Moore-Love, Karla

From: Dee White <deewhite1@mindspring.com>
Sent: Thursday, April 30, 2015 4:48 PM
To: Council Clerk – Testimony
Subject: Comment for the record Type IV Demolition Review WA Park Reservoirs
Attachments: Opflow_Nitrification.523459.pdf

Op Flow nitrification project document attached

Please send acknowledgement.

Thanks,
Dee White

Brian White is a biologist with the Los Angeles Department of Water and Power (www.ladwp.com), Los Angeles. Martin Adams is director of the department's Water Operations Division.

The Los Angeles Department of Water and Power is experimenting with near-ultraviolet (UVA) radiation to mitigate nitrification. Water is relatively transparent to UVA radiation, which can inactivate nitrifying bacteria at low intensities. BY BRIAN WHITE AND MARTIN ADAMS

BATTLING NITRIFICATION WITH BLACKLIGHTS

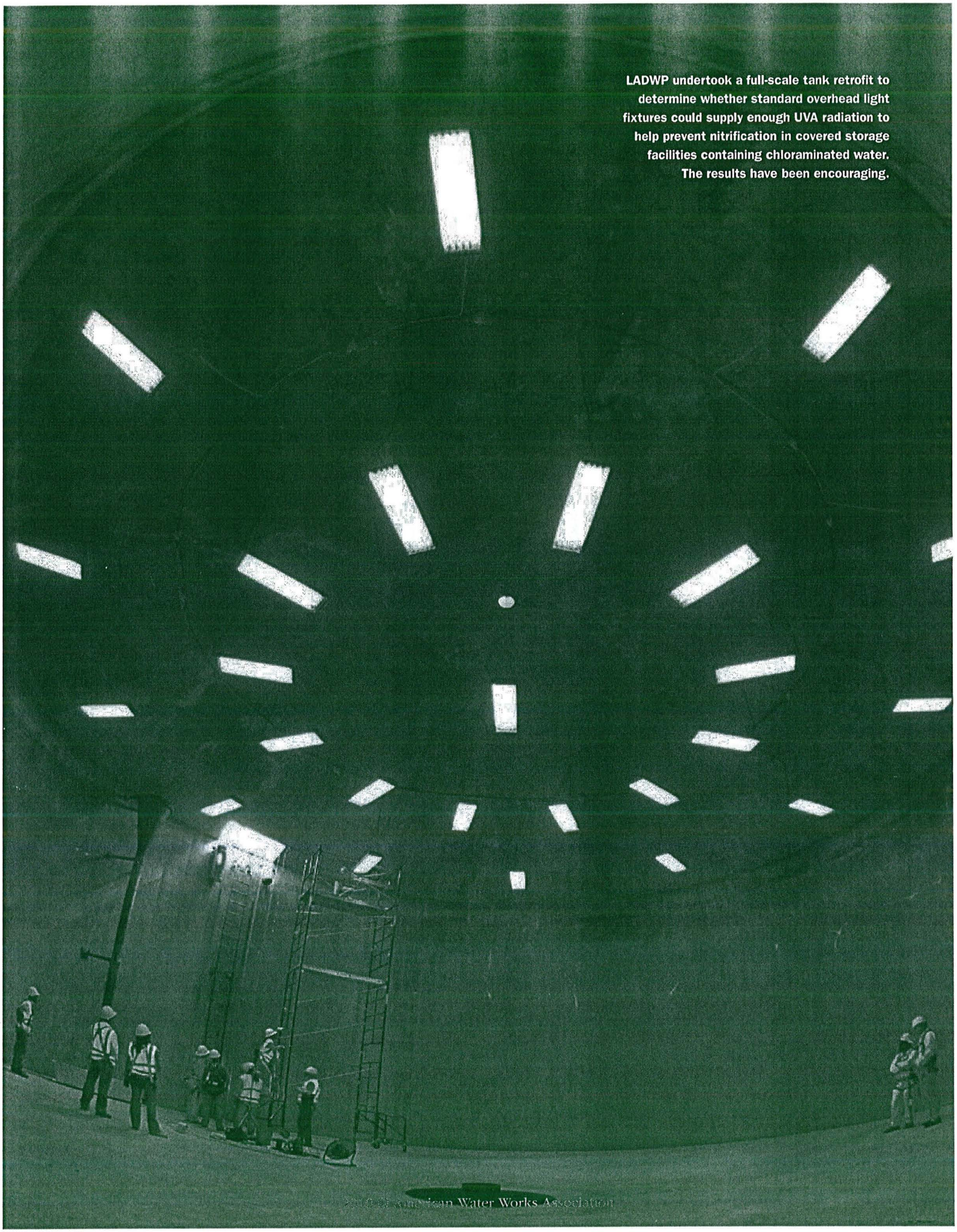
THE LOS ANGELES DEPARTMENT of Water and Power suspended a bank of fluorescent blacklights in the head-space of Mount Washington Tank 2 in July 2009. The idea was to test whether standard overhead light fixtures could supply enough near-ultraviolet (UVA) radiation to prevent nitrification onset in covered storage facilities containing chloraminated water. The utility undertook a full-scale tank retrofit to explore this practical application for combating nitrification.

LADWP is currently expanding its replacement of chlorine with chloramines as the city's secondary disinfectant. Although chloramines form fewer disinfection by-products and eliminate chlorinous odor, they encourage nitrification in covered storage facilities. The nitrification process begins with routine decomposition of chloramine disinfectant, which consists of chlorine and ammonia. As ammonia and chlorine separate, resulting ammonia becomes a source of energy for ammonia oxidizing bacteria, such as *Nitrosomonas*, which convert ammonia to nitrite. Nitrite-oxidizing bacteria, including *Nitrobacter*, complete the process by converting nitrite to nitrate. Both *Nitrosomonas* and *Nitrobacter* are sensitive to low-intensity UVA radiation.

Nitrification can rapidly deplete tank chloramines, and maintaining tank residuals with unforeseeable spot treatments is labor intensive and contrary to maintaining low disinfection by-products. To prevent nitrification, LADWP is experimenting with the application of UVA radiation.

PHOTOGRAPH: ART MOCHIZUKI, LADWP

2010 © American Water Works Association



LADWP undertook a full-scale tank retrofit to determine whether standard overhead light fixtures could supply enough UVA radiation to help prevent nitrification in covered storage facilities containing chloraminated water. The results have been encouraging.

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PILOT PROJECT

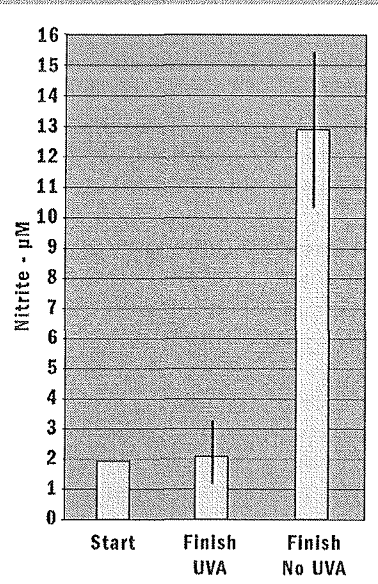
The pilot project was conducted at full-scale at Mount Washington Tank 2 because the optical, chemical, biological, and operational complexities of a fill-and-draw tank couldn't be duplicated in a laboratory. In addition, sufficient information to devise realistic lighting specifications was already available in scientific literature. The literature-derived minimum UVA intensity assumed 24 hr of continuous exposure across the bottom of a full tank. This conservative approach assured overexposure of the overlying water column.

Mount Washington Tank 2 was selected as the test bed for several reasons:

- The tank has distributed chloraminated water to a small pressure zone near downtown Los Angeles since 2003.
- The tank has a history of nitrification and is sampled three times each week for numerous nitrification-related water quality variables.
- A companion tank, Mount Washington Tank 1, provides a convenient control setting for side-by-side tests.

Test Results

Low-intensity UVA radiation can inhibit nitrifying bacteria in a tank as strongly as it does in nature.



Four design features—reactor size and exposure intensity, duration, and waveband—distinguish the Mount Washington UV facility from all others. At more than 67,500 ft^3, Tank 2's UV reactor is the world's largest; daylong exposures to it of twilight intensities had never been attempted. The reactor pairs lowest exposure intensities with longest exposure times and is the first to use longwave UVA radiation instead of shortwave UVC radiation.

Constructed of reinforced concrete in 1954, Mount Washington Tank 2 has a diameter of 62.5 ft, maximum depth of 22 ft, and storage capacity of 524,000 gal. Theoretically, the transparency of water to UVA radiation can accommodate large dimensions and long detention times, which compensate for low-intensity exposures.

LIGHTING DESIGN

Several laboratory and field studies have established that UVA radiation can inhibit the first step in nitrification, ammonia oxidation, at intensities < 0.1 percent of solar UVA during a 24-hr period. Solar inhibition of nitrifying bacteria has been implicated in the persistence of a prominent nitrite maximum at depths near the 1 percent light level throughout much of the world's oceans. Sunlight also suppresses ammonia oxidation in wastewater treatment plants. Sunlight contains considerable UVA, little UVB, and no UVC radiation.

Three optical criteria—the absorbance spectra of chlorophyll *a*, monochloramine, and water—were used to set wavelength boundaries for an ideal design spectrum. The monochloramine and chlorophyll absorbance spectra were used as bookends to minimize unwanted photolysis of disinfectant residual on the low end and unwanted algal photosynthesis on the high end. The water's absorbance spectrum was used to maximize the applied radiation's penetrating power.

To find the best UVA fit, the output spectra of several fluorescent and light-emitting diode (LED) lamps were measured with a scanning spectroradiometer. In terms of ready availability, spectral emission, spectral transmittance, and service life, an ordinary blacklight proved to be the best available technology.

A fluorescent blacklight waveband occupies a spectral optimum between shorter UVA wavelengths that penetrate water relatively poorly and longer violet-to-blue wavelengths that stimulate unwanted algal photosynthesis. The dominant photosynthetic pigment chlorophyll *a* strongly absorbs blue light. Although the violet-to-blue region of the solar spectrum inhibits nitrification at low intensities, it was excluded from the design spectrum to avoid possible growth of a green bathtub ring. In the future, UV LEDs may make it possible to target the spectral optimum more precisely.

Sizing the Mount Washington blacklight system posed a special design problem. For the first time, water transparency had to be factored into an overhead lighting plan. This was accomplished by using five years of underwater UVA attenuation measurements taken with a remote electro-optical sensor (REOS) in nearby Los Angeles Reservoir. The REOS system has been used by LADWP to track and treat nuisance algal blooms in Los Angeles Reservoir for nearly 20 years and was the enabling design technology for the Mount Washington UVA project.

Historical REOS data show that UVA transparency varies over time. However, when the Mount Washington tanks were full, water could be expected to transmit > 15 percent of UVA wavelengths 90 percent of the time. This 90th percentile transparency value was used with a commercial-lighting software tool to specify a surface intensity of 1 percent of solar UVA. This surface intensity was considered necessary to achieve a minimum design intensity of 0.1 percent of solar UVA in the tank's deepest, darkest

2010 © American Water Works Association

LADWP personnel are optimistic that low-intensity UVA radiation will prove to be a practical, safe, and effective safeguard against nitrification onset in water storage facilities.

reaches after accounting for radiant losses from surface reflection, distance from lamps, and absorbance by 22 ft of water.

LIGHTING VALIDATION

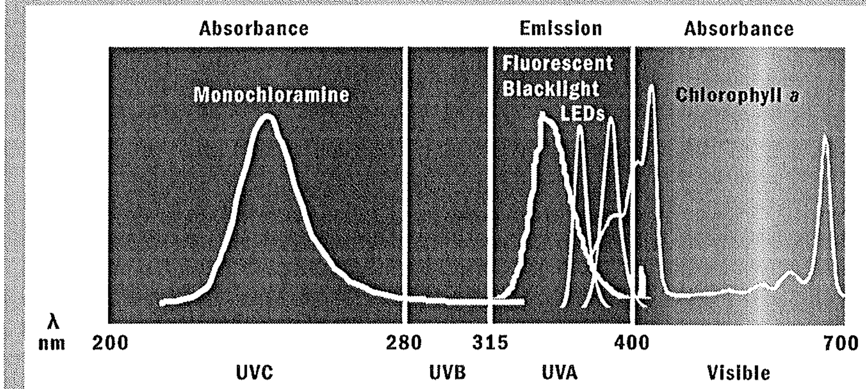
Measurements made by a pair of REOS radiometers suspended at different depths in Mount Washington Tank 2 revealed a complex UV field. As expected, when the tank's water level rose, underwater UVA intensity fell; and when the tank's water level fell, underwater UVA intensity rose. In addition, UVA radiation was about twice as intense near the tank's center as it was along the walls. UVA intensity on the bottom of a full tank near the wall exceeded minimum design specifications of 0.1 percent of solar UVA most of the time, with the surface intensity about nine times higher. Although difficult to quantify, horizontal, vertical, and temporal UVA gradients such as these provide a considerable design cushion because free-swimming bacteria in the water column are continuously exposed to UVA intensities higher than the design minimum.

As expected, absorbance of blacklight radiation by the water column had a spectral bias. The longer blacklight wavelengths penetrated about three times better than shorter ones. This bias is an important design consideration. With all other things being equal, the most penetrating wavelengths are the most efficient. For this reason, narrow-band LEDs are an attractive alternative.

To test the pilot system's photoinhibitory effectiveness, three bottles containing water from the nearby Verdugo tank, which was just beginning to nitrify, were placed near the bottom of Mount Washington Tank 2, and another three bottles were placed in the unlit Mount Washington Tank 1 late one Friday afternoon. The test water had a starting nitrite concentration of 1.9 μM. When the Mount Washington test bottles were retrieved the following Monday morning, nitrite concentrations in the three bottles exposed to UVA radiation in Tank 2 were largely unchanged, but nitrite concentrations in the three bottles retrieved from the dark Tank 1 had more than quintupled. Meanwhile, during the same weekend, nitrite concentration in the Verdugo tank more than tripled.

Wavelength Boundaries

Fluorescent blacklight and UV LED wavebands occupy a spectral optimum between shorter UVA wavelengths and longer violet-to-blue wavelengths.



Taken together, these observations support the underlying assumption that low-intensity UVA radiation can inhibit nitrifying bacteria in a tank as strongly as it does in nature. In addition, the routine nitrification-monitoring program showed that UVA radiation can accomplish this with no unforeseen consequences.

Nitrifying bacteria have attached and free-swimming life stages. Attached bacteria live year-round on bottom sediments and in biofilm that coats internal tank surfaces. Sediments and biofilm may shield attached bacteria from UVA radiation. Active nitrification, however, usually coincides with a bloom of free-swimming bacteria in the water column. Free-swimming bacteria would be fully exposed to and presumably inhibited by low-level UVA radiation. The relative contribution of attached and free-swimming bacteria to tank nitrification remains the largest unknown factor of the Mount Washington project.

FUTURE WORK

As encouraging as the pilot results have been so far, much remains to be done. The lighting installation followed the simplest, round-the-clock, proof-of-concept design. Other configurations and photoperiods are conceivable; however, large-scale, long-term flow-through experiments in a series of tanks deep enough to absorb UVA radiation are needed to further assess and optimize the approach.

An experimental tank farm, known as the Subaquatic Inhibiting-Light Observatory, is nearing completion at the Los Angeles Aqueduct Filtration Plant. Four 17,000-gal covered tanks are already in the ground. Fabricated from 20-ft lengths of surplus 144-in. ASTM A36 rusted steel pipe, the tanks are plumbed to receive chlorinated or chloraminated water and are being equipped with dimmers, timers, mixers, and heaters. This facility allows different lamps and fixtures, radiation intensities, and photoperiods to be tested against an array of flow, temperature, and circulation conditions in the presence of natural biofilm. LADWP personnel are optimistic that low-intensity UVA radiation will prove to be a practical, safe, and effective safeguard against nitrification onset in water storage facilities.

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Moore-Love, Karla

From: floy jones <floy21@msn.com>
Sent: Thursday, April 30, 2015 4:45 PM
To: Council Clerk – Testimony; Hales, Mayor; Adam, Hillary
Subject: Washington Park Demolition LU Review

Submitted for the Washington Park Land Use Review record:

http://www.ladwpnews.com/posted/1475/Opflow_Nitrification.523459.pdf (attached under separate cover)

The above American Water Work Association article addresses experimental actions that LA undertook to address the covered storage public issue of Nitrification. Demolition of the Washington Park Reservoirs does not support many of the Comprehensive Plan goals simply as relates to the new risks it creates.

See attachment
Dee White
4/30/15
4:48PM

Moore-Love, Karla

From:	Schwab Mary Ann <e33maschwab@gmail.com>
Sent:	Thursday, April 30, 2015 4:20 PM
To:	Moore-Love, Karla
Cc:	Walsh Joe
Subject:	mas response to: mas response to: LU 14-249689, Washington Park Reservoir Demolition as related to Goal 9 and Portland

To Whom It May Concern

LU 14-249689, Washington Park Reservoir Demolition

It has been brought to my attention many inter-governmental employees, City, County, State do not believe they can express their opinion
on any political issue for fear of retaliation: e.g., AirBnB, Uber, Street Fees, City of Cascade Locks water transfer to benefit Nestle,
Oregon Fish and Wild Life, Columbia River Inter-Tribal Fish Commission, for a few examples.

I am disappointed to report, those I have spoken with living East of the Willamette River were not aware of the Water Bureau's postcards or the "Sounding Board" meeting nine (9) months regarding Washington Park Reservoir Demolition. What I learned listing to Joe Walsh, Individuals for Justice, when addressing City Council during the three (3) minute pubic communication? You must take time to click-open the Agenda #. Why? Because too often the subject is "sugarcoated" and does not always reflect the action to be considered. Should the Hearings Officer have questions, feel free to contact Joe Walsh, by phone: (503) 503-946-8428, or by email: Walsh Joe <lonevet2008@comcast.net> . The same goes for yours truly, Mary Ann Schwab, by phone: (503) 236-3522, or by email: e33maschwab@gmail.com,

1.) Here is the link to City of Portland Public Involvement
Principles: http://www.portlandonline.com/oni/index.cfm?c=51069&a=312804

City's 2013 State and Federal Legislative Agendas
City of Portland Public Involvement Principles
Adopted by the City of Portland, Oregon on August 4, 2010
Portland City government works best when community members and government work as partners. Effective public involvement is essential to achieve and sustain this partnership and the civic health of our city. This:
- Ensures better City decisions that more effectively respond to the needs and priorities of the community.
- Engages community members and community resources as part of the solution.
- Engages the broader diversity of the community–especially people who have not been engaged in the past.
- Increases public understanding of and support for public policies and programs.
- Increases the legitimacy and accountability of government actions.

The following principles represent a road map to guide government officials and staff in establishing consistent, effective and high quality public involvement across Portland's City government.
These principles are intended to set out what the public can expect from city government, while retaining flexibility in the way individual city bureaus carry out their work.

2.) Here is the link to review On The Community Engagement Input Sessions, Sept 27, 2012: http://www.portlandonline.com/oni/involve

3.) Here is the link to Goal 9: http://www.oregon.gov/LCD/docs/goals/goal9.pdf

Oregon's Statewide Planning Goals & Guidelines GOAL 9: ECONOMIC DEVELOPMENT

OAR 660-015-0000(9)

To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.

Comprehensive plans and policies shall contribute to a stable and healthy economy in all regions of the state. Such plans shall be based on inventories of areas suitable for increased economic growth and activity after taking into consideration the health of the current economic base; materials and energy availability and cost; labor market factors; educational and technical training programs; availability of key public facilities; necessary support facilities; current market forces; location relative to markets; availability of renewable and non-renewable resources; availability of land; and pollution control requirements.

Comprehensive plans for urban areas shall:

1. Include an analysis of the community's economic patterns, potentialities, strengths, and deficiencies as they relate to state and national trends;
2. Contain policies concerning the economic development opportunities in the community;
3. Provide for at least an adequate supply of sites of suitable sizes, types, locations, and service levels for a variety of industrial and commercial uses consistent with plan policies;
4. Limit uses on or near sites zoned for specific industrial and commercial uses to those which are compatible with proposed uses.

In accordance with ORS 197.180 and Goal 2, state agencies that issue permits affecting land use shall identify in their coordination programs how they will coordinate permit issuance with other state agencies, cities and counties.

GUIDELINES

A. PLANNING

1. A principal determinant in planning for major industrial and commercial developments should be the comparative advantage of the region within which the developments would be located. Comparative advantage industries are those economic activities which represent the most efficient use of resources, relative to other geographic areas.
2. The economic development projections and the comprehensive plan which is drawn from the projections should take into account the availability of the necessary natural resources to support the expanded industrial development and associated populations. The plan should also take into account the social, environmental, energy, and economic impacts upon the resident population.

1

3. Plans should designate the type and level of public facilities and services appropriate to support the degree of economic development being proposed.
4. Plans should strongly emphasize the expansion of and increased productivity from existing industries and firms as a means to strengthen local and regional economic development.
5. Plans directed toward diversification and improvement of the economy of the planning area should consider as a major determinant, the carrying capacity of the air, land and water resources of the planning area. The land conservation and development actions provided for by such plans should not exceed the carrying capacity of such resources.

B. IMPLEMENTATION

1. Plans should take into account methods and devices for overcoming certain regional conditions and deficiencies for implementing this goal, including but not limited to
(1) tax incentives and disincentives;
(2) land use controls and ordinances;
(3) preferential assessments; (4) capital improvement
programming; and (5) fee and less-than-fee
acquisition techniques. 2. Plans should provide for a
detailed management program to assign respective implementation roles and responsibilities to those private and governmental bodies which operate in the planning area and have interests in carrying out this goal and in supporting and coordinating regional and local economic plans and programs.

2

Repsectfully,

Mary Ann Schwab
Sunnyside Neighborhood Resident, 44 years
also serving on the SE Uplift Board of Directors
2013 Spirit of Portland Recipient

Moore-Love, Karla

From: floy jones <floy21@msn.com>
Sent: Thursday, April 30, 2015 4:05 PM
To: Council Clerk – Testimony; Hales, Mayor; Adam, Hillary
Subject: [User Approved] Washington Park Reservoir Demolition LU 14-249689 DM
Attachments: Infrastructure Masterplan Summary Oct 2000.pdf

Submitted for the record Washington Park Reservoir Demolition LU Review 14-249689

The following supplements earlier comments.

The relevant criteria of the Demolition Review LU process supports providing the "community opportunity **to fully consider alternatives to demoliton"** has not been met. Portland City Council adopted the Principles of Public Involvement on August 4, 2010. This process has violated these principles in numerous ways as measured by the noted Principles, Indicators, and Outcome dileaneated in the city's Public Involvement Principles, https://www.portlandoregon.gov/oni/article/312804 (attached under separate cover.)

The scope of the work of the Water Bureau-selected "sounding board" which as described on April 23, 2015 by member Annie Mahoney was restricted to what happens after the Demolition thus the WB selected and unrepresentative "sound board" did not discuss let alone focus on "fully considering alternatives to demolition" a key purpose of Demoliton Review, thus the Public Involvement criteria is not met.

