal Emergency Management Agency (FEMA). This designation enabled the City to receive funding to enlist the US Geological Survey (USGS) to develop hazard maps and other landslide forecasting tools. The hazard maps that were developed used infinite slope models and the City’s robust landslide record to produce relative hazard maps based on factor of safety or probability of sliding. The USGS also developed a relationship between rainfall and landslides. Two models were developed. The first was based on the cumulative rainfall and the second based on rainfall intensity (Alan F. Chleborad, Rex L. Baum, and Jonathan W. Godt, 2006).

The Cumulative Rainfall Threshold model was developed using historical landslide data. The model plots the previous 3 days of precipitation versus the previous 15 days of precipitation. When this plot exceeds an empirically derived threshold there is a higher probability that shallow landslides could occur. This model allows the input of forecast rainfall to become a predictive model. The second model plots rainfall intensity versus duration. When this plot exceeds an empirically derived threshold it is possible for multiple landslides to occur. This model typically has a shorter lead time in predicting landslides. The City has found these models to be useful for anticipating operations staffing needs especially during weekends and holidays.

The City of Seattle is working to reduce its risk of damage due to landslides by executing a capital improvement program (CIP). The Seattle Landslide Study identified 50 potential landslide mitigation project sites. Of these 50 sites Seattle Public Utilities was identified as the major stakeholder on 17. The projects were ranked and included in the Utility’s CIP to further investigate and implement. Included in the CIP is a program to address small landslide mitigation projects. These are projects that are typically identified annually by residents and operations crews. These small projects typically address control of drainage in steep slope areas or repairs to damage caused by inadequate control of drainage.

RÉSUMÉ
Les éboulements se sont produits au sein de la ville de Seattle bien avant qu'elle ait été développée et ont été documentés au cours des 100 dernières années. La combinaison de géologie quaternaire, de terrain escarpé et de précipitations hivernales rendent cet endroit particulièrement susceptible aux éboulements. Les tempêtes d’hiver de 1996-97 étaient particulièrement dévastatrices à la propriété publique et privée. Ces tempêtes ont déclenché plus de 300 éboulements et ont causé environ 30 millions de dollars en dommages à l'infrastructure publique. Les questions du public au sujet de ces dommages ont incité la ville de Seattle à réexaminer ses responsabilités relatives aux dommages et la réduction des éboulements. Cet examen a eu pour résultat une politique de gestion des risques d’éboulements qui a été adoptée par le conseil municipal. La politique des éboulements peut être lâchement groupée en tant qu’identification du problème, éducation des propriétaires dans les secteurs prédisposés aux éboulements, la

préparation face aux urgences et la réduction des risques qui effectuent les installations publics. Cet entretien se concentrera sur deux secteurs. Le premier serait les études et les outils qui ont été développés pour identifier les dangers et les risques des éboulements. Le deuxième traite de la manière dont la ville travaille afin de réduire le risque de dommages à son infrastructure en continuant la mise en place d'un programme de réduction des éboulements.