The overwhelming majority of the affected community was not notified of the existence of a so-called "sounding board" nor aware of their meeting schedule. By chance a few members of the public apparently learned of the final meeting of the sounding board. As the meeting summary reflects they were told by Water Bureau consultants that they could not speak about the drivers of the project, alternatives to demolition or anything beyond their "what happens after" task , https://www.portlandoregon.gov/water/article/512855

Virtually every principle of the city's adopted principles of public involvement have been violated. The following are but examples:

- A key principle in the City's Adopted Principles of Public Involvement is inclusiveness. The PWB's "sounding board" membership excluded the broad-based community and key community stakeholders.

- The composition of the board did not respect the right of stakeholders to be involved in decisions that affect them
- The principle of early public involvement was violated. In defiance of the promise of the 2004 Reservoir Panel Council Resolution, the Portland Water Bureau made the decision to demolish backroom

- Building Relationships and Community Capacity- Public involvement processes invest in and develop long-term, collaborative working relationships and learning opportunities with community partners and stakeholders. **This principle was violated. All significant decisions particularly those related to LT2 compliance were made backroom in an uncollaborative way despite the investment of tens of thousand of hours by community stakeholders addressing all aspects of Portland's water system and in particular the LT2 rule including working with other utilities on more rational LT2 alternatives.**
- Principle of Inclusiveness and Equity Public dialogue and decision- making processes identify, reach out to, and encourage participation of the community in its full diversity. Processes respect a range of values and interests and the knowledge of those involved. Historically excluded individuals and groups are included authentically in processes, activities, and decision and policy making. Impacts, including costs and benefits, are identified and distributed fairly. **This principle was violated.**

The suggestion on April 23, 2015 by the City Attorney that City Council's awarding corporate contracts to demolish the reservoirs constitutes the process whereby the community has fully considered alternatives to demolition makes a mockery of the City Council's promises as represented by the 2004 *Independent* Reservoir Panel Resolution (submitted under separate cover) and the City's adopted Public Involvement Principles.

Overstating Earthquake Risks
Supplemental information to comments and documents previously submitted for the record:

The PWB CH2MHill/ Montgomery Watson Harza (contract 31559) Infrastructure Master Plan Report lists at least six capital improvement actions to seismically upgrade the Portland water system. Not a single one of the six is an open reservoir. **See excerpt CH2MHill/MWH/PWB 2000 Infrastructure Master Plan excerpt attached**

Referenced in the Infrastructure Master Plan are four high priority projects that were recommended in a referenced PWB consultant System Vulnerablity Study to "ensure basic supply system capable of providing seasonal average demands during events that occur once in 100 years such as winter storms, and ...once in 500 years such as earthquakes." Again not one of the four is an open reservoir.

While neither the Portland Water Bureau or their consultants raised any concern related to earthquake risk or landslide problems at Mt. Tabor or Washington Park during the lengthy and comprehensive 2004 *Independent* Reservoir Panel that examined every conceivable issue with storage tanks, an anonymous caller to an Urban league panel member at the tail end of the panel process suggested the open reservoirs were a seismic risk. Subsequent extenisive examination of Water Bureau documents and PSU geologic documents countered the suggestion that the open reservoirs were at serious seismic risk given that they were so well constructed. The panel did not change their position subsequent to the anonymous phone call, finding no reason to "treat or cover" Portland's open reservoirs.

A 1990 study, funded by the Department of the Interior, U.S. Geological Survey stated, with regard to the Mt. Tabor reservoirs, liquefaction was considered not to be a problem. (This was reconfirmed by a subsequent Mt. Tabor Seismic Stability Analysis by Portland Water Bureau geotechnologic consultant Cornforth Consultants,http://www.cornforthconsultants.com/projects-earthquake-mt-tabor.htm.) The embankment was considered stable. Instead, it is the piping that is likely to develop leaks or rupture. The loss estimation table developed by the study estimates that an earthquake of 6.0 would result in $2,000 losses total for all Tabor structures. That loss number only begins to exceed $100,000 at an 8.0, becomes $139,000 at a 9.0 and $347,000 at a 10.0 earthquake. See excerpt of Earthquake Loss Estimation of the Portland, Oregon Water and Sewage System.

Montgomery, Watson, Harza held a PWB contract to study the open reservoirs since 1995, a contract that was amended and extended nine times extending until 2004. One of MWH's tasks was to identify the maintenance requirements necessary to keep the open reservoirs at Mt. Tabor and Washington Park in good condition, safely operating for the next fifty years. They listed 97 maintenance actions most if which have since been completed via a variety of contracts submitted via separate e-mail. Not a single one of these 97 actions makes reference to the seismic upgrading of the Mt. Tabor reservoirs.

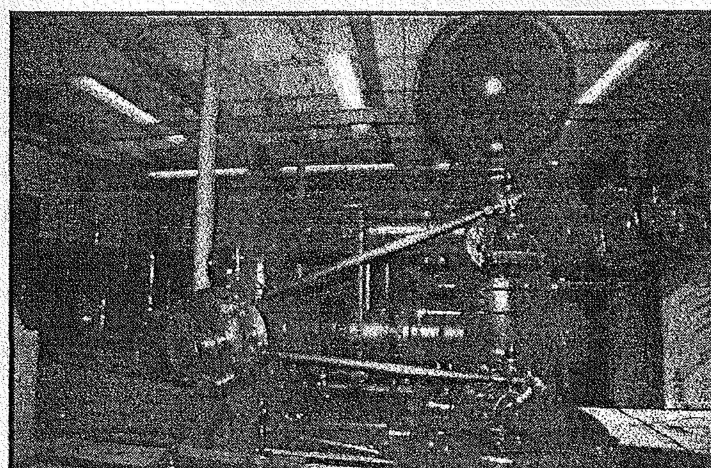
NEW UNDERGROUND RESERVOIRS SEISMIC RISK

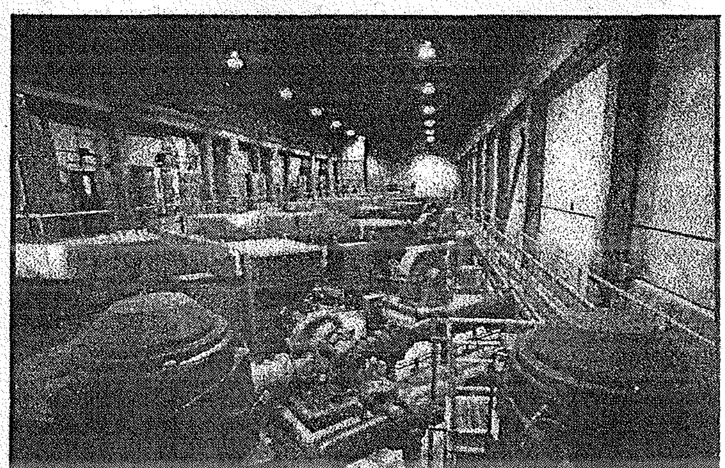
Seattle recently completed construction of a supposedly "seismically" sound 60 Million gallon Maple Leaf tank, a $55 million dollar project designed by a Portland Water Bureau favored consultant, MWH Global (designer Kelly Butte tank), the former home of Portland's long running revolving-door consultant, Joe Glicker who since 2006 is a CEO at CH2MHill (designer of the PWB's Powell Butte II tank with the 3200 cracks). The Portland Water Bureau's cost estimate for the demoliton of Portland's Washington Park reservoirs and construction of a tank 1/4 the size of the Maple Leaf tank, 15 million gallons is $80 million. The Seattle Times reported on June 18, 2014 that Seattle's new seismic underground Maple Leaf tank may present an earthquake risk, http://www.seattletimes.com/seattle-news/quake-concerns-loom-over-cityrsquos-4-underground-reservoirs/ and that more money may need to be invested.

"The utility began investigating the seismic deficiencies in March 2011, after the engineering company that designed the reservoirs, MWH, disclosed it had made an error in evaluating whether the structures would meet code using industry-standard calculations, which are based on aboveground reservoirs instead of underground ones, Ryan said. "

FINAL DRAFT REPORT

Infrastructure Master Plan





PREPARED FOR

Portland Water Bureau

PREPARED BY

CH2MHILL

Montgomery Watson

October 2000

SECTION 3

Summary of Findings

Introduction

This section provides a brief summary of the major findings of the main studies that provide the technical foundation for the policies described in the next chapter. These studies were described in Section 1. The studies are:

- System Vulnerability Assessment (SVA)
- Open Reservoir Study (ORS)
- Supply, Transmission, and Storage Analysis (STSA)
- Regional Transmission and Storage Strategy (RTSS)
- Powell Butte Master Plan

System Vulnerability Assessment

The Portland water system has been subjected to numerous significant hazard events in its 100-year history that have affected the means and methods of supplying water to the community. As examples of these events, several recent storm events have affected the Bull Run supply, requiring activation of the backup groundwater system. In late November 1995, a landslide resulting from heavy sustained rainfall damaged two of the three conduits delivering Bull Run water. The Bureau was able to maintain service by supplementing the supply from the remaining conduit with the groundwater supply. In February 1996, another intense rainstorm caused turbidity in the Bull Run supply to increase beyond regulatory acceptable water quality standards. The Bureau shut down the Bull Run supply and once again turned to the groundwater source. There were similar storms causing similar responses on New Year's Eve 1998-99 and Thanksgiving Day 1999.

The SVA was a probabilistic-based risk assessment of the vulnerability of Bureau's backbone water system to various hazard events. Its purpose was to identify the risk of system damage and failure relative to all hazards that could be expected to occur related to

SECTION 3

Summary of Findings

Introduction

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The SVA was a probabilistic-based risk assessment of the vulnerability of Bureau's backbone water system to various hazard events. Its purpose was to identify the risk of system damage and failure relative to all hazards that could be expected to occur related to the backbone supply, storage, and transmission system. The study examined 38 specific natural and human-caused hazards, such as earthquake, storm, flood, volcanic eruption, and malicious acts. The study did not investigate the impact of drought, which was instead reviewed in the STSA. The risks of both system-wide and more localized outages were quantified. The potential for correlation between various hazards also was assessed.

The study found that the events that are most likely to cause significant outages of the backbone system were:

- Earthquakes
- Intense rain-on-snow storms in the Bull Run Watershed

The study also concluded that while various winter storms could cause outages of both the Bull Run Watershed and the CSSW, these storms were not correlated. That is, it was unlikely that outage of both the Bull Run Watershed and the CSSW would occur at the same time.

Four high priority projects were recommended in the SVA to ensure that the basic supply system is still capable of providing seasonal average demands during events that occur once in 100 years, such as winter storms, and annual average demands that occur once in 500 years, such as major earthquakes. These high priority projects were:

- Upgrades to the Groundwater Pump Station, which supplies water from the CSSW to Powell Butte, to address seismic and mechanical reliability.
- Increase the capacity and reliability of the groundwater system through expansion of wells.
- Seismic upgrades to trestles along the conduits from the Bull Run Watershed to town.
- Constructing a tunnel under the Sandy River for the conduits.

The SVA also identified other moderate-high, moderate, and "quick fix" priority projects to increase the reliability of subsystems of the water system and avoid localized outages. These projects included:

- Mitigating landslide vulnerabilities along the supply conduits
- Constructing a new Willamette River crossing to bring water from Powell Butte to the west side in a seismically secure pipeline
- Constructing interties between the conduits

Other examples include mechanical and electrical improvements to Dams 1 and 2 in the Bull Run Watershed, upgrades of various transmission lines that are in soils that are subject to liquefaction during earthquakes, and projects that address seismic stability of various reservoirs and tanks.

Constructing a filtration plant on the Bull Run Watershed also was recommended as a long-term strategy that will ultimately be required to achieve a high reliability of the Bull Run supply for intense rain-on-snow storm events. In the short-term, however, the recommended strategy is to increase the capacity and reliability of the groundwater system and make stronger connections to other water systems with their own supplies to meet demand when the Bull Run Watershed is unavailable due to intense storm events.

Open Reservoir Study

Five of the six largest distribution reservoirs in the City of Portland distribution system are uncovered, or open, reservoirs. Three of these reservoirs, Reservoirs 1, 5, and 6, are located in Mt. Tabor Park on the east side of the city. Two of them, Reservoirs 3 and 4, are located in Washington Park on the west side of the city. A sixth open reservoir, Reservoir 2 at Mt. Tabor, was removed from service in the late 1970s due to water quality problems, and subsequently demolished.

The combined nominal storage capacity of the five open reservoirs is 170 MG. The reservoirs range in size from 12 MG to 75 MG. Reservoirs 1, 3, and 4 were constructed in 1894 and

Moore-Love, Karla

From: Scott Fernandez <scottfernandez.pdx@gmail.com>
Sent: Thursday, April 30, 2015 4:01 PM
To: Moore-Love, Karla; Scott Fernandez
Subject: Scott Fernandez - rebuttal testimony
Attachments: 4=30=15 4 Testimony rebuttal- Washington Park Reservoirs Landslide Review.pdf

Hi Karla,

Attached is my Washington Park reservoir land use rebuttal testimony. Please send a response of receipt.

Thank you,

Scott

April 30, 2015

To: Portland City Council

Washington Park Case File- LU-14-249689 DM

Demolition Review for Washington Park

From: Rebuttal Scott Fernandez   M.Sc Biology/ microbiology, chemistry

Mayor appointed – Portland Utility Review Board 2001-2008

Portland Water Quality Advisory Committee 1995-2000

My graduate work involved groundwater research including past geological curriculum.

The historic value of the Washington Park open reservoirs is based on structure and engineering foresight as well as public health benefits of no illnesses for over 100 years.

There is time and scientific basis to save and preserve our historic open reservoirs and community health; ask for EPA LT2 waiver as New York City and New Jersey have requested for their open reservoirs. We ask for a community wide discussion when submitting our scientifically supported request for a waiver from EPA LT2 regulation.

1. Landslide

Table 1: Historical Slide Movements Since Reservoir Construction

Date	Annual Rate of Movement	Description of Events
1893-1894	Unknown	Reservoirs constructed
1895-1896	15 inch/year	Water Bureau assessing cause of movements
1897-1898	1½ inch/year	Pump dewatering of exploratory shafts reduces movement rate; focuses stabilization techniques on dewatering options
1899-1900	4 inch/year	Exploratory shafts completed; movement rates increase due to stoppage of dewatering pumps; survey grid installed
1901-1904	¼ inch/year	Drainage tunnels constructed
1904-1906	1⅓ inch/year	Movements increase; additional drainage tunnels are installed
1906-1916	½ inch/year	Detailed survey monitoring
1920-1970	½ inch/year	Continued survey monitoring
1975-1986	¼ inch/year	Measurements obtained from 2 EDR casings
1987-2010	0.14 inch/year	Measurements obtained from 7 inclinometer casings

table 1. from- Geotechnical Data Report-Washington Park Reservoir Improvements

Cornforth Consultants December 2010

* Benchmarks proving stable* in establishing ***long term reduction of movement*** using increased engineering improvements; ground water pumping, drains , and dewatering applications. *definition of stable- consistent, and resists fluctuation

Rebuttal to PWB representative Dan Hogen

"claim that landslide is stabilized is not quite true". The landslide by definition meets "stable" criteria.

From information provided by PWB Washington Park Improvement Project.

There has only been ***one*** major landslide event. (PWB communication 2012)

This single major landslide event took place in 1893.

Continued movements were observed during the winter of 1894-95 at both reservoirs causing them to be out of service for about 10 years.(Evaluation of a Rate of Movement of a Reactivated Landslide 2008)

The surface of the slip was practically a plane and its slope a fairly uniform one so that the friction angle can be easily approximated with precision. Slipping was stopped by draining off the water, thus reducing the percentage of saturation of the clay.
(A Phenomenal Landslide. D.D. Clark 1904)

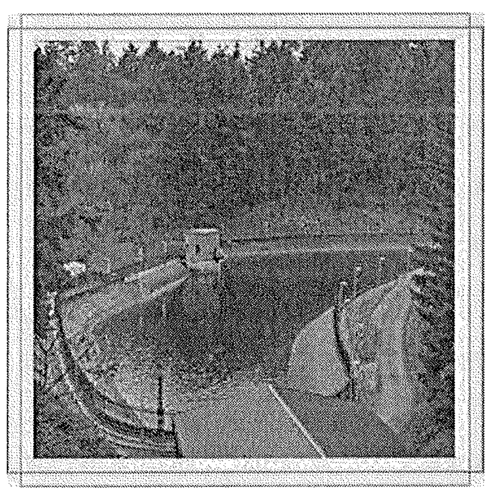
The Washington Park landslide was stabilized in the early years of reservoir construction by first utilizing pumps to draw down the water table; followed by digging tunnels along the slip surface to provide a network of interconnecting gravity drains. Being stabilized for decades, today the lanslide creeps at only a fraction of an inch each year. It is not the catastrophic situation PWB wants us to believe exists. Engineering reports show 14/100 of an inch movement that is diminishing for the last few decades. The underground water mitigation programs have worked as they should, de-watering and impeding movement. The reservoirs have survived rain inundation from Christmas 1964, and more importantly the **100 year** "rain on snow" event lasting for many days in February 1996 all without landslide issue. (Seven Deadly Sins of Landslide Investigation -Cornforth 2007) (Landslides in Portland,Oregon Metropolitan Area Resulting from Storm of February 1996, Inventory Map, Datadbase, and Evaluation Metro/PSU 1998)

Rebuttal to Mike Stuhr comments of 100 year precipitation event-

Portland Water Bureau had a vague response to 100 year 1996 precipitation event; Portland Water Bureau unable to demonstrate a landslide event at Washington Park 1996. This is confirmed by Table 1. above demonstrating no deviation in landslide movement for that double decade timeline period; from such a devastating regional precipitation event. Pumps, drains and dewatering applications functioned as designed

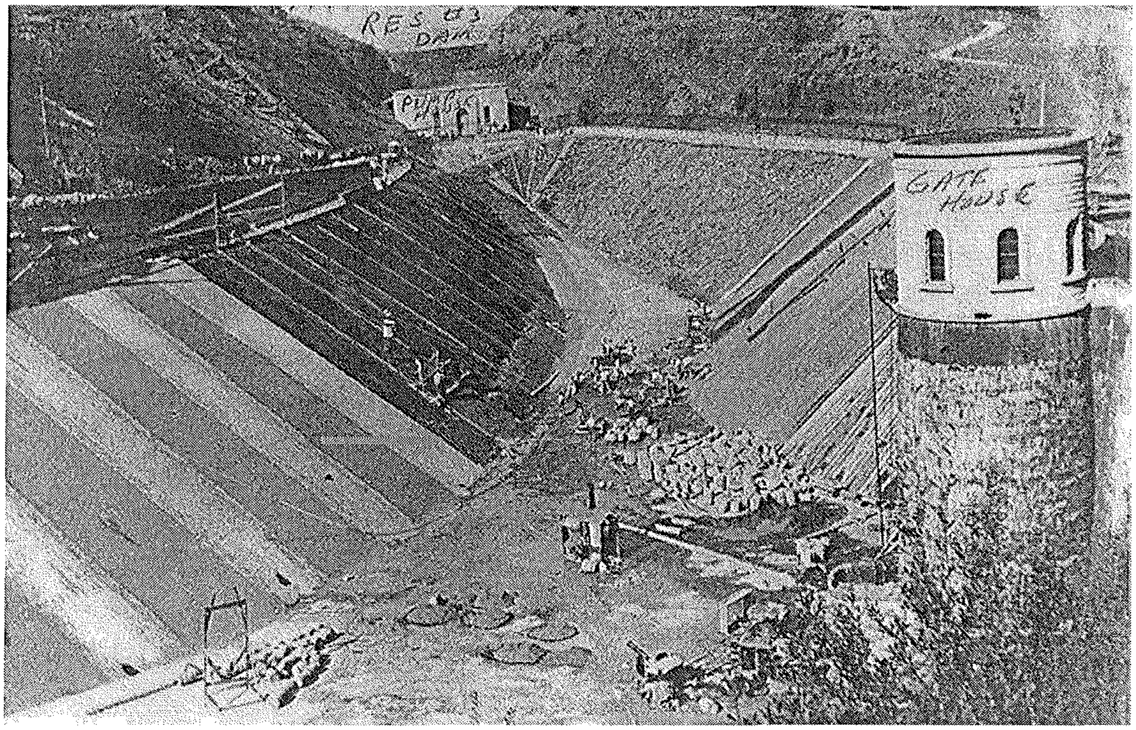
2. Rebar-In early September 2013 citizens toured the Powell Butte 2 facility in the final stages of construction. At the tour wrap-up meeting in the office trailer we asked Portland Water Bureau for reservoir blueprints to contrast Powell Butte 2 construction. We never received the reservoir blueprints for edification to compare systems.

Reservoir walls and fences remain in good condition.



Portland Water bureau rebar summary - red arrow → points to area where secured rebar grid would be consistent with Fig 61 Ransome concrete building practices after 1893 rebuilding continues.

Criticism of Washington Park Reservoir's rebar construction patterns being deficient is inconclusive.



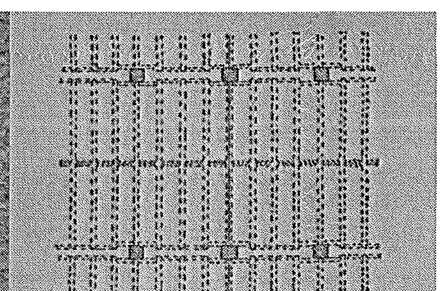
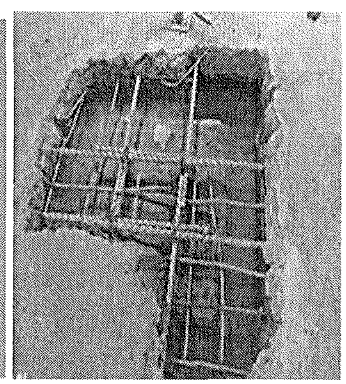


Fig. 61. Ransome System.
Plan of typical floor.



<u>**Ernest Ransome Systems used in Concrete = Cold Twisted Steel Construction** (</u>ref.)

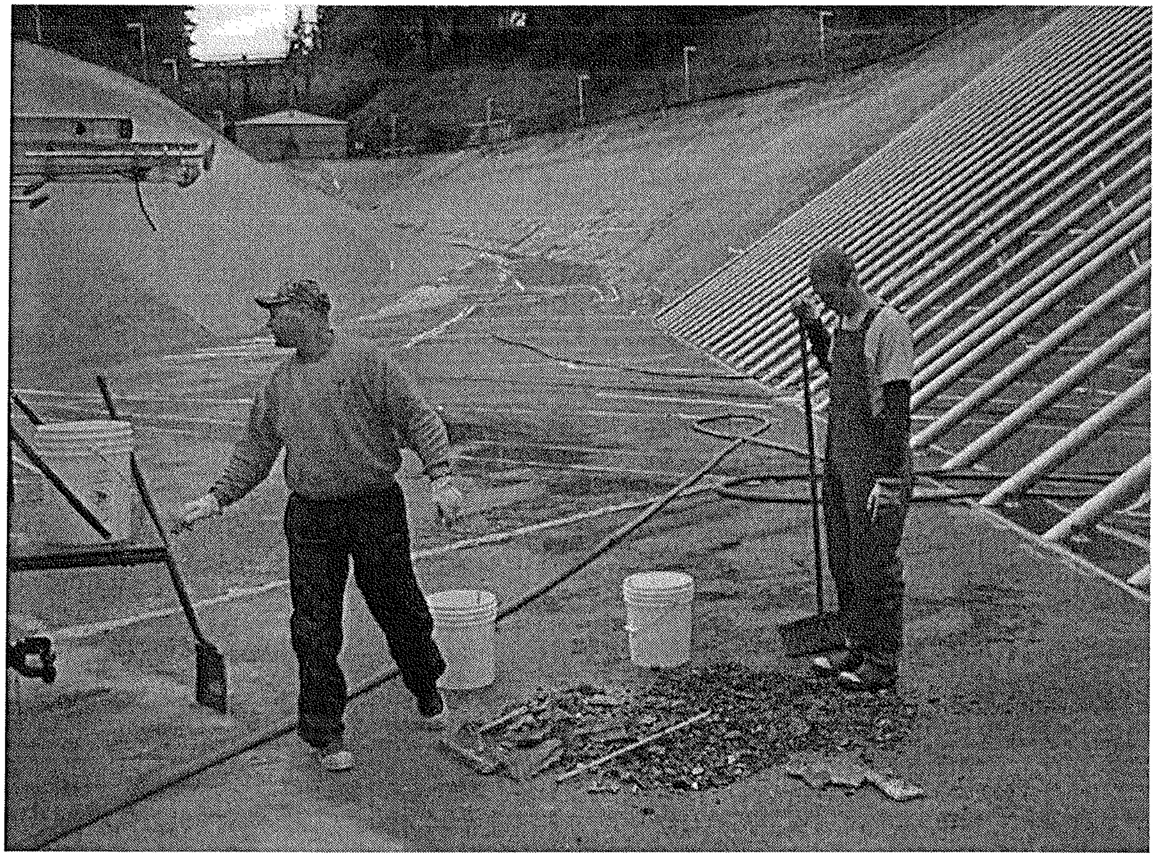
SEWERS, WATER CONDUITS, RESERVOIRS,
TUNNELS, SUBWAYS, ETC.

Images- Gluedideas.com Oldstructures.com

Rebuttal to rebar comments from Portland Water Bureau-

The Portland Water Bureau says the rebar was placed every 10' compromising stability as opposed to every 16" in newer reservoirs. While 10' rebar was "reported" in Historical Landmark application, 10' rebar was not "confirmed" to public. Having no access to blueprints there was no way to confirm what the true building structure was at different stages and then placing public again at disadvantage for construction transparency. In 1893 the reservoir design engineers along with landslide engineers worked for 10 years to make the reservoirs 3 & 4 functional again. A local construction consultant confirmed the 20% slope could not be functional with only 10' rebar. Ernest Ransome building systems reinforced wall, floors and ceilings as seen in floor example below. 20% slopes must have rebar grids between the 10' rebar to stabilize cement on basin walls. Added to grid would need to have 20'-30' rebar anchored in basin wall soils.

What we see is reservoir 4 rebuilt and strengthened in the 1894 10 year process to remain functional for over a century.



What we see here is a well-built reservoir 4 with solid floor and solid walls living up to the engineer reports acknowledging many decades of functionality left. We do see some minor maintenance needed as acknowledged by City of Portland Auditor reports from 2004, 2011, 2012 where "Portland Water Bureau does not meet industry maintenance standards."

The rebar issue at Washington Park and amount of cement used has become secondary. With maintenance and removal of steel girders for unused covering reservoir tarps, in addition to a new properly fitting liner for reservoir 3, the reservoirs function well. Comparing the reservoirs 3 & 4 with the success of newer Powell Butte 2 reservoir having thicker walls and more rebar makes no sense. The 30" floors and 26" walls that were defective and always will be, showing to be problematic losing millions of gallons of water weekly. Patching defective cement only adds to more maintenance costs, not a better facility.

3. Landslide mitigation barrier- new information

Portland Water Bureau withheld this information from a community wide discussion and review; thus removing a cost effective and uniformly accepted industry application to mitigate landslides. Portland water Bureau has no responsible explanation why this was withheld.

"The western portion of the site sits at the toe of an ancient active landslide that was reactivated during construction of the reservoirs in the late 1890s. The slide continues to move at a rate of about 14/100's inch a year. Mitigation work will occur in the upper reservoir (referred to as Reservoir No.3) including construction of a compressible inclusion system that would accommodate the slide movement without additional loading on the new reservoir. The compressible inclusion system will consist of Expanded Polystyrene (EPS) Geofoam. Mitigation at Reservoir No. 4 will consist of partially backfilling the basin and building a new embankment to re-establish the original 1893 grade. This will require placing an excess of 140,000 cubic yards of fill material." (City of Portland RFP 115122 October 22, 2013. Request for Proposals for WASHINGTON PARK RESERVOIR IMPROVEMENT PROJECT)

A compressible inclusion is any material that compresses readily under applied stress or displacement. Geotechnical applications for a compressible inclusion include behind earth retaining structures; around foundation elements; and above pipes, culverts and tunnels. Using a compressible inclusion can result in significant reduction in earth pressures under static and dynamic loading. A compressible inclusion can also accommodate ground or structure movement (landslides). Using a compressible inclusion can also be cost effective for rehabilitating or upgrading existing structures. Compressible inclusions applications are the solution to retaining open reservoirs without disconnecting, destroying, or demolishing Washington Park reservoirs 3&4. The Compressible Inclusion Function of EPS Geofoam: An Overview. JS Horvath 1996

Applicant deficiencies-

- Did not prove February 1996 100 year precipitation event caused landslide, catastrophic or otherwise. Dewatering system stabilized landslide as shown by Table 1, Cornforth Consultants 2010.
- Portland Water Bureau did not provide reservoir blueprints for public review and construction assessment.
- Portland Water Bureau withheld landslide "compression inclusion system" mitigation plan from community wide awareness and discussion. But more importantly withheld it as a meaningful money saving alternative to reservoir 3&4 destruction and demolition. Portland Water Bureau knowingly and willfully placing our public health at risk from toxic and carcinogenic contaminants.
- Did not acknowledge; only one major Washington Park landslide event 1893. During Washington Park reservoir process Portland Water Bureau continuously provided misleading and deceptive communication to public that catastrophic events took place.
- Portland Water Bureau did not acknowledge 2004 Independent Review Panel reviewed science presentations on seismic and landslide risk determining they were not an issue of public health concern. IRP voted to retain open reservoirs.

Public recognitions-

- Confirms Ransome rebar system holds up to 7.8 magnitude seismic event.
- Ransomed floor system used in all projects
- Because reservoir blueprints withheld; 10' spaced rebar issue makes no sense in wall and floor construction. Ransome floor plan in Figure 61 would be logically applied during 1894 10 year upgrade to provide needed support in holding concrete in place on 20% slope, and pressure challenges on reservoir floor.
- Portland Water Bureau seismic modeling program showing small landslide risk is irrelevant considering it is formulated using "estimates based on assumptions" techniques that can be easily influenced to get uncertain and inconclusive outcomes. We have seen this happen with EPA LT2 and EPA Chesapeake Bay "modeling" where algorhythmic conclusions never came true. Reliable science is based on observation.

- Landslide *stability* has been confirmed by definition using reliable dewatering engineering showing decades of consistent movement reduction with only one major landslide in 1893.

Summary-

The community has participated in the reservoir process for well over a decade with continued disrespect, disregard and contradiction of the issues by the applicant. The landslide, seismic, and public health science has been solid and settled from the beginning (2004). Estimations based on assumptions provided by the applicant have little significance or meaning when scientific data (landslides, public health) are based on observations providing the true answers. We have no scientific problems with the open reservoirs. Withholding information requests and not providing material in a timely manner has not advanced a transparent community involvement process promised by the applicant. Concealing "compressible inclusion" information from the community as an alternative solution that is cost effective by the applicant is unacceptable. The increased costs, deceitful practices, and public health risks that have been promoted by the applicant's rush to demolish and destroy Washington Park's reservoirs 3&4, can only be addressed by initiating an immediate cease and desist demolition order by Council.

Moore-Love, Karla

From: Dee White <deewhite1@mindspring.com>
Sent: Thursday, April 30, 2015 3:45 PM
To: Council Clerk – Testimony
Subject: Public Comment for the Record Type IV Demolition Review for WA Park Reservoirs
Attachments: City of Portland Public Involvement Principles.pdf

Karla, Can you please send me a receipt? Thank you once again and probably again. Dee White

Attached:
City of Portland Public Involvement Principles

City of Portland Public Involvement Principles

Adopted by the City of Portland, Oregon on August 4, 2010

Preamble

Portland City government works best when community members and government work as partners. Effective public involvement is essential to achieve and sustain this partnership and the civic health of our city. This:

- Ensures better City decisions that more effectively respond to the needs and priorities of the community.
- Engages community members and community resources as part of the solution.
- Engages the broader diversity of the community–especially people who have not been engaged in the past.
- Increases public understanding of and support for public policies and programs.
- Increases the legitimacy and accountability of government actions.

The following principles represent a road map to guide government officials and staff in establishing consistent, effective and high quality public involvement across Portland's City government.

These principles are intended to set out what the public can expect from city government, while retaining flexibility in the way individual city bureaus carry out their work.

City of Portland Public Involvement Principles

- **Partnership**
  Community members have a right to be involved in decisions that affect them. Participants can influence decision-making and receive feedback on how their input was used. The public has the opportunity to recommend projects and issues for government consideration.

- **Early Involvement**
  Public involvement is an early and integral part of issue and opportunity identification, concept development, design, and implementation of city policies, programs, and projects.

- **Building Relationships and Community Capacity**
  Public involvement processes invest in and develop long-term, collaborative working relationships and learning opportunities with community partners and stakeholders.

- **Inclusiveness and Equity**
  Public dialogue and decision-making processes identify, reach out to, and encourage participation of the community in its full diversity. Processes respect a range of values and interests and the knowledge of those involved. Historically excluded individuals and groups are included authentically in processes, activities, and decision and policy making. Impacts, including costs and benefits, are identified and distributed fairly.

- **Good Quality Process Design and Implementation**
  Public involvement processes and techniques are well-designed to appropriately fit the scope, character, and impact of a policy or project. Processes adapt to changing needs and issues as they move forward.

- **Transparency**
  Public decision-making processes are accessible, open, honest, and understandable. Members of the public receive the information they need, and with enough lead time, to participate effectively.

- **Accountability**
  City leaders and staff are accountable for ensuring meaningful public involvement in the work of city government.

City of Portland
Public Involvement Principles, Indicators and Outcomes

Principles Public agencies that achieve excellence in public involvement follow the principles below.	**Indicators** Public involvement processes that follow these principles commonly exhibit the following characteristics.	**Outcomes** High quality public involvement processes often produce the following outcomes and benefits.
Partnership Community members have a right to be involved in decisions that affect them. Participants can influence decision-making and receive feedback on how their input was used. The public has the opportunity to recommend projects and issues for government consideration.	• Community members are kept informed of issues and processes. • Community members know how to be involved and decide the degree of their involvement. • Community members are advised how their input will affect the decision, and are followed up with contact from the lead agency throughout the decision-making process. (feedback loop) • Process constraints are clarified and understood by community members. • The decision making process and decision makers and their power are explained and understood.	• A better project or policy will result from community participation. • Government will have a better understanding of the community and its concerns. • The policy or project will have greater community acceptance.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	**Indicators** Public involvement processes that follow these principles commonly exhibit the following characteristics.	**Outcomes** High quality public involvement processes often produce the following outcomes and benefits.
Early Involvement Public involvement is an early and integral part of issue and opportunity identification, concept development, design, and implementation of city policies, programs, and projects.	• Community members help set priorities and shape policies, programs, and projects. • Key stakeholders are involved as early as possible. • Key stakeholders help define the problem, issues, and project parameters. • Community members help define the process for outreach and decision making.	• Better project scoping, more predictable processes, and more realistic and defendable assessments of process time and resource needs. • Early and broad community support for the project or policy. • Identification of potential problem areas before they become an issue.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	Indicators Public involvement processes that follow these principles commonly exhibit the following characteristics.	Outcomes High quality public involvement processes often produce the following outcomes and benefits.
Building Relationships and Community Capacity Public involvement processes invest in and develop long-term, collaborative working relationships and learning opportunities with community partners and stakeholders.	• Community members feel heard and feel that their input is valued and used by city staff. • Community members trust the process and city staff. • City staff have consistent and reliable connections with stakeholders and community groups that facilitate effective two-way communications. • City staff engage in ongoing monitoring of relationships. • City staff continually assess which communities and populations are missing key information, or are not involved.	• Processes leave neighborhoods and communities stronger, better informed, increase their capacity to participate in the future, and develop new leaders.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	**Indicators** Public involvement processes that follow these principles commonly exhibit the following characteristics.	**Outcomes** High quality public involvement processes often produce the following outcomes and benefits.
Inclusiveness and Equity Public dialogue and decision-making processes identify, reach out to, and encourage participation of the community in its full diversity. Processes respect a range of values and interests and the knowledge of those involved. Historically excluded individuals and groups are included authentically in processes, activities, and decision and policy making. Impacts, including costs and benefits, are identified and distributed fairly.	• A strong effort is made to accommodate diverse needs, backgrounds values and challenges. • Participation in the process reflects the diversity of the community affected by the outcome. • Culturally appropriate and effective strategies and techniques are used to involve diverse constituencies. • City staff follow-up with under-engaged groups to see how the process worked for their community members. • An assessment is made to identify communities impacted by a project or policy. The active participation of these communities is made a high priority. • The demographics, values, and desires of and impacts on affected communities are identified early on, influence the process design, and are reaffirmed throughout the process.	• City policies, projects, and programs respond to the full range of needs and priorities in the community. • Trust and respect for government increases among community members. • City staff and members of more traditionally-engaged communities understand the value of including under-engaged communities. • Equity is increased by actively involving communities that historically have been excluded from decision making processes. • Members of under-engaged communities increase their participation in civic life. • New policies do not further reinforce the disadvantaged position of historically disadvantaged people or groups.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	Indicators Public involvement processes that follow these principles commonly exhibit the following characteristics.	Outcomes High quality public involvement processes often produce the following outcomes and benefits.
Good Quality Process Design and Implementation Public involvement processes and techniques are well-designed to appropriately fit the scope, character, and impact of a policy or project. Processes adapt to changing needs and issues as they move forward.	• The public is allowed an opportunity to give meaningful input regarding what the community needs from government. • Process facilitators have the skills, experience, and resources needed to be effective. • Careful planning of project timelines take into account the length of time community media, neighborhoods and organizations require for effective public involvement. • Information is sent out in a timely manner so people and organizations can respond. • Input is sought from participants periodically on how the process is working for them. • Community partners have input into whether processes should change and how they should be modified.	• People understand the purpose of the project and why it's being done. • Conflict is reduced as are challenges to the process. • Communication is more efficient and effective. • Outcomes are more sustainable. • Public confidence and trust built through good processes can carry on to future processes.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	**Indicators** Public involvement processes that follow these principles commonly exhibit the following characteristics.	**Outcomes** High quality public involvement processes often produce the following outcomes and benefits.
Transparency Public decision-making processes are accessible, open, honest, and understandable. Members of the public receive the information they need, and with enough lead time, to participate effectively.	• Roles and responsibilities are clearly identified, understood and accepted. • All meetings are open to the public and held in venues that are accessible and welcoming to community members. • Relevant documents and materials are readily available to the public. • Materials are available prior to the meeting so people are informed and ready to participate fully. • Materials that are lengthy or complex are made available with additional lead time to ensure community members can review and understand the materials, clarify with bureau staff, and check back with the communities they represent as needed. • Adequate time and resources are given for translation of materials and interpretation services and accommodations at meetings and forums as necessary.	• Community members have a better understanding of the project or policy and are better able to participate effectively. • Government understanding of community opinions and needs is enhanced.

Principles Public agencies that achieve excellence in public involvement follow the principles below.	**Indicators** Public involvement processes that follow these principles commonly exhibit the following characteristics.	**Outcomes** High quality public involvement processes often produce the following outcomes and benefits.
Accountability City leaders and staff are accountable for ensuring meaningful public involvement in the work of city government.	• Resources are applied appropriately to public engagement activities. • Community members' time and resources are respected and used effectively. • Public involvement processes are evaluated on a regular basis to foster ongoing learning and improvement. • Evaluation methods are tailored to different audiences to ensure meaningful feedback from all parties involved in a process, including community members, stakeholder groups, staff and management. • Best practices are identified and shared.	• Improved strategies and tools for outreach and decision-making. • Increased sense of trust in government from community members.

Moore-Love, Karla

From:	Dee White <deewhite1@mindspring.com>
Sent:	Thursday, April 30, 2015 3:37 PM
To:	Council Clerk – Testimony
Cc:	Hales, Mayor; Adam, Hillary
Subject:	Email 1 of 4 Comment on Type IV Demolition Review WA Park Reservoirs
Attachments:	Dee White Comments for Type IV Demolition Review WA Park.docx

<<Karla,>> I will be sending three additional emails to you with attachments, for the record. Please ensure that these attachments are all together along with my comment. I have attached the below comment as a Word Document as well. Could you please kindly send me a confirmation receipt of these four emails? Thanks so much, Dee White>>

Comment on proposed demolition
Portland Water Bureau Type IV Demolition Review

April 30, 2015

As testified by Katherine Kirkpatrick (April 23), Jeff Boly (March 19 to Historic Landmark Commission and admitted to record for City Council 4-23), Dee White (April 23) and multiple others, there is significant cause to believe that the city/applicant has not complied with Oregon's LCDC Statewide Planning Goals as incorporated in Portland's Comprehensive Plan and the 2014 Oregon Structure Specialty Code AND;

Failed to meet the approval criteria for all zoning processes applicable to this project including but not limited to: Demolition Review, Type III Historic Review, Type III Conditional Review (the latter two public processes of which the City/applicant has not complied with despite City staff's admission that they must be complied with—see *6/3/2014, Land Use Planner Responses from planners Castlebury and Wallhood, included in Applicant's pre-application conference documentation of the record in this case).*

The following excerpts from documentation (which I am submitting as attachments and hyperlinks in this document) raises doubts that the city/applicant, BDS and the city attorney have carried out due diligence in approving the application with regards to safety, liability, structural soundness and has failed to provide concrete evidence that points to reservoir damage caused by the minimal movement of the landslide in its current state, thus further diminishing one of the key issues driving the project.

For submission into the record is a paper written by Derek Cornforth, a highly respected geotechnical engineer, founder of Cornforth and Associates in Portland and a longtime Portland city contractor. This paper was presented in June 2007 to the First North American Conference on Landslides in Vail, CO. I am submitting the entire report for the record in the form of a hyperlink: http://www.landslidetechnology.com/resources/2007-DHC-Seven_Deadly_Sins.pdf and as an attachment. I am citing portions of the paper as key points, although more key points are made throughout the paper and as Cornforth indicated:

"The case histories are not intended to be complete, but be sufficient to illustrate the "sin" under discussion. In most cases, they are one example amongst several that could be cited. Discussing the mistakes of others within a technical paper is a sensitive undertaking. However, our profession advances by the continuing development of good practices. The goal of this paper is to help fellow practitioners avoid these costly and embarrassing mistakes in the future. "

The Seven Deadly Sins Are (red emphasis mine):
•Failing to recognize pre-existing landslide conditions
•Interpreting the depth of slippage of a landslide from boring logs or test pits instead of inclinometer observations
•Incorrectly interpreting inclinometer data
•Using an inappropriate factor of safety
•Allowing a contractor to remove support from a landslide for extended periods during remedial construction
•Disregarding artesian pressures in design
•Constructing large fills over soft sediments underlain by steeply-inclined bedrock

From a layman's perspective, Portland Water Bureau will be committing at the very least 2 of these sins (which I have indicated above in red) as I will illustrate below with excerpts from Cornforth's paper. The city has not proved that the landslide is moving at a rate that is detrimental to the structure of the reservoirs such that they require demolition. Merely stating it in the BDS Staff Report (LU14-249689DU) and The WB Application for Historic Demolition review proposing demolition is not justification without supporting evidence such as inclinometer readings.

Cornforth's paper offers proof that demolition will: 1. expose citizen's physical safety, private property, and taxpayer-owned property to danger from retriggering the landslide 2. Will place the ratepayers in a precarious financial position as a result of probable large lawsuits. The conditions of approval for demolition require that the non-demolition alternative be economic hardship.

Cornforth, the professional, uses the WA Park Reservoirs as the example of the **first deadly sin:**

•Failing to recognize pre-existing landslide conditions

"**Sin No. 1. Failing to recognize pre-existing landslide conditions** Pre-existing landslides usually can be recognized by the landform at a site. Therefore, a reconnaissance of the ground by an experienced engineering geologist should be one of the first requirements for developments proposed on hillsides. It is especially needed on proposed pipeline alignments, large subdivisions, and wherever landslide hazard maps indicate a past history of instability. Although this requirement may seem self-evident, owners and developers often rush to construction, omitting this simple step that could forewarn them of potentially unstable ground.

"Example B: Washington Park Reservoirs Slide, Portland, Oregon
In the early 1890s, the city of Portland built two reservoirs on the city's west side for water supply. The chosen site was a ravine at the base of a long hillside (Figures 4, 5). The project required excavation of 100,000 cu.yds. (76,000 cu. m) of soil from the bottom of the ravine. During construction of the two reservoirs, a large landslide developed upslope that was 1700 feet (520 m) long and 1100 feet (335 m) wide at the base of the slope. The top of the slope was a flat, marshy area – a graben feature of the ancient landslide. Between December, 1894 and

October, 1897, down slope movements of up to 3.24 feet (0.99 m) were measured by surface hubs (Clarke, 1904).

"During the site investigations, 22 deep shafts and 9 borings showed that the slip surface was 56 to 111 feet (17 to 34 m) below ground (Figure 6), generally occurring within a seam of highly plastic clay. The landslide debris was a heterogeneous mixture of stiff clay and broken rock. The landslide was stabilized by first using pumps to drawdown the water table, followed by digging tunnels along the slip surface to provide a network of interconnecting gravity drains. Today, the landslide creeps downhill at only a fraction of an inch per year.

"The Washington Park landslide is an example of ancient landslide terrain reactivation. The excavation for the reservoirs was about 3% of the landslide mass. In a major lawsuit that followed construction, the city was exonerated from liability for residential damages because the judge could not accept that such a minor excavation, relative to the entire landslide mass, could be responsible for the large observed movements. However, in current knowledge, there have been many examples similar to this one showing that minor adverse changes in slope stability can produce disproportionately large movements in pre-existing landslides that are marginally stable prior to the changes.

"Comments on Pre-Existing Landslide Conditions

Once a pre-existing landslide condition has been recognized, steps can be taken to discover whether or not the old landslide is currently active. This procedure includes examination of the site for signs of recent movements, enquiries of local residents and city records, and installation of inclinometers to monitor the ground through one or more wet seasons (if feasible due to the owner's time constraints).Pre-existing landslides can range from being fully stable to active year-round. A simple classification system (see Cornforth 2005; page 23) is to describe a pre-existing landslide as either: (i) currently stable, (ii) generally stable, but occasionally active during exceptionally high rainfall, (iii) stable during the drier months of the year, but generally active during periods of winter rainfall, or (iv) active throughout the year. These distinctions provide the geotechnical practitioner with a framework to determine what actions need to be taken to provide the necessary stability for a specific project (or to determine if stability measures are feasible). As a general comment, a pre-existing landslide (such as ancient landslide terrain)in a wet temperate climate that appears to be stable should be treated as "marginally" stable unless there is some redeeming factor at the site to indicate otherwise. Therefore, as a minimum, any development must be designed so that the overall and local stabilities are not reduced as a result of construction. Lawsuits involving reactivation of pre-existing landslides can be very contentious, with the key technical issue being whether the activation is due to natural or manmade cause. The larger movements that produce such lawsuits usually occur during or shortly after a period of intense rainfall. The defense typically takes the position that the rainfall at the time of movement was extraordinary (as an example, that the three-day cumulative rainfall was the highest for the past 40 years). Other natural causes could be erosion from springs, rivers, or sea in combination with high intensity rainfall.

The plaintiff position is likely to focus on manmade fills or cuts that destabilize a slope, or on poorly designed control of surface water, such as springs, holding ponds, broken water and sewer pipes, ditches, and drains."

The second sin that city/applicant has neglected in consideration of demolition:

"Sin No. 5. Allowing a Contractor to Remove Support to a Landslide for Extended Periods during Remedial Construction
In performing the tasks of analyzing a landslide and the options for correcting it, a geotechnical practitioner may forget to consider the temporary excavation that a contractor must do as part of the remediating construction work. Contract specifications usually transfer responsibility for temporary works and site safety from the owner (and their agents) to the contractor. However, the reality is that, should things go awry, it is likely that the design geotechnical engineer will be named as a defendant in a lawsuit or as the responsible party for a site-related problem in a construction claim. Therefore, it is advisable for the design engineer to think through the construction process and try to avoid these types of claim.

The common feature of these causes is that temporary excavations into the middle or lower reaches of a landslide almost always reduce slope stability and may reactivate movements. Since many landslide treatments require temporary excavations, the geotechnical design engineer generally needs to take an active role to prevent further movements. "

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6 SUMMARY AND CONCLUSIONS

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Table 1: Historical Slide Movements Since Reservoir Construction

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1893-1894	Unknown	Reservoirs constructed
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1897-1898	1½ inch/year	Pump dewatering of exploratory shafts reduces movement rate; focuses stabilization techniques on dewatering options
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1906-1916	½ inch/year	Detailed survey monitoring
1920-1970	⅓ inch/year	Continued survey monitoring
1975-1986	¼ inch/year	Measurements obtained from 2 EDR casings
1987-2010	0.14 inch/year	Measurements obtained from 7 inclinometer casings

As you can see from the above table, the slide has BEEN SLOWING DOWN since 1906 and between 1987-2010, it has been reduced to “the speed of a fingernail growing” at 14/100 inch per year.

From:
Portland Water Bureau Type IV Demolition Review page 70

“The restored fill on the toe of the slide at the Reservoir 4 site will help slow the overall slide movement above both Reservoirs 3 and 4.”

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It is clear to me, even as a layman, that the Water Bureau is overstating the movement as being dangerous and that by adding an air pocket and/or foam, the landslide could conceivably SPEED UP, further putting the public, the park AND the water supply in danger. Both reservoirs survived the snow/rain event in 1996, when thousands of landslides occurred all over the state, even with 5 deaths. Both of the reservoirs, according to the inclinometer readings in the chart above, continued creeping the speed of a growing fingernail – at 14/100 inch per year, exactly the same as the previous 9 years before the catastrophic 1996 water/snow event.

FROM:

Oregon’s Statewide Planning Goals and Guidelines GOAL 7: AREAS SUBJECT TO NATURAL HAZARDS
To protect people and property from natural hazards.
http://www.oregon.gov/LCD/docs/goals/goal7.pdf

“A. NATURAL HAZARD PLANNING

1. Local governments shall adopt comprehensive plans (inventories, policies and implementing measures) to reduce risk to people and property from natural hazards. "

FROM:

Planning for Natural Hazards
Landslide TRG
July 2000
Oregon Department of Land Conservation and Development

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"Section 2: Is Your Community Threatened by Landslide Hazards?

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Landslides are a naturally occurring event and their effect on new and existing development in our communities can be devastating. Three conditions may put people and property at risk of landslide damage:

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Development on or adjacent to existing landslides is generally at risk of future movement regardless of excavation practices. Excavation and drainage practices can further increase risk of landslides, which can be very large. In many cases there are no development practices that can completely assure stability. Homeowners and communities in these situations accept some risk of future landslide movement. Slopes can be very gentle (under 10 percent) on some portions of existing landslides.

Section 3.1 Oregon Laws Related to Landslide Hazards
3.1.1 Goal 7: Areas Subject to Natural Disasters and Hazards

Goal 7: Areas Subject to Natural Disasters and Hazards
Goal 7 is the Statewide Planning requirement that directs local governments to address natural hazards in their comprehensive plans. Goal 7 states that "Developments subject to damage or that could result in loss of life shall **not** be planned or located in known areas of natural disasters and hazards without appropriate safeguards. Plans shall be based on an inventory of known areas of natural disasters and hazards..." "

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Comment on proposed demolition
Portland Water Bureau Type IV Demolition Review

April 30, 2015

As testified by Katherine Kirkpatrick (April 23), Jeff Boly (March 19 to Historic Landmark Commission and admitted to record for City Council 4-23), Dee White (April 23) and multiple others, there is significant cause to believe that the city/applicant has not complied with Oregon's LCDC Statewide Planning Goals as incorporated in Portland's Comprehensive Plan and the 2014 Oregon Structure Specialty Code AND;

Failed to meet the approval criteria for all zoning processes applicable to this project including but not limited to: Demolition Review, Type III Historic Review, Type III Conditional Review (the latter two public processes of which the City/applicant has not complied with despite City staff's admission that they must be complied with—see *6/3/2014, Land Use Planner Responses from planners Castlebury and Wallhood, included in Applicant's pre-application conference documentation of the record in this case).*

The following excerpts from documentation (which I am submitting as attachments and hyperlinks in this document) raises doubts that the city/applicant, BDS and the city attorney have carried out due diligence in approving the application with regards to safety, liability, structural soundness and has failed to provide concrete evidence that points to reservoir damage caused by the minimal movement of the landslide in its current state, thus further diminishing one of the key issues driving the project.

For submission into the record is a paper written by Derek Cornforth, a highly respected geotechnical engineer, founder of Cornforth and Associates in Portland and a longtime Portland city contractor. This paper was presented in June 2007 to the First North American Conference on Landslides in Vail, CO. I am submitting the entire report for the record in the form of a hyperlink:
http://www.landslidetechnology.com/resources/2007-DHC-Seven_Deadly_Sins.pdf and as an attachment. I am citing portions of the paper as key points, although more key points are made throughout the paper and as Cornforth indicated:

"The case histories are not intended to be complete, but be sufficient to illustrate the "sin" under discussion. In most cases, they are one example amongst several that could be cited. Discussing the mistakes of others within a technical paper is a sensitive undertaking. However, our profession advances by the continuing development of good practices. The goal of this paper is to help fellow practitioners avoid these costly and embarrassing mistakes in the future. "

The Seven Deadly Sins Are (red emphasis mine):
•Failing to recognize pre-existing landslide conditions

•Interpreting the depth of slippage of a landslide from boring logs or test pits instead of inclinometer observations
•Incorrectly interpreting inclinometer data
•Using an inappropriate factor of safety
•Allowing a contractor to remove support from a landslide for extended periods during remedial construction
•Disregarding artesian pressures in design
•Constructing large fills over soft sediments underlain by steeply-inclined bedrock

From a layman's perspective, Portland Water Bureau will be committing at the very least 2 of these sins (which I have indicated above in red) as I will illustrate below with excerpts from Cornforth's paper. The city has not proved that the landslide is moving at a rate that is detrimental to the structure of the reservoirs such that they require demolition. Merely stating it in the BDS Staff Report (LU14-249689DU) and The WB Application for Historic Demolition review proposing demolition is not justification without supporting evidence such as inclinometer readings.

Cornforth's paper offers proof that demolition will: 1. expose citizen's physical safety, private property, and taxpayer-owned property to danger from retriggering the landslide 2. Will place the ratepayers in a precarious financial position as a result of probable large lawsuits. The conditions of approval for demolition require that the non-demolition alternative be economic hardship.

Cornforth, the professional, uses the WA Park Reservoirs as the example of the **first deadly sin:**

•Failing to recognize pre-existing landslide conditions

"**Sin No. 1. Failing to recognize pre-existing landslide conditions** Pre-existing landslides usually can be recognized by the landform at a site. Therefore, a reconnaissance of the ground by an experienced engineering geologist should be one of the first requirements for developments proposed on hillsides. It is especially needed on proposed pipeline alignments, large subdivisions, and wherever landslide hazard maps indicate a past history of instability. Although this requirement may seem self-evident, owners and developers often rush to construction, omitting this simple step that could forewarn them of potentially unstable ground.

"Example B: Washington Park Reservoirs Slide, Portland, Oregon
In the early 1890s, the city of Portland built two reservoirs on the city's west side for water supply. The chosen site was a ravine at the base of a long hillside (Figures 4, 5). The project required excavation of 100,000 cu.yds. (76,000 cu. m) of soil from the bottom of the ravine. During construction of the two reservoirs, a

large landslide developed upslope that was 1700 feet (520 m) long and 1100 feet (335 m) wide at the base of the slope. The top of the slope was a flat, marshy area – a graben feature of the ancient landslide. Between December, 1894 and October, 1897, down slope movements of up to 3.24 feet (0.99 m) were measured by surface hubs (Clarke, 1904).

"During the site investigations, 22 deep shafts and 9 borings showed that the slip surface was 56 to 111 feet (17 to 34 m) below ground (Figure 6), generally occurring within a seam of highly plastic clay. The landslide debris was a heterogeneous mixture of stiff clay and broken rock. The landslide was stabilized by first using pumps to drawdown the water table, followed by digging tunnels along the slip surface to provide a network of interconnecting gravity drains. Today, the landslide creeps downhill at only a fraction of an inch per year.

"The Washington Park landslide is an example of ancient landslide terrain reactivation. The excavation for the reservoirs was about 3% of the landslide mass. In a major lawsuit that followed construction, the city was exonerated from liability for residential damages because the judge could not accept that such a minor excavation, relative to the entire landslide mass, could be responsible for the large observed movements. However, in current knowledge, there have been many examples similar to this one showing that minor adverse changes in slope stability can produce disproportionately large movements in pre-existing landslides that are marginally stable prior to the changes.

"Comments on Pre-Existing Landslide Conditions

Once a pre-existing landslide condition has been recognized, steps can be taken to discover whether or not the old landslide is currently active. This procedure includes examination of the site for signs of recent movements, enquiries of local residents and city records, and installation of inclinometers to monitor the ground through one or more wet seasons (if feasible due to the owner's time constraints).Pre-existing landslides can range from being fully stable to active year-round. A simple classification system (see Cornforth 2005; page 23) is to describe a pre-existing landslide as either: (i) currently stable, (ii) generally stable, but occasionally active during exceptionally high rainfall, (iii) stable during the drier months of the year, but generally active during periods of winter rainfall, or (iv) active throughout the year. These distinctions provide the geotechnical practitioner with a framework to determine what actions need to be taken to provide the necessary stability for a specific project (or to determine if stability measures are feasible). As a general comment, a pre-existing landslide (such as ancient landslide terrain)in a wet temperate climate that appears to be stable should be treated as "marginally" stable unless there is some redeeming factor at the site to indicate otherwise. Therefore, as a minimum, any development must be designed so that the overall and local stabilities are not reduced as a result of construction. Lawsuits involving reactivation of pre-existing landslides can be very contentious, with the key technical issue being whether the activation is due to natural or manmade cause. The larger movements that produce such lawsuits usually occur during or shortly after a period of intense rainfall. The defense typically takes the position that the rainfall at the time of movement was extraordinary (as an example, that the three-day cumulative rainfall was the highest for the past 40 years). Other natural causes could be erosion from springs, rivers, or sea in combination with high intensity rainfall. The plaintiff position is likely to focus on manmade fills or cuts that destabilize a slope, or on poorly designed control of surface water, such as springs, holding ponds, broken water and sewer pipes, ditches, and drains."

The second sin that city/applicant has neglected in consideration of demolition:

"Sin No. 5. Allowing a Contractor to Remove Support to a Landslide for Extended Periods during Remedial Construction
In performing the tasks of analyzing a landslide and the options for correcting it, a geotechnical practitioner may forget to consider the temporary excavation that a contractor must do as part of the remediating construction work. Contract specifications usually transfer responsibility for temporary works and site safety from the owner (and their agents) to the contractor. However, the reality is that, should things go awry, it is likely that the design geotechnical engineer will be named as a defendant in a lawsuit or as the responsible party for a site-related problem in a construction claim. Therefore, it is advisable for the design engineer to think through the construction process and try to avoid these types of claim.

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Moore-Love, Karla

From: Dee White <deewhite1@mindspring.com>
Sent: Thursday, April 30, 2015 3:38 PM
To: Council Clerk – Testimony
Subject: Email 2 of 4 Comment on Type IV Demolition Review WA Park Reservoirs
Attachments: Cornforth 2007-DHC-Seven_Deadly_Sins.pdf

Attached
Seven Deadly Sins of landslide Investigation, Analysis & Design by Derek Cornforth

PROCEEDINGS OF THE FIRST NORTH AMERICAN CONFERENCE ON LANDSLIDES, VAIL, COLORADO, U.S.A., JUNE 3-8, 2007

Landslides and Society

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SEVEN DEADLY SINS OF LANDSLIDE INVESTIGATION, ANALYSIS, AND DESIGN

Derek H. Cornforth, *former president, Cornforth Consultants, Inc., Portland, Oregon*

Abstract: In practicing as a geotechnical consultant for more than 45 years, the author has observed that certain types of error recur in landslide studies and design. These errors, quite apart from their technical ramifications, frequently lead to costly lawsuits and sometimes fatalities.

The seven deadly "sins," as selected herein, are:

- Failing to recognize pre-existing landslide conditions
- Interpreting the depth of slippage of a landslide from boring logs or test pits instead of inclinometer observations
- Incorrectly interpreting inclinometer data
- Using an inappropriate factor of safety
- Allowing a contractor to remove support from a landslide for extended periods during remedial construction
- Disregarding artesian pressures in design
- Constructing large fills over soft sediments underlain by steeply-inclined bedrock

All such "sins" are avoidable. The paper describes each error, provides one or two illustrative examples, and comments on how they can be avoided. The case histories are, by necessity, brief summaries. More detailed descriptions of some of them are available in Cornforth (2005).

Introduction

Near the end of a geotechnical consulting career that has been largely devoted to landslide studies, the author has observed that certain errors and misjudgments are repeated and can be very costly to the perpetrators. Using data obtained entirely from projects within his experience (including materials made available through legal proceedings), the Author has selected seven categories of landslide-related "sins" and offers, with very brief case histories, examples of each "sin" and how they can be prevented. The case histories are not intended to be complete, but be sufficient to illustrate the "sin" under discussion. In most cases, they are one example amongst several that could be cited.

Discussing the mistakes of others within a technical paper is a sensitive undertaking. However, our profession advances by the continuing development of good practices. The goal of this paper is to help fellow practitioners avoid these costly and embarrassing mistakes in the future.

Sin No. 1. Failing to recognize pre-existing landslide conditions

Pre-existing landslides usually can be recognized by the landform at a site. Therefore, a reconnaissance of the ground by an experienced engineering geologist should be one of the first requirements for developments proposed on hillsides. It is especially needed on proposed pipeline alignments, large subdivisions, and wherever landslide hazard maps indicate a past history of instability. Although this requirement may seem self-evident, owners and developers often rush to construction, omitting this simple step that could forewarn them of potentially unstable ground.

Figure 1. The Capes landslide. General view of slide adjoining the Pacific Ocean.

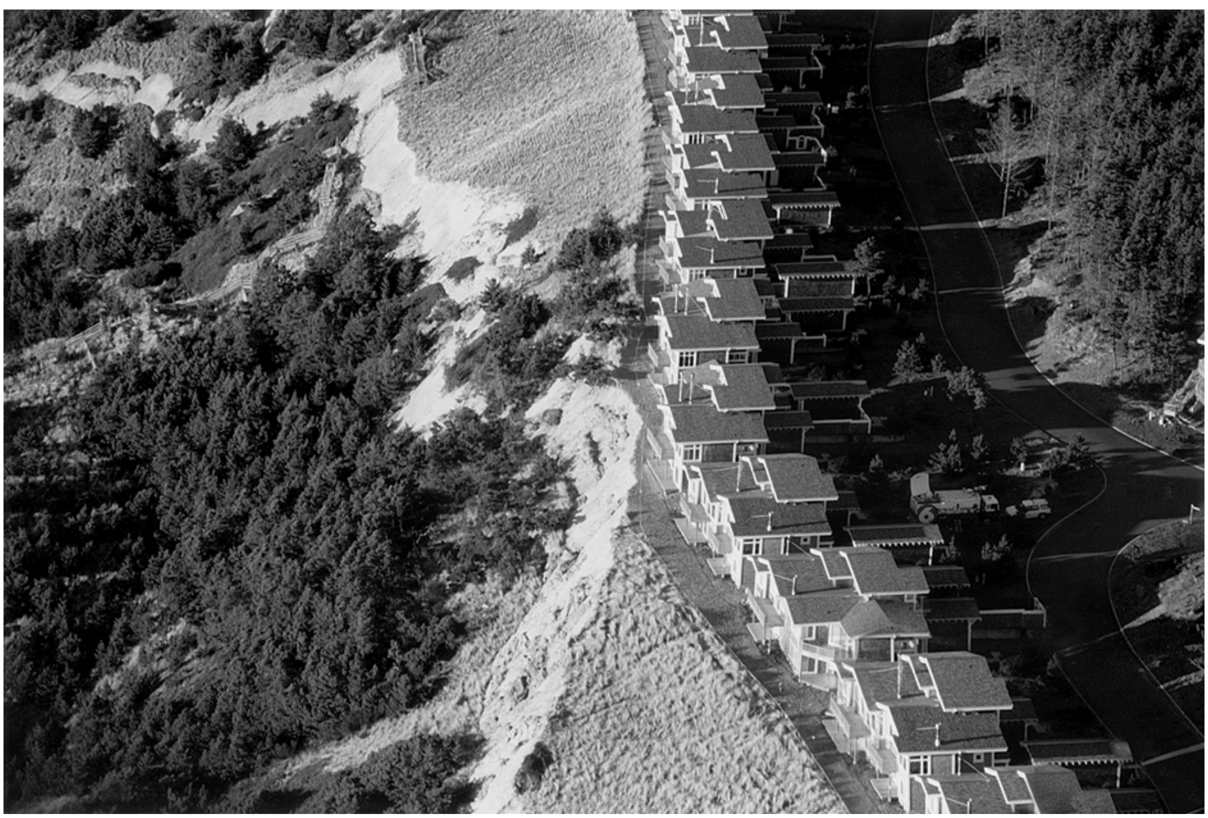

Figure 2. The Capes landslide. Headscarp close to houses on bluff.

Example A: The Capes development, near Oceanside, Oregon

The Capes is an upscale residential development built on the Oregon coast above a steep slope of dense sand. The houses are clustered along the slope top to provide spectacular oceanfront views (Figure 1).

In February, 1998, the ground below the cliff abruptly moved towards the sea creating a landslide headscarp that, in one part of the site, extended to the top of the slope and threatened the safety of several houses (Figure 2). The cause of the landslide was severe erosion of the sandy beach by a winter storm.

The landslide caused many homeowners to file lawsuits against the developers and their consulting engineers. Meetings of lawyers to discuss compensation for homeowners were described by one participant as “chaotic”. During this time, the beach restored itself and landslide movements stopped. Although legal settlements were reached, the landslide has not been treated. It is probable, therefore, that any future severe loss of beach sand will reactivate the slide and cause further movements.

The author was retained by one party to this lawsuit, but did not participate in the ground investigations that occurred after the failure. Based on available information, a triple wedge landslide model ABCD is appropriate (Figure 3). The main slippage occurred near the contact between the dense sand and an underlying stratum of very stiff clay that was a pre-existing slip plane.

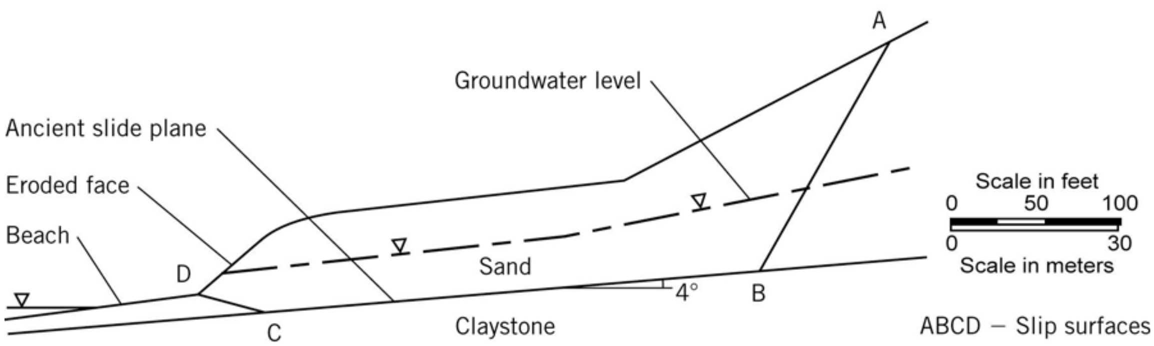

Figure 3. The Capes landslide. Geological cross-section.

This site had been examined by a geotechnical firm before development, but the pre-existing landslide condition at the base of the cliff was missed. An experienced engineering geologist could have recognized the landslide condition from the landform. Although the houses were placed on stable ground at the top of the slope, it is clear from Figure 2 that they were too close to the cliff edge and thus vulnerable to regressive movement of the ground should the pre-existing landslide reactivate.

Example B: Washington Park Reservoirs Slide, Portland, Oregon

In the early 1890s, the city of Portland built two reservoirs on the city’s west side for water supply. The chosen site was a ravine at the base of a long hillside (Figures 4, 5). The project required excavation of 100,000 cu.yds. (76,000 cu.m) of soil from the bottom of the ravine. During construction of the two reservoirs, a large landslide developed upslope that was 1700 feet (520 m) long and 1100 feet (335 m) wide at the base of the slope. The top of the slope was a flat, marshy area – a graben feature of the ancient landslide. Between December, 1894 and October, 1897, downslope movements of up to 3.24 feet (0.99 m) were measured by surface hubs (Clarke, 1904).

During the site investigations, 22 deep shafts and 9 borings showed that the slip surface was 56 to 111 feet (17 to 34 m) below ground (Figure 6), generally occurring within a seam of highly plastic clay. The landslide debris was a heterogeneous mixture of stiff clay and broken rock. The landslide was stabilized by first using pumps to drawdown the water table, followed by digging tunnels along the slip surface to provide a network of interconnecting gravity drains. Today, the landslide creeps downhill at only a fraction of an inch per year.

Figure 4. Washington Park Reservoirs landslide. The two reservoirs are at lower left. Perimeter of slide shown by broken white line.

The Washington Park landslide is an example of ancient landslide terrain reactivation. The excavation for the reservoirs was about 3% of the landslide mass. In a major lawsuit that followed construction, the city was exonerated from liability for residential damages because the judge could not accept that such a minor excavation, relative to the entire landslide mass, could be responsible for the large observed movements. However, in current knowledge, there have been many examples similar to this one showing that minor adverse changes in slope stability can produce disproportionately large movements in pre-existing landslides that are marginally stable prior to the changes.

Ancient landslide terrain covers large areas of the northern United States. Some of these landslides originated in the late Pleistocene (about 8,000 years ago) when high groundwater levels, abundant runoff, and depressed sea and river levels existed. It is of interest that a camel's molar from the Pleistocene era was found during the excavation of landslide debris at the Washington Park reservoirs site described in Example B above (Clarke, 1904).

Comments on Pre-Existing Landslide Conditions

Once a pre-existing landslide condition has been recognized, steps can be taken to discover whether or not the old landslide is currently active. This procedure includes examination of the site for signs of recent movements, enquiries of local residents and city records, and installation

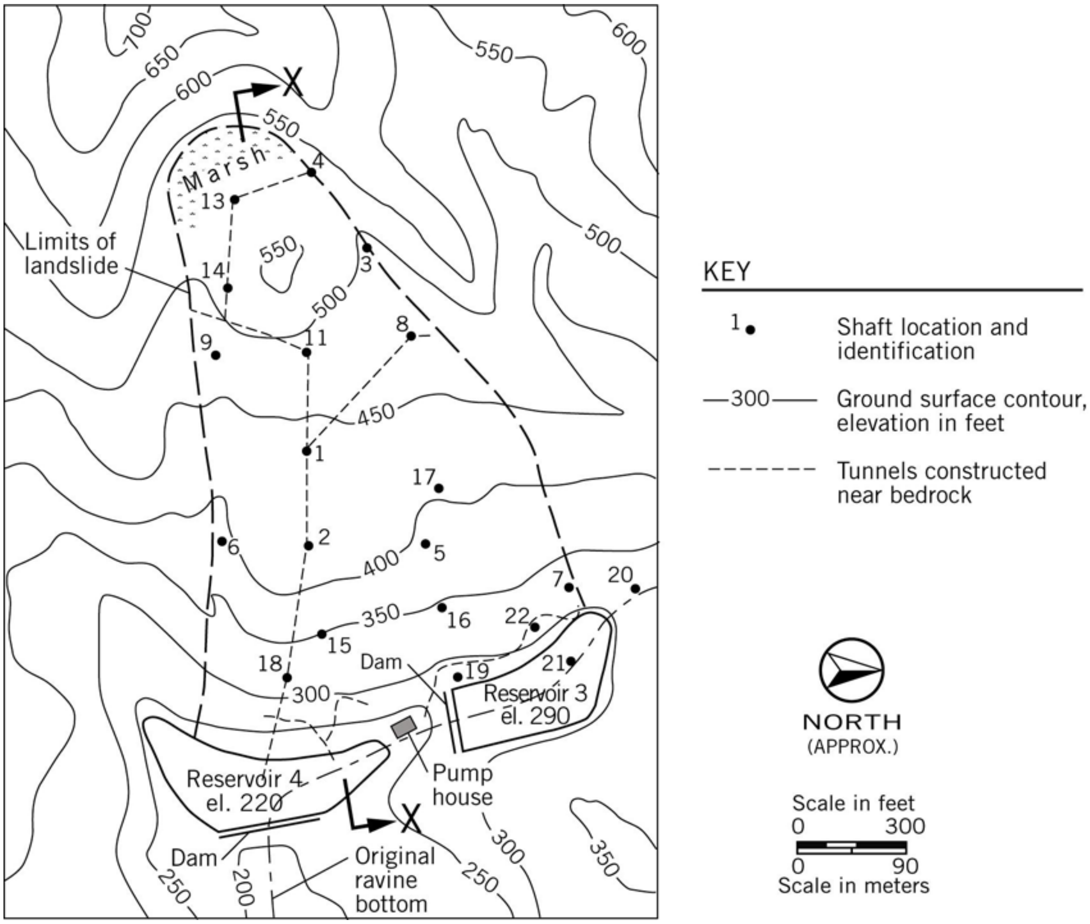

Figure 5. Washington Park Reservoirs landslide: site plan

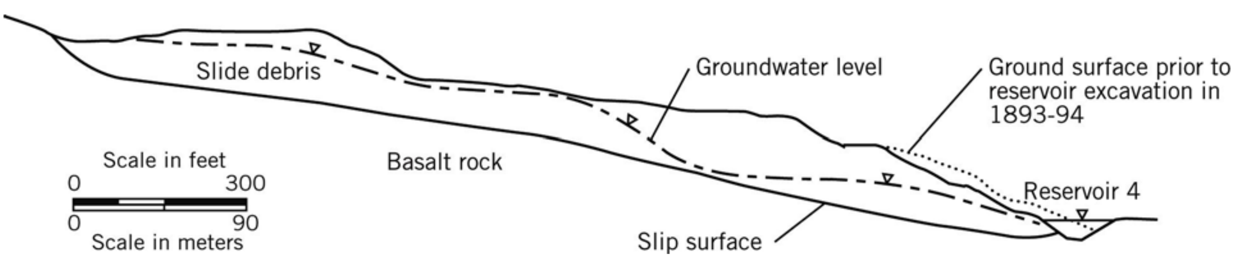

Figure 6. Washington Park Reservoirs landslide: Geological section X-X

of inclinometers to monitor the ground through one or more wet seasons (if feasible due to the owner's time constraints).

Pre-existing landslides can range from being fully stable to active year-round. A simple classification system (see Cornforth 2005; page 23) is to describe a pre-existing landslide as either: (i) currently stable, (ii) generally stable, but occasionally active during exceptionally high rainfall, (iii) stable during the drier months of the year, but generally active during periods of winter rainfall, or (iv) active throughout the year. These distinctions provide the geotechnical practitioner with a framework to determine what actions need to be taken to provide the necessary stability for a specific project (or to determine if stability measures are feasible).

As a general comment, a pre-existing landslide (such as *ancient landslide terrain*) in a wet temperate climate that appears to be stable should be treated as "marginally" stable unless there is some redeeming factor at the site to indicate otherwise. Therefore, as a minimum, any development must be designed so that the overall and local stabilities are not reduced as a result of construction.

Lawsuits involving reactivation of pre-existing landslides can be very contentious, with the key technical issue being whether the reactivation is due to natural or manmade cause. The larger movements that produce such lawsuits usually occur during or shortly after a period of intense rainfall. The defense typically takes the position that the rainfall at the time of movement was extraordinary (as an example, that the three-day cumulative rainfall was the highest for the past 40 years). Other natural causes could be erosion from springs, rivers, or sea in combination with high intensity rainfall. The plaintiff position is likely to focus on manmade fills or cuts that destabilize a slope, or on poorly designed control of surface water, such as springs, holding ponds, broken water and sewer pipes, ditches, and drains.

Sin No. 2. Interpreting the depth of slippage in a landslide from boring logs or test pits instead of inclinometer observations

Larger size landslides have to be reliably modeled prior to analysis. The field instrument of choice to measure the slip surface depth is an inclinometer system, comprising a grooved casing (Figure 7) and a probe to measure the tilt of the casing in the ground (Figure 8). The lateral

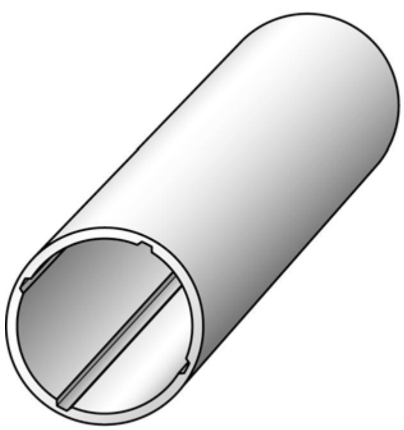

Figure 7. Isometric view of inclinometer casing showing internal longitudinal grooves

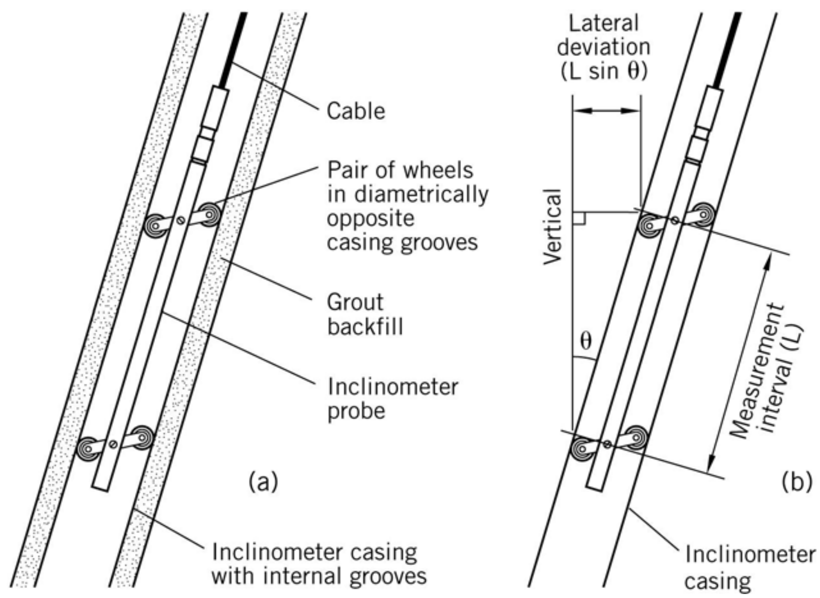

Figure 8. Inclinometer system: (a) probe and casing within borehole.
(b) measurement of tilt (courtesy: Slope Indicator Co.)

deflection of the casing can be calculated by comparing a series of tilt readings taken at close intervals along the casing with an initial reading set to measure the change of tilt, if any, at each depth interval (Figure 9). When correctly installed and read, the inclinometer system can detect lateral movements of less than ¼ inch (6 mm). The equipment has been available for about 50 years and current versions (available from several manufacturers) provide a mature, reliable technology.

Surprisingly, there are still many landslide investigators who do not use the inclinometer system but instead rely on their personal judgment to estimate the slippage depth. This lack of

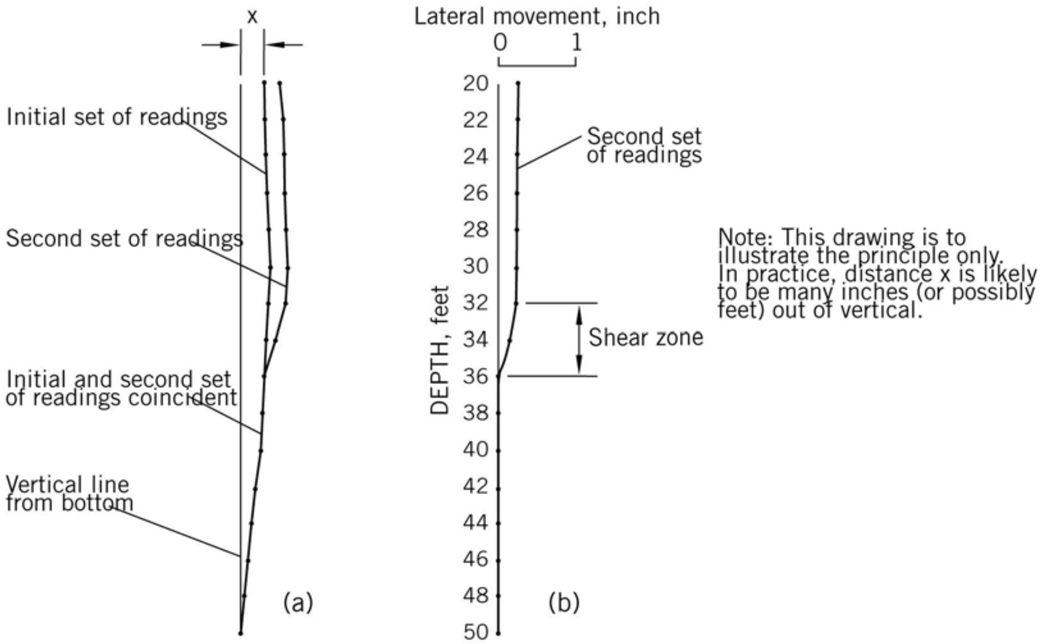

Figure 9. Examples of inclinometer data: (a) shape of casing in the ground for two sets of inclinometer readings (b) determination of shear movement and depth of shear during time interval between reading sets

inclinometer use can be attributed to cost, time to install and read, and general lack of experience in performing the work. However, interpreting field logs or looking at test pits to determine the slippage depth can be seriously flawed, and result in significant errors in modeling a landslide.

Example C: Northern Wasco County Landfill landslide, The Dalles, Oregon

Cell 1 of this landfill expansion was excavated in 1993 with side slopes of 3:1 (horizontal:vertical), and involved removal of 325,000 cu.yds. (250,000 cu.m) of dense silt (Figure 10). In December, 1993, shortly after the excavation had been completed, a crack 700 feet (210 m) long was observed 100 to 200 feet (30 to 60 m) behind the top of the deep cut slope at the south end of the cell. The project consultants dug a 30-foot (9 m) deep test pit near the mid-length of the crack and concluded that the slip surface was at a depth of about 20 feet (6 m) below the ground surface.

In being asked to provide a second opinion, the author suspected that such a long crack would have a slip surface penetrating much deeper than was being estimated from the test pit evidence. Accordingly, two inclinometers were installed in the cut slope. They passed through tuffaceous, very dense fine sandy silt and very dense slightly clayey to clayey silt with relatively high SPT blow counts (Figure 11). Underlying the silts was a very dense stratum of silty fine sand. Because movements had stopped, a small surcharge berm was constructed over the crack at the top of the slope to "nudge" the landslide into additional movement.

The result for inclinometer LT-2 was movement at a depth of 74 to 76 feet (22 to 23 m), as shown on Figure 12, and movement at 114 to 118 feet (35 to 36 m) in LT-1 (not illustrated). Clearly, the estimated depth of the slip surface in the test pit was a large error and could have resulted in serious design repercussions if it had been accepted as correct.

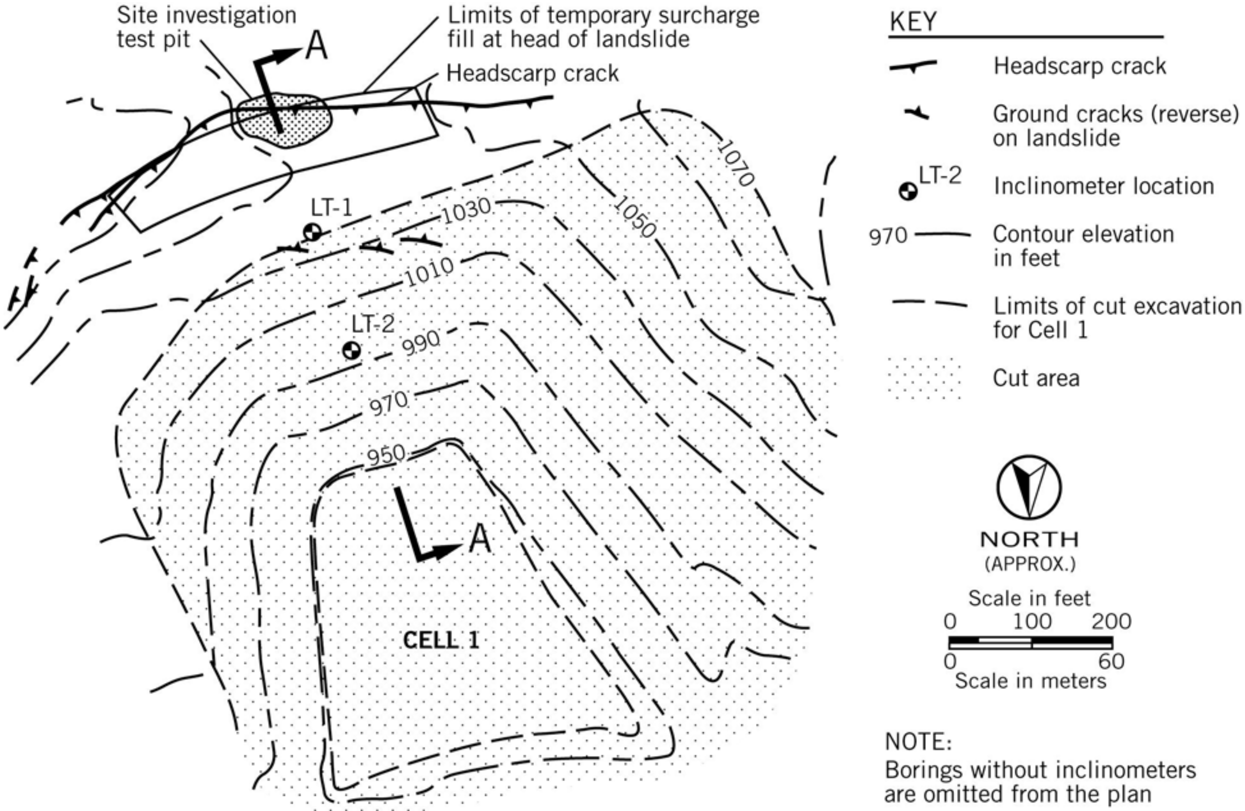

Figure 10. Northern Wasco County landfill landslide. Site plan, Cell 1

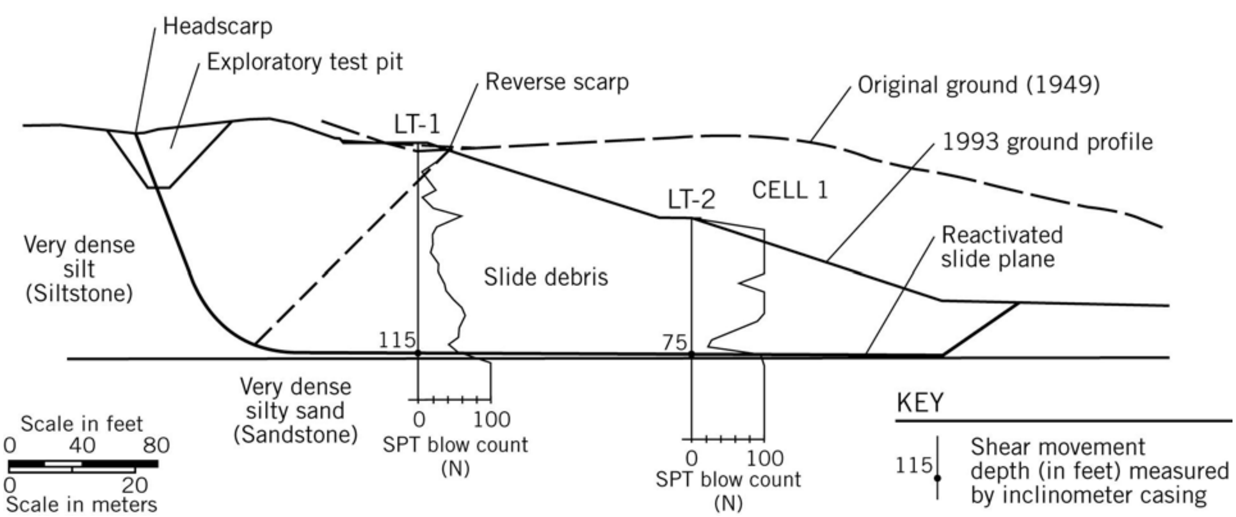

Figure 11. Northern Wasco County Landfill landslide. Section A-A

The landslide was modeled as a triple-wedge failure with slippage occurring along a near-horizontal ancient slip surface. Geological studies confirmed that the site was an ancient landslide.

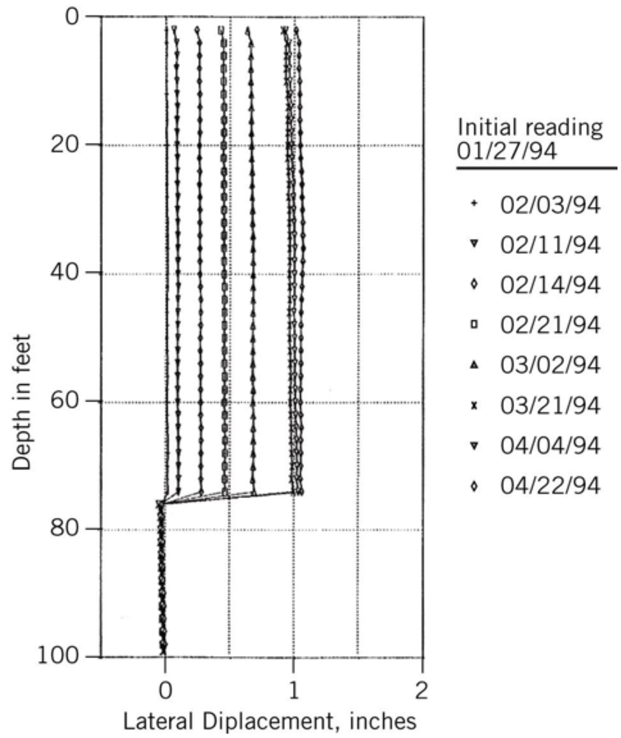

Figure 12. Northern Wasco County Landfill landslide. Inclinometer LT-2

Example D: Faraday landslide, Estacada, Oregon

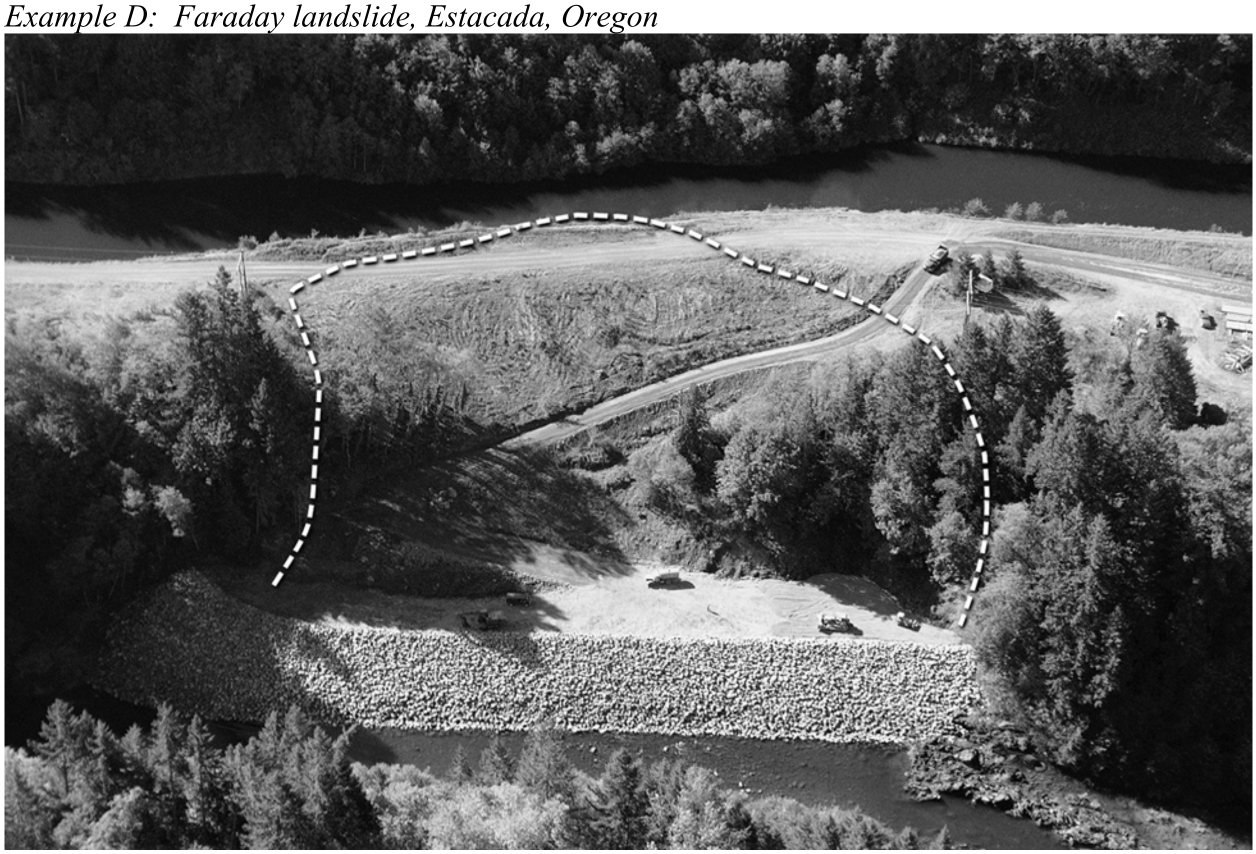

Figure 13. Faraday Canal landslide. Faraday Canal at top. Clackamas River at bottom (with remedial buttress in place). Perimeter of landslide shown by broken white line.

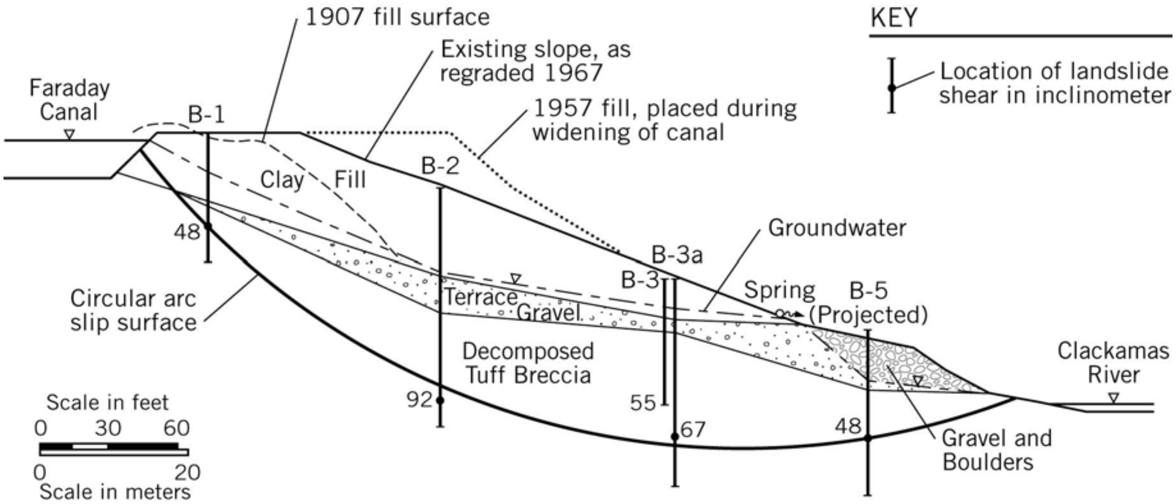

Figure 14. Faraday Canal landslide. Geological section through center of slide

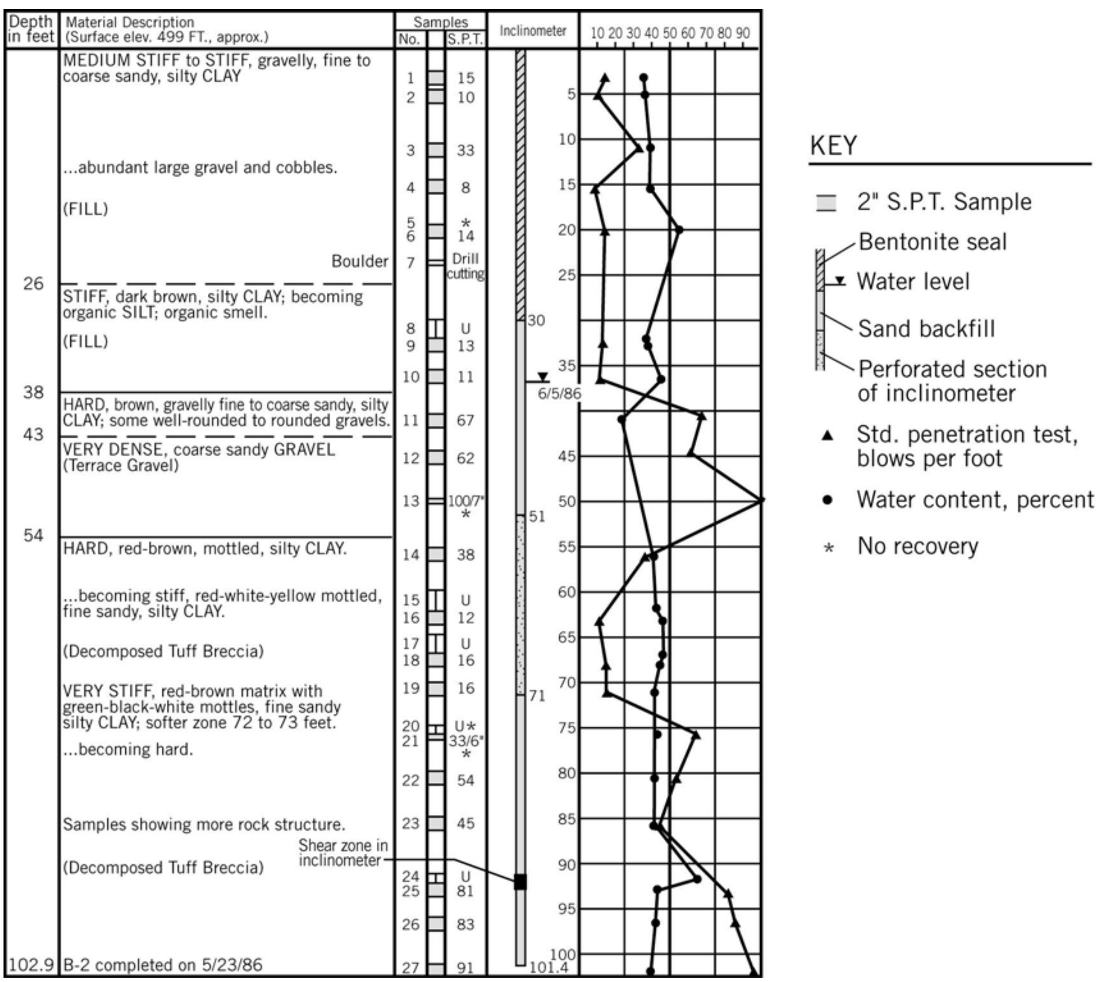

Figure 15. Faraday Canal landslide. Boring log for B-2.

The Faraday Canal diverts water from the Clackamas River to a hydroelectric generating plant. The original project was constructed in 1907. In 1957, the canal was widened and deepened to provide more power. Excavated soils were placed as fill on the slope between the canal and river. After cracks were observed on the slope in 1967, the slope was flattened to the current configuration. However, in 1977, new cracks appeared and landslide movements began to be monitored by surface survey hubs. The rates of movement steadily accelerated, and the landslide was stabilized by a rockfill buttress in 1989 (Figure 13). For additional details, see Cornforth, 2005, Case History 8.

The site investigation of 1986 included four borings through the center of the landslide to provide a geological section for stability analysis (Figure 14). The section shows a thick layer of clay fill overlying dense terrace gravel (old river channel) and hard silty clay (decomposed tuff breccia). A typical boring log from the site investigation is reproduced on Figure 15. There are exposures of the tuff breccia in the river bank close to the site where it stands at a near-vertical slope and has a rock-like appearance.

All the borings were instrumented with inclinometers. The observed movements (Figure 14) are a good example of a deep-seated circular arc slope failure. The slip surface passes almost entirely through the hard clay stratum below the fill and terrace gravel.

Without the benefit of inclinometer data, where would an experienced geotechnical practitioner expect the slip surface to be located? The probable choice would be at the base of the clay fill at the fill/dense gravel contact. This would be significantly in error. If using the boring logs as a guide, a second choice might be the "softer zone" at 72-73 feet (approx. 22 m) in Figure 15, for example. However, the actual depth of slippage at this location is 20 feet (6 m) deeper. Therefore, both choices would be wrong.

Sin No. 3. Incorrectly Interpreting Inclinometer Data

Although inclinometers play a vital role in determining the position of the slip surface in larger landslides, the plotted data of deflection versus depth can sometimes cause confusion to inexperienced users because they have unrealistic expectations of reliability. The probe itself takes very precise readings, but the overall reliability of the measurements is collectively controlled by the inclinometer *system* (i.e. the probe, casing, cable, quality of backfill, and skill of the operator).

The output graph usually shows the lateral movement of the ground relative to an initial set of readings. Two of the more common problems in interpreting inclinometer data are: (i) to leave systematic errors uncorrected, and (ii) to plot the data using highly exaggerated scales of lateral movement.

Systematic errors in inclinometer readings usually can be separated from actual displacement by mathematical techniques. Mikkelsen (2003) provides an excellent summary of these corrections. They include: (i) bias shift error, (ii) rotation error, and (iii) depth positioning error. Manuals and software are available from manufacturers to make these corrections. For difficult issues, specialist instrumentation consultants can be hired.

Bias shift is the more common error, and it is useful for all geotechnical practitioners to be able to recognize it and make the correction. This error is caused by the probe itself and, in multiple data sets, gives rise to the "windshield wiper" appearance on the plots. An example is shown on Figure 16(a). When bias shift error occurs, the stable portion of the casing below any actual movement shows an approximately linear plot, radiating from the bottom of the casing.

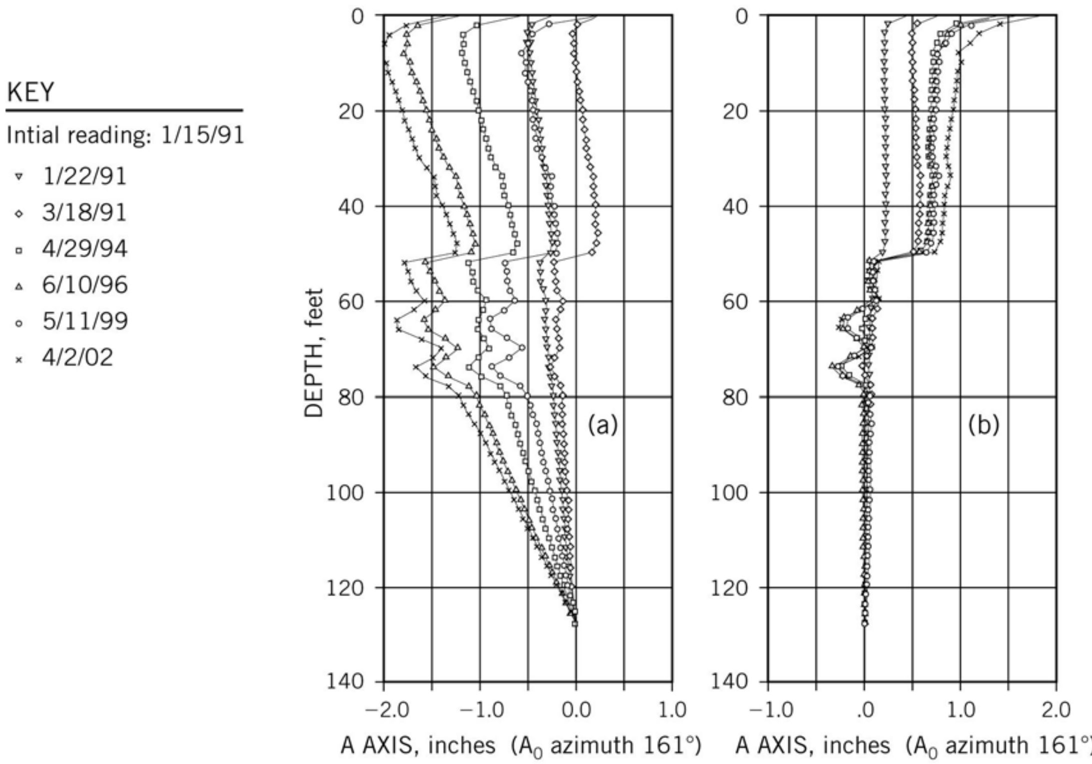

Figure 16. "Windshield wiper" effect for inclinometer readings, Percy Slide, Oregon: (a) date uncorrected (b) data corrected for bias shift error

When corrected, as shown on Figure 16(b), the data shows that the actual landslide shear movement is occurring from 50 to 52 feet (15.2 to 15.9 m) below the surface.

The sloping lines of bias shift error should never be mistaken as representing actual movement and it is an easy correction to make, if needed. Whenever feasible, it is advisable to extend inclinometer casings 10 to 20 feet (3 to 6 m) below the likely depth of slippage. This makes it simpler to correct for bias shift error when analyzing the data.

The second error that some practitioners make when interpreting inclinometer data is to plot the graph to an exaggerated horizontal scale. This usually results from the desire on the part of the investigator to find out where the slip surface is located at the earliest opportunity.

An example of an exaggerated scale is shown on Figure 17(a). Such graphs can cause bizarre speculations of what is occurring within the landslide. In reality, the various wiggles in the graph are due to limitations of the inclinometer *system*, as mentioned earlier. When corrected for bias shift error and plotted to a more normal scale, as shown for this example on Figure 17(b), there is no movement occurring. Later, small movements occurred at this landslide site between 15 and 21 feet (4.6 and 6.4 m) below the ground surface (Figure 17c).

The author recommends that at least 0.15 inch (4 mm) of simple shear displacement should be observed at the discrete shear zone to confirm the depth of slippage. Also, displacements above the shear zone should be downslope of those below the shear zone.

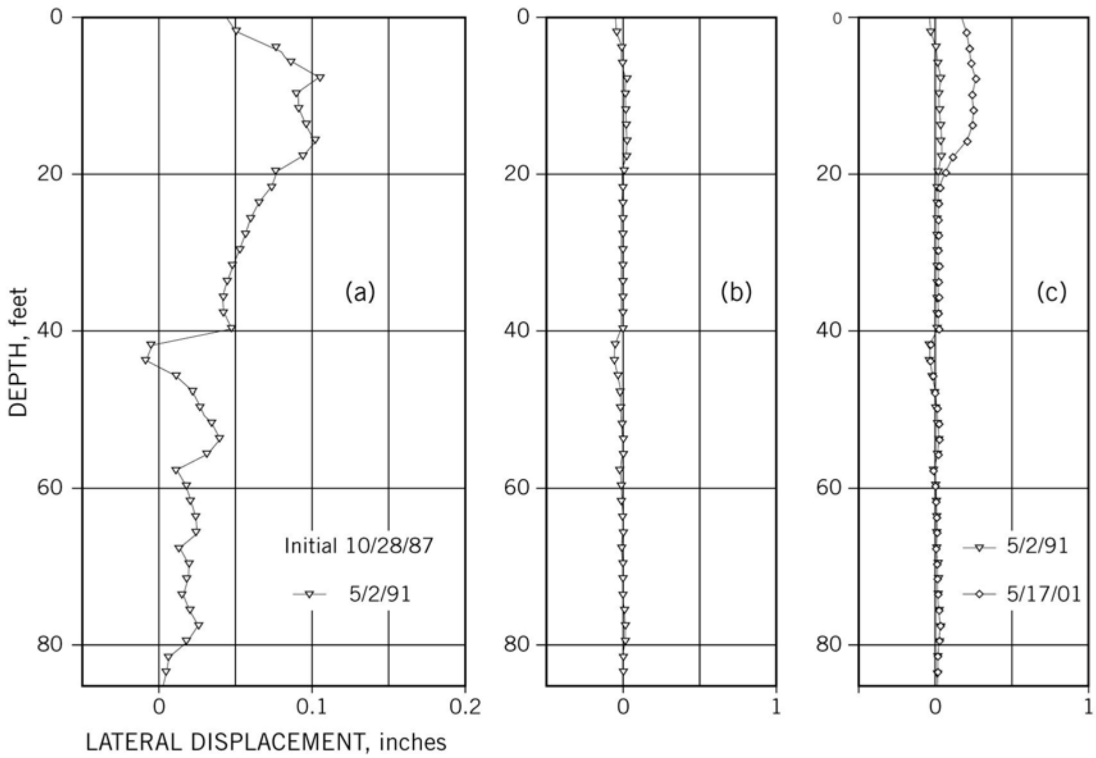

Figure 17. Effect of using highly exaggerated scales:

(a) horizontal scale 1 inch = 0.1 inch
(b) same data to a scale of 1 inch = 1 inch with bias shift error corrected
(c) later data showing actual shear movement at 15 to 21 feet (including correction for bias shift error)

Note: All scales reduced to 80% of original

Sin No. 4. Using an Inappropriate Factor of Safety

From the earliest days of soil mechanics, a factor of safety (F) of 1.50 has been the accepted norm for *slope stability* studies. This is appropriate, especially since most slope stability studies are performed for the design of relatively small earthworks, such as highway embankments, or for high risk projects, such as water-retaining dam embankments where there is a high risk of wide-scale property damage or fatalities resulting from a slope failure.

Unfortunately, the mindset of F=1.50 is sometimes treated as the norm for *landslides*. It can lead to designs that clearly exceed the need. Although such designs are conservative and ensure success, they are not in the broad interest of society if they are inappropriate for the type of landslide being studied. There is also the likelihood that no action will be taken to remediate the landslide because of the high cost or technical difficulties of providing an excessive level of remediation. In this case, a high factor of safety is being counter-productive. In recent years, some regulators have set a standard of F=1.30. However, a set limit, whether it is F=1.50 or F=1.30, is inappropriate as a standard for landslide work.

In contrast to most slope stability studies, where a fixed factor of safety can be accepted as standard, landslides:

- ... cover a very wide range of volume
- ... are performed at different levels of technical study

- … are highly variable in their geological site conditions
- … have a known factor of safety (F=1.00) at the onset of instability

The last of these differences is especially important because it provides one parameter of certainty in the mathematical analysis i.e. that the resisting force (or moment) is exactly equal to the driving force (or moment) at the onset of instability. Such information obviously does not apply to a stability analysis of a non-failure situation. Since a remediation analysis is a "before" and "after" study of the same landslide model, the geotechnical practitioner can, with some confidence, reduce the selected factor of safety in a landslide analysis compared to that of a conventional slope stability analysis.

A general guideline for landslide remediation is that the treatment should be sufficient to provide permanent stability against existing and reasonably foreseeable future site conditions. In the author's opinion, the selected factor of safety should be set according to the professional judgment of the geotechnical practitioner, taking account of the factors listed in the matrix of Table 1 below.

Table 1. Factors influencing the selection of an appropriate factor of safety F

Variable	**Factor of Safety should be relatively** **Higher**	⟷	**Lower**
Type of landslide movement	Very fast	⟷	Very slow
Level of study performed	Minimal	⟷	Sophisticated
Size of the landslide	Small	⟷	Large
Potential consequences to life and property of continuing movements	Significant	⟷	Insignificant
Experience of geotechnical practitioner	Limited	⟷	Very experienced

Assuming that the site has been adequately explored for geology and subsurface conditions (including laboratory tests of soil properties), the landslide has been modeled using piezometers and inclinometers, and that back analysis has been used to assign appropriate soil properties to the slip surfaces, it is the author's opinion that design factors of safety can range from about 1.15 to 1.50. Factors of safety below 1.15 may be used in particular circumstances where a marginal improvement in stability is preferable to inaction.

Sin No. 5. Allowing a Contractor to Remove Support to a Landslide for Extended Periods during Remedial Construction

In performing the tasks of analyzing a landslide and the options for correcting it, a geotechnical practitioner may forget to consider the temporary excavation that a contractor must do as part of the remediating construction work. Contract specifications usually transfer responsibility for temporary works and site safety from the owner (and their agents) to the contractor. However, the reality is that, should things go awry, it is likely that the design geotechnical engineer will be named as a defendant in a lawsuit or as the responsible party for a site-related problem in a construction claim. Therefore, it is advisable for the design engineer to think through the construction process and try to avoid these types of claim.

Some common causes of landslide reactivation during remedial work are:

- oversteepening the landslide lower face to create space for a buttress or wall
- excavating soft ground below a landslide to provide a firm, level base for a buttress or wall foundation
- excavating a trench ("slot") across a landslide for a shear key or interceptor drain

The common feature of these causes is that temporary excavations into the middle or lower reaches of a landslide almost always reduce slope stability and may reactivate movements. Since many landslide treatments require temporary excavations, the geotechnical design engineer generally needs to take an active role to prevent further movements.

The means to combat the loss of stability include: (i) performing remedial work at the time of year when groundwater is seasonally low i.e. during the late summer and fall in North America (ii) using sophisticated dewatering methods (not just sump pumping) before and during construction to temporarily lower groundwater levels (iii) using strutted support for trenches, if appropriate for the site (iv) designing walls with "top-down" construction methods that support the landslide at all times (Examples: tied-back soldier pile walls; concrete slurry trench walls; anchor block walls; soil anchors) (v) using closely-sequenced construction methods in which excavation is followed quickly by backfilling so that the time that the excavated face is kept open is limited to a practicable minimum (see below).

Another precaution at some construction sites is to monitor adjacent "sensitive" structures or pipelines before, during, and after construction. This may require structural surveys, photography, and inclinometer/piezometer installations. Such techniques provide factual information that can be used to separate claims for actual damages from claims based on perception or fraud.

Example E: Kalama landslide, Washington

A relatively minor excavation at the base of a hillside caused cracks to develop in the slope between the excavation and the road above (Figure 18). Borings put down alongside the road showed that hard bedrock (breccia) was 12 to 15 feet (4 to 5 m) below the existing ditch. A geotechnical consultant recommended that a 450-foot (137 m) long interceptor drain be constructed along the ditchline to intercept groundwater before it reached the unstable area below. The overburden soil was hard silt mixed with rock fragments (colluvium).

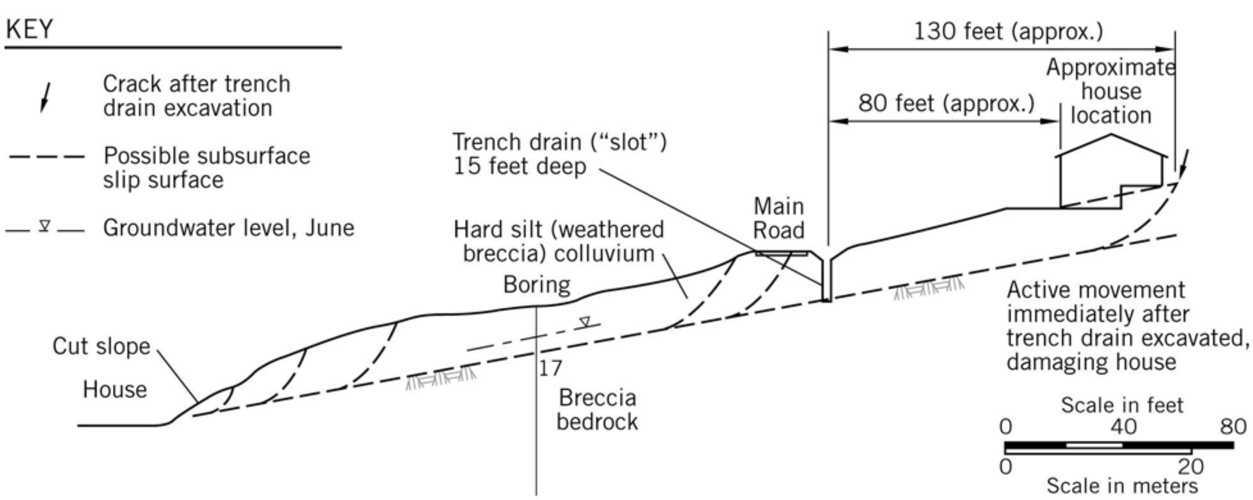

Figure 18. Kalama landslide: trench drain excavation causing movements in the upper slope.

In late spring, the contractor started trenching across the ancient landslide (colluvium) using a trench box to protect the workers from cave-ins. Almost immediately, there were reports that the uphill wall of the open trench was periodically collapsing. A house (Figure 18) uphill from the trench experienced severe cracking. This house was 130 feet (40 m) away from the trench, and there was anecdotal evidence that cracks were seen several hundred feet further upslope.

In this example, the consultant did not recognize the ancient landslide condition (see Sin No. 1 earlier) at the site, and the specifications did not require that closely-sequenced construction procedures would be needed to support the hillside during the trench construction. Instead, the contractor simply dug the trench leaving substantial lengths of it open for many days. This "slot" reactivated the ancient landslide terrain above it, and thus duplicated the cause of the original failure in the slope below.

The interceptor drain was finally installed using closely-sequenced construction procedures (see below). However, there was a substantial claim for damages from the affected homeowner due to the error of allowing an open trench to be cut across a pre-existing landslide.

Example F: Lorane Road landslide, Oregon

A highway improvement project near Lorane, Oregon, required a cut of 47 feet (14 m) horizontally into the hillside (Figure 19a), which was within ancient landslide terrain. Although the cut was made during the drier summer months, numerous vertical cracks developed over a distance of 90 feet (27 m) behind the top of the cut slope.

To prevent further regression towards a building upslope, a replacement buttress was designed. To build a replacement buttress, the weak soils at the outer face of the landslide are replaced by a stronger fill; in this example, shot rockfill was selected for the repair (Figure 19b).

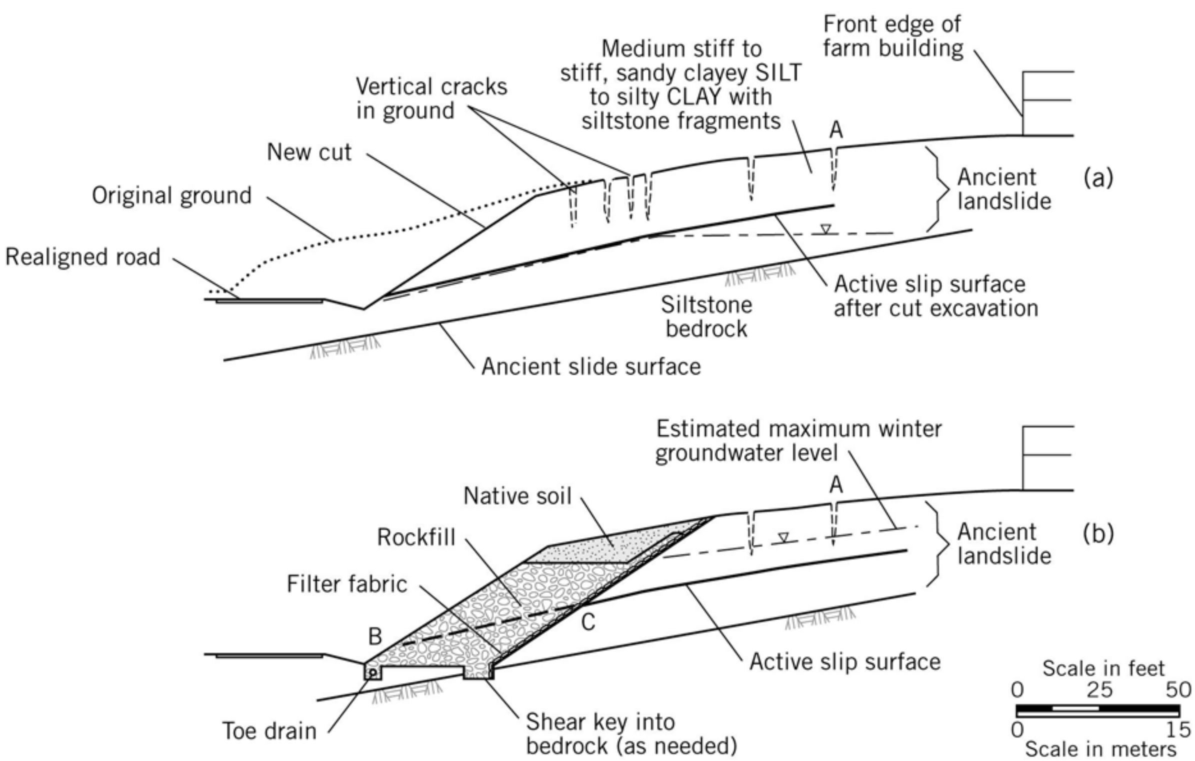

Figure 19. Lorane Road landslide: (a) landslide section (b) remedial section

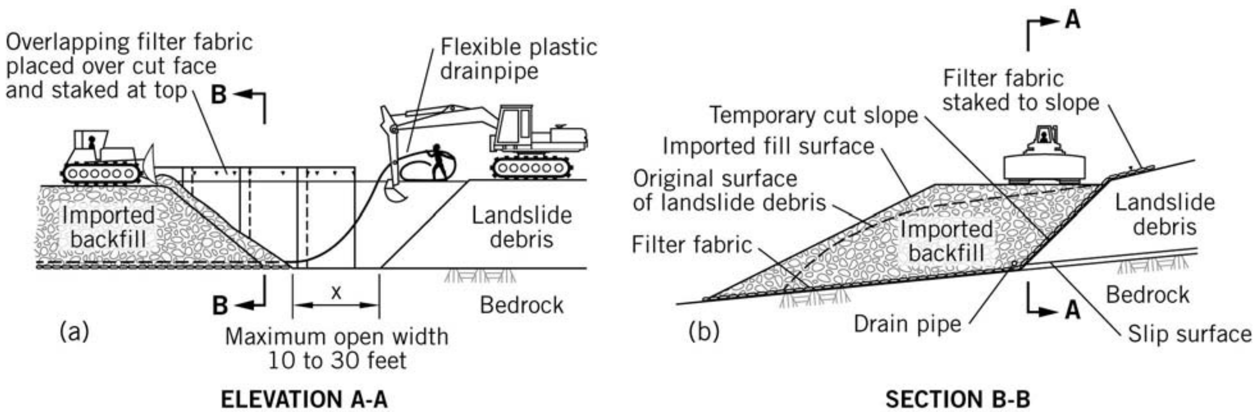

Figure 20. The closely-sequenced construction method

To build the lower section of the rockfill buttress, closely-sequenced construction was specified as mandatory.

The closely-sequenced construction technique is illustrated on Figure 20 and requires that excavation and backfilling occur together such that the length of open excavation is kept to a practical minimum at all times. When site work is suspended overnight or at weekends and holidays, the excavation is temporarily backfilled with loose excavated soils. These soils are quickly re-excavated at the start of the next shift. The need to totally backfill the open excavation overnight is discretionary, depending on site conditions, public safety, etc. On many sites, backfilling to zero base width (i.e. distance x=0 on Figure 20) is sufficient.

Figure 21. Closely-sequenced construction method being applied at Lorane Road landslide. On right, a backhoe excavates soil and loads spoil into a dump truck. On left, rockfill is being dumped and spread to build a buttress. Filter fabric (dark gray) is laid on the cut slope behind the rockfill.

Two stages of excavation were needed at the Lorane Road site. The first stage was to excavate the upper part of the slope, above the water table, by customary open excavation methods. For the second stage, a closely-sequenced construction procedure was followed, restricting the maximum width between the bases of the excavated soils and the rockfill (distance x, Figure 20) to 20 feet (6 m). A photograph of the work at Lorane Road is shown on Figure 21.

At this site, the pre-existing landslide condition was not recognized prior to construction of the cut. Excavating into the slope removed support from the marginally stable slope, thereby reactivating the ancient landslide. This example demonstrates the use of closely-sequenced construction to provide support when a "slot" or downhill removal of support is cut into a landslide condition.

Sin No. 6. Disregarding Artesian Pressures in Design

There is occasionally a "disconnect" between the group responsible for site investigations and their colleagues involved with design and specifications. One issue that has occurred twice in the author's landslide experiences (and also in other foundation projects) has been disregard for flowing artesian conditions. It is included in the Seven Deadly Sins because, in each landslide case, the result of the oversight was extremely disruptive and costly for the affected parties.

Artesian groundwater is a well-known phenomenon to geologists and geotechnical engineers. To briefly recap, artesian conditions can develop where a water-bearing permeable stratum is overlain by a less permeable stratum (Figure 22). If the groundwater level in the permeable stratum (as measured by a standpipe or pressure gage) is above the ground surface, it is known as a *flowing* artesian groundwater. It can occur in slopes, especially those composed of colluvium, or it can be created by making a cut into a slope.

The hydraulic gradient between the artesian layer and the ground surface is h / L (Figure 22). If a cut is made into the impermeable upper stratum, the distance L decreases and the hydraulic

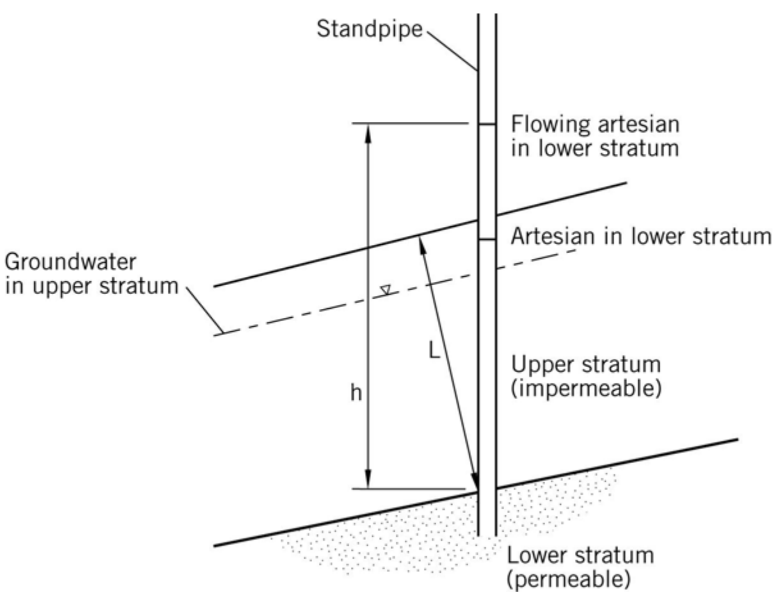

Figure 22. Artesian groundwater conditions

gradient increases. Should the hydraulic gradient rise sufficiently high, the flowing artesian pressure can erupt through the confining layer and cause a flow slide to occur. Therefore, if a flowing artesian pressure is encountered during a site investigation of a slope or landslide, it should be seen as a warning that excavations into the surficial impermeable stratum could cause instability.

Example G: Bonners Ferry landslide, Idaho

U.S.Highway 95 formerly passed around a ravine incised into glacial sediments near Bonners Ferry, Idaho. A road improvement project to shorten and straighten the highway required the construction of a 95-foot (29 m) high embankment crossing the ravine. The ravine bottom was partly covered with old landslide debris – a mixture of soft silt, sandy silt, and clay.

The site plan, Figure 23, shows the footprint of the proposed embankment. The contract required about 50,000 cu. yd. (38,000 cu. m) of the loose landslide materials to be excavated to provide a firm foundation for the embankment fill. This area is shown cross-hatched within the footprint.

The site investigation for the project encountered a flowing artesian condition in boring A-3 on the north (uphill) side of the excavation area (Figure 23). The boring log, simplified from the original, is shown on Figure 24. The artesian head, at a depth of 31 feet (9.5m) in the boring, was 9.6 feet (2.9m) above the ground surface in January, 1997.

The contract specifications warned the contractor that the slide debris was saturated, and that excavation would be needed below the water table. As commonly occurs in such contracts, a special provisions clause stated: "Any dewatering necessary for the excavation operation shall be considered incidental to Slide Debris Removal."

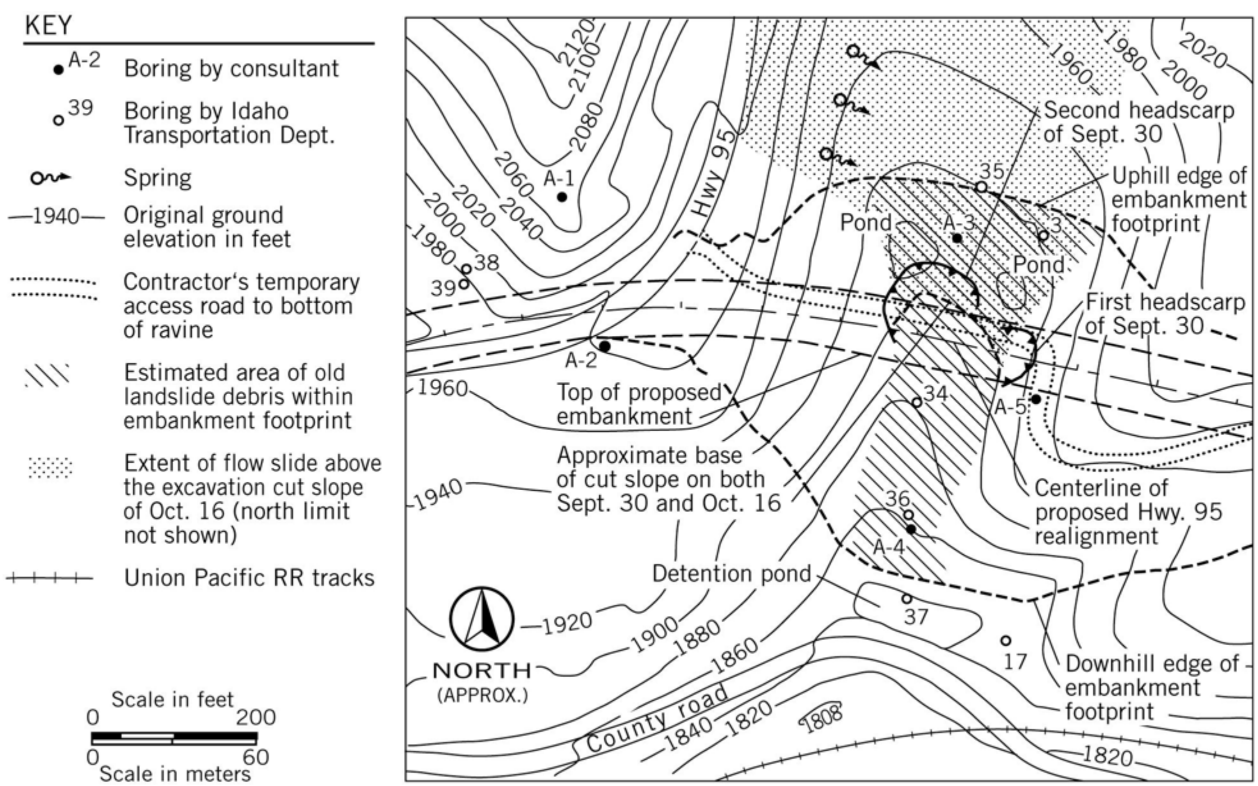

Figure 23. Bonners Ferry landslide: Site plan

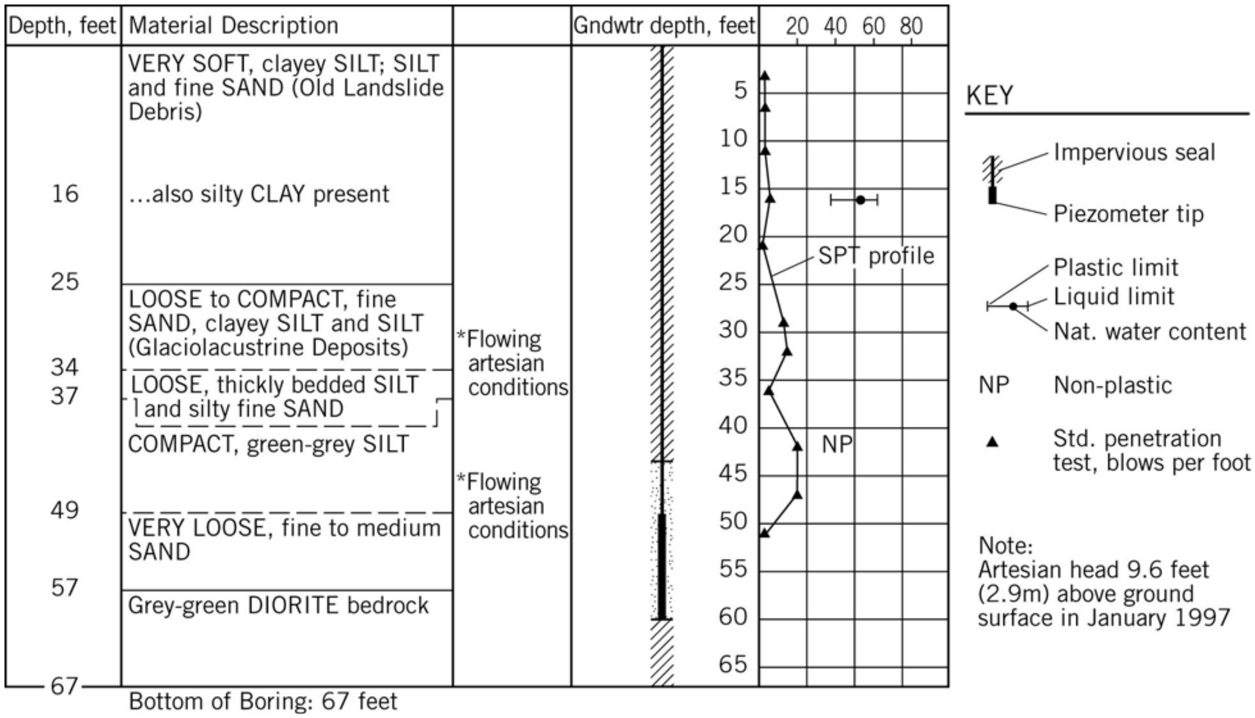

Figure 24. Bonners Ferry landslide. Summary log for boring A-3

In August, 1998, foundation excavation work began at the south (downhill) side of the embankment footprint and proceeded upslope. The track-mounted backhoe sat on the excavation floor, digging soil from the toe of the cut and loading it into trucks. After reaching the required excavation depth, rockfill was spread as a mat over the prepared foundation area. As this rockfill mat advanced into the excavation, the backhoe was able to sit on the edge of the rockfill as landslide debris was pushed off the slope towards it by a dozer. Seepage at the cut face caused the soft soils to slump, making it easier for the backhoe to pick up the soil.

On several occasions, fairly large collapses occurred due to the landslide debris liquefying and flowing down towards the excavator. On September 30, 1998, a flow slide of two “pulses” occurred. In the first flow, a dump truck was hit broadside and was pushed 100 feet (30 m) downslope. The second flow, 15 minutes later, pushed the dump truck all the way into the detention pond (see Figure 23). Three other mud waves followed, filling the 22-foot (7 m) deep detention pond and crossing the road below.

After these flow slides stopped, the construction crew built drains to pick up springs on the uphill side of the excavation. The height of the rockfill mat was raised from 5 to 8 feet (1.5 to 2.4 m) as a safety measure. After two weeks of cleanup and additional rockfill placement, the contractor renewed the excavation work at about the same place that had been reached before the flow slides.

On October 16, another small flow slide occurred at about 3 p.m., and this was followed by a major mudflow at 5:30 p.m. Numerous flow pulses continued from this time until about 3 p.m. of the next day (i.e. more than 20 hours). These flows built up behind the high railroad embankment downslope and then broke through the embankment onto the flood plain below (Figure 25). A video was taken of the flowing soils, estimated to be 10 feet (3 m) deep, coming down the ravine. When the movements stopped, the former cut face had regressed into a large headscarp that was 700 feet (210 m) further upslope. It eroded part of Highway 95, which was still in use. However, there were no fatalities or injuries.

Figure 25. Bonners Ferry landslide. Aftermath of the major flow slide, showing rupture through the railroad embankment and into the flood plain (in foreground).
(Photo: David Kramer)

It is likely that the depth of cut left only a relatively thin layer of in-place sediments above the artesian stratum, causing a critical hydraulic gradient. The upwelling of artesian groundwater liquefied the soils to begin the flow slide. Once initiated, it progressed steadily upslope as ground was lost and flowed away, undermining the ground above to continue the flow.

There were severe economic losses. The main line of the railroad was closed for several days until the embankment could be rebuilt. Highway 95 was closed for 18 days, and required construction of an alignment shift into the hillside where it had been undermined by the flow slides. The road closure required a 112-mile (180 km) detour. Power to the town of Bonners Ferry was lost and schools were closed for several days. The construction contract was delayed, and there were lawsuits to recover damages.

Construction Dewatering for Temporary Works

It is a longstanding practice in civil engineering projects to make the contractor responsible for the construction and safety methods employed to build a project. At Bonners Ferry, a very experienced contractor was using a risky excavation method i.e, allowing the springs in the cut face to cause a local failure that moved loose, saturated soils towards the excavator. This technique cannot be easily controlled and several flows and slumps preceded the September 30 and October 16-17 mudflows. This method of excavation is common practice in construction.

The catastrophic mudflows could have been prevented by suitable dewatering of the site area prior to the excavation i.e. by deep wells or wellpoints. This would have allowed excavation to occur under drawndown groundwater conditions. As previously stated, the special provisions of the construction contract required the contractor to provide any dewatering as part of the bid price for excavation. However, dewatering covers a wide range of practices and cost, ranging from low-cost sump pumps to a sophisticated design of deep dewatering wells that are installed and made operative before any excavation takes place. Without specific instructions to use a sophisticated dewatering method, no contractor would include such costly and time-consuming measures in a bid price. To do so would ensure that their bid would be high in comparison to others who had made no such allowance.

The type of problem described in this case history is common whenever excavations pass below the groundwater table in sands and silts, and frequently cause delays, cost overruns and lawsuits. Furthermore, the foundation area is loosened in comparison to the pre-existing conditions at the site. This change is undesirable for the finished project, and may change the design assumptions with respect to soil strength and compressibility.

One procedure that can avoid these contractual problems is to treat construction dewatering at sites with artesian groundwater or groundwater above the depth of temporary excavation as a *design* issue rather than as a temporary measure under the control of the contractor. It can be specified that the contractor employ an experienced consultant to design a site dewatering system and verify that it is properly installed and working before excavation begins. This can be a separate price item in the bill of quantities to emphasize its importance to the project. The effect of such an approach is that instability due to high groundwater is avoided, the contract work proceeds smoothly, and the foundation integrity has not been compromised by ground softening.

Sin No. 7. Constructing Large Fills Over Soft Sediments Underlain by Steeply-Inclined Bedrock

Glaciers of the Pleistocene era left behind steeply-inclined hard rock surfaces which today provide fjords and deep lakes. At the shoreline, these slopes may have a narrow gravel beach above the hard rock that can support manmade structures, such as roads, railroads, or other commercial developments. However, the offshore environment may be very different and have deep deposits of soft silts and clays brought into the area by rivers and streams. These fine-grained sediments generally are normally consolidated and have a high sensitivity to remolding.

There have been many examples of slope failures where fills of significant mass have been put into the water above such weak soils. In projects known to the author, these failures have occurred rapidly . Some fatalities have occurred. In each case, site explorations were minimal prior to construction, probably due to the longer time and higher costs involved with over-water borings and probes. In most situations where soft, sensitive sediments overlie steeply-inclined bedrock, it is impractical to build fills above them.

Example H: Lake Pend Oreille landslide, Idaho

The northeast side of Lake Pend Oreille in Idaho has steep rock slopes and a narrow strip of flatter ground along the shoreline. In 1966, the U.S. Bureau of Public Roads decided to realign Highway 200 from Hope to Denton to eliminate hazardous curves. The start of this project required the road to cross the Northern Pacific Railroad and curve back to an alignment parallel to the railroad tracks (Figures 26, 27). The horizontal curve required a substantial fill to be placed into the lake near the overpass structure.

Figure 26. Lake Pend Oreille landslide. Hope Overpass site. Piers 2 and 3, on opposite sides of the Northern Pacific railroad tracks, are under construction in the background.

The embankment fill was a shot rock, primarily of gravel size. This was end-dumped and pushed into the lake. However, the fill simply "disappeared" into the lake as quickly as it was being placed. According to an eye-witness report, sliding was continuous and dump truck operators refused to drive their trucks near the fill edge. Work was suspended after an estimated 30,000 cu.yds.(9,100 cu.m) of fill had slid into the water.

The only site investigations in this area prior to the work suspension were on-land borings (1, 2, 3, 4, Figure 27) that encountered terrace gravels overlying bedrock. After the failure, seven over-water borings were put down (5 to 11, Figure 27). They encountered soft, silty clay underlain by argillite bedrock.

A hydrographic survey of the failure area (Figure 27) showed that a deep trough had been scoured out below the lake by the landslide. A cross-section taken through the center of the trough (Figure 28) showed a mound below water with the top at depths of 50 to 60 feet (15 to 18 m) below the lake surface. The steep outer slope of the mound (maximum 45 degrees to the horizontal), is interpreted to be angular rockfill that slid to this position. The clay that was formerly at this location apparently had been eroded and flowed into a deeper part of the lake. Unfortunately, none of the over-water borings were within the trough. However, the borings on both sides of it provide a means (by interpolation) to draw approximate contours of the ground surface, bedrock surface, and the depth of clay sediments. These contours (not reproduced here) show that the clay progressively thickens from 0 at the shoreline to 60 feet (18 m) in boring 10.

Boring B-6 is typical of the near shore conditions (Figure 29). This boring had gravelly soils near the ground surface, the gravels being either beach gravel and/or fill from the construction work (there was poor sample recovery in this stratum). For all borings, the lacustrine clay

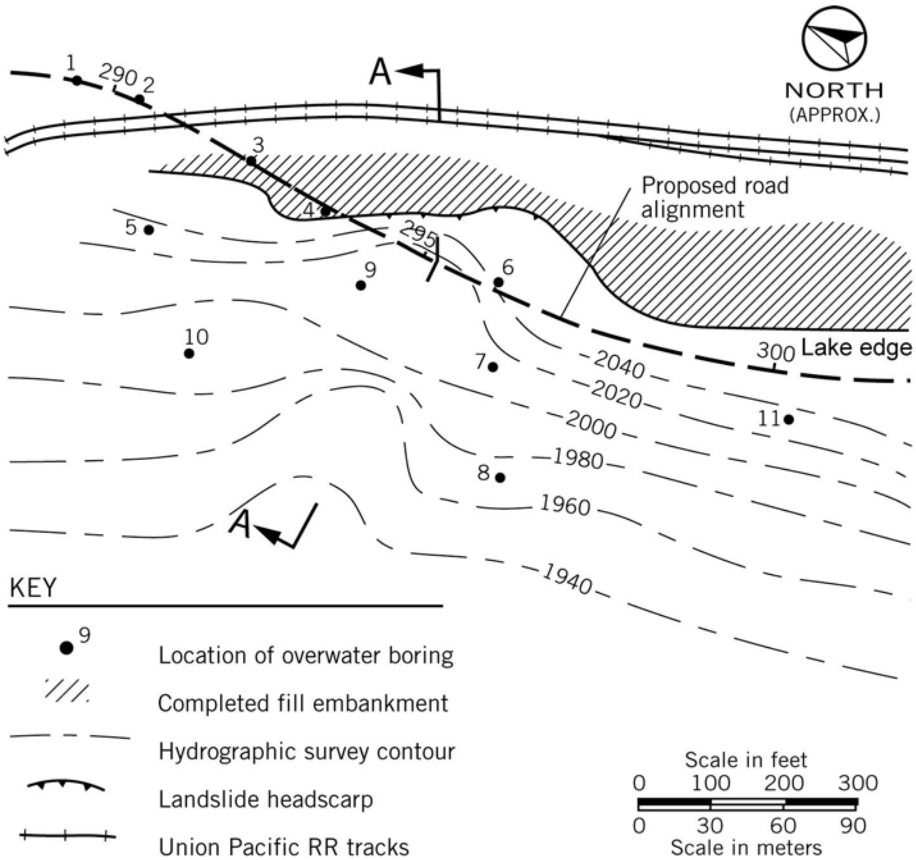

Figure 27. Lake Pend Oreille landslide: Site plan

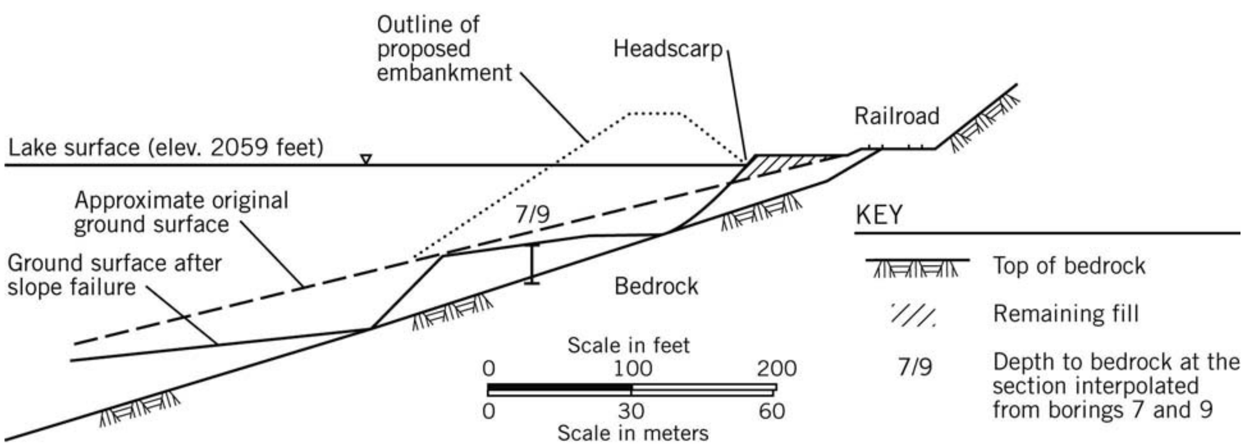

Figure 28. Lake Pend Oreille landslide: Section A-A

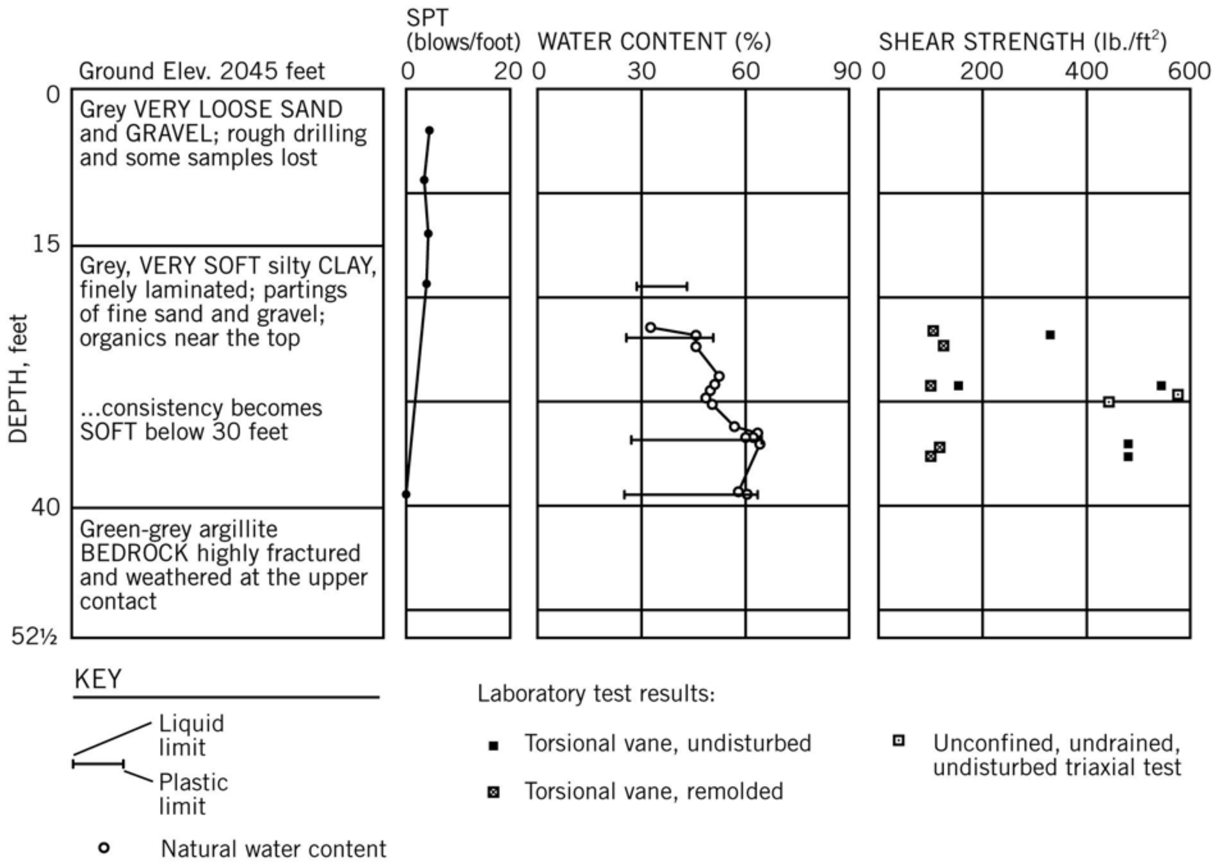

Figure 29. Boring log and clay properties in boring B-6

sediments were described as very soft clayey silt to silty clay containing thin layers and partings of sandy silt, fine sand, and occasionally gravel. Many samples had a laminated (varved) structure. The average index properties were: liquid limit 54; plastic limit 27; natural water content 68%. The shear strengths, based on torvane tests, increased approximately linearly from only 50 lbs./sq. ft. near the surface to 250 to 600 lbs./sq. ft. at a depth of 30 feet (metric: 2.4 kPa near surface to 12 to 29 kPa at 9m depth). The median value of sensitivity to remolding is 5. The measured effective stress parameters in consolidated-drained triaxial tests using very slow rates of strain were: c' = 0, i'= 24 degrees.

As can be seen from the above data, the Pend Oreille lake clays are very weak and normally consolidated. They were completely incapable of supporting the planned high embankment. At a site with these subsurface conditions, non-displacement piles driven or predrilled through the soft sediments to bearing in bedrock can be used to support a bridge or causeway.

Example I: Copper Ore Facility landslide, Skagway, Alaska

The east side of Skagway harbor has a very steep slope of hard rock that plunges into the fjord of Taiya Inlet (Figures 30, 31). Below water, a slope of soft marine silt has been deposited between the steep rock slope and the delta of the Skagway River.

In 1966, a contract was let to build a copper ore loading facility next to the south end of the existing Pacific and Arctic Railway and Navigation Company (PARN) dock. The project was to build a platform fill into the bay and construct a 60-foot x 160-foot (18 x 50 m) building on the fill.

Figure 30. Steep rock walls on the east side of Skagway harbor.

The "site investigation" consisted of driving seven wooden piles into the ground from a floating barge. Four of the seven piles sank 10 to 15 feet (3 to 4.5 m) under the weight of the pile-driving hammer, indicating very soft underwater conditions. An old timber wharf was demolished and fill was placed into the bay on 12-hour shifts. Four weeks later on October 29, 1966, when the work was nearly completed, most of the fill collapsed and disappeared below water overnight.

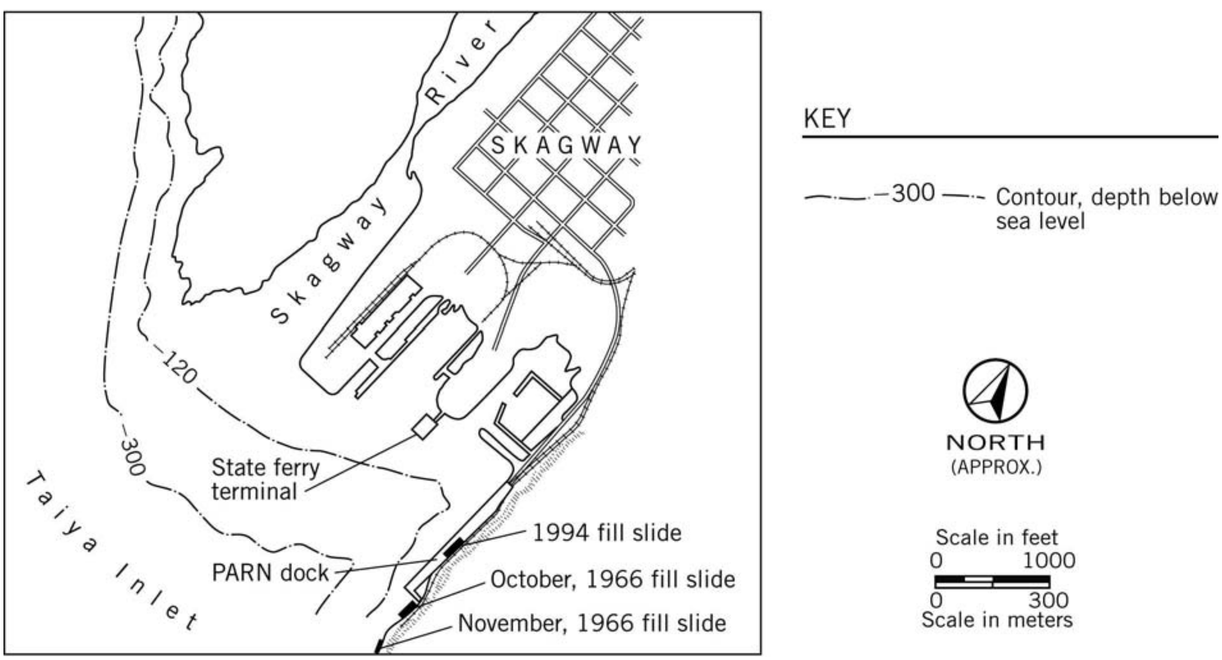

Figure 31. Skagway harbor and landslide sites

Subsequent investigations showed that the Skagway tide gauge, close to the site, recorded a wave occurring near the low tide of elevation -1 foot (-0.3 m) at about 7 p.m. on the night of the failure. A ferry terminal employee in Skagway lost telephone contact at about the same time. It is understood that the submarine telephone cable broke approximately 1.5 miles (2.4 km.) south of the slide. This suggests that a flow slide resulting from the fill failure traveled a considerable distance down the slope into Taiya Inlet. Bjerrum (1971) cites a similar occurrence in Norway. Seed (1983) reported that several failures of fill slopes in coastal areas occurred at extreme low tide. At such times, the stability is most critical because, at higher tide levels, the water outside the slope provides support.

The approximate plan of the fill (Figure 32) shows that the level top surface was about 230 feet (70 m) long parallel to the shoreline and extended 50 to 70 feet (15 to 21 m) into the bay. A "before" and "after" cross-section X-X near the center of the fill (Figure 33) shows the loss of ground. It is calculated that about 13,000 cu.yds. (10,000 cu.m) of fill was lost.

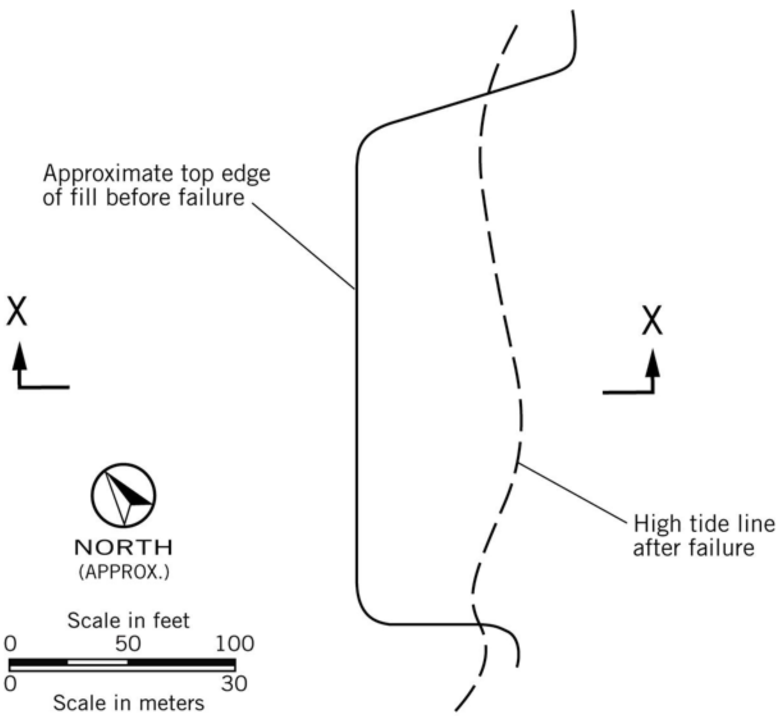

Figure 32. Skagway October 1966 flow slide: Site plan

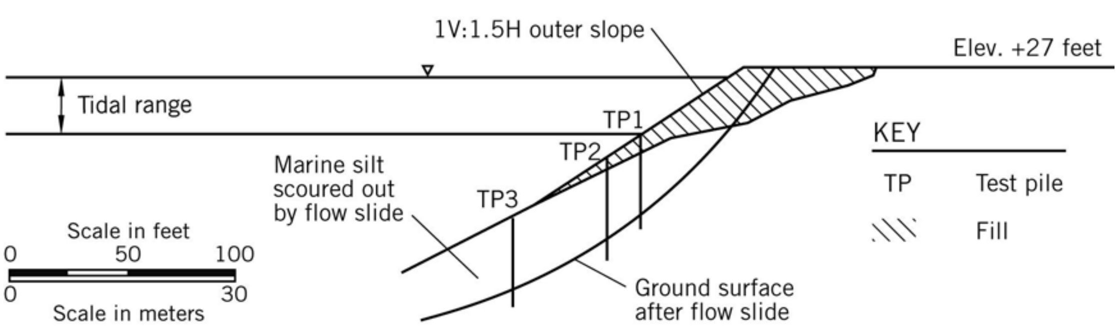

Figure 33. Skagway October 1966 flow slide: Section X-X

Following the October 29, 1966 landslide, the project developers tried to build another fill. On November 8, 1966 the original contract was amended to build a fill into the harbor 400 feet (120 m) further south (see Figure 31 harbor plan). The contractor began filling immediately, but the project was stopped on November 30 because a 300-foot (90 m) long crack with a 2-inch (50 mm) vertical displacement had appeared on the fill surface parallel to the shoreline. The site was abandoned.

Lest any reader should think that this type of event is confined to the "old" days of 1966, it should be mentioned that yet another fill was built into the harbor at Skagway in 1994 as part of the PARN dock improvement. In this case, a platform fill was built out from the shoreline and a very large heap of riprap was placed on it. This slope failed at extreme low tide on November 3, 1994 taking out the remains of the old wooden dock to the south and the partly-completed improvements. The wave, estimated to be 60-feet (18 m) high from peak to trough, pulled the floating ferry terminal out of its moorings on the other side of the harbor. The volume of fill, including riprap, at the time of failure was calculated to be 12,700 cu.yds.(9,700 cu.m). This is almost the same fill volume as the Copper Ore Facility landslide of 1966, which occurred only a short distance away on the same side of the harbor. The 1994 landslide requires more description than is possible here. It is described in some detail in Cornforth (2005).

The marine silt properties measured on samples taken at the two Skagway sites were almost identical. The soils ranged from non-plastic silt to clayey silt and were soft to medium stiff in consistency. As measured after the PARN dock failure, the average silt properties were: natural water content 31%; liquid limit 27%; plastic limit 22%; plasticity index 5. The average undrained shear strength was 1100 lbs./sq. ft. (53 kPa), based on in-situ vane tests at 17 feet (5m) below the mudline (after failure), and the sensitivity to remolding was 6. Effective stress parameters were a surprisingly high c' = 0, i' =38 degrees.

Conclusions and Recommendations

Sin No. 1. At a site proposed for development, an essential first step is to determine whether or not there is a landslide on the property. Pre-existing landslides can range from fully stable to active. It usually takes only minor adverse changes in loading or support for such landslides to become more active. Therefore, any pre-existing landslide needs to be fully evaluated during design to maintain or improve stability.

Sin No. 2. The depth of slippage is needed to model a medium or larger size landslide in a stability analysis. Interpreting boring logs or shallow test pits to estimate the slippage depth is generally unreliable. It should be measured by field instrumentation designed for this purpose, such as inclinometers.

Sin No. 3. Unrealistic expectations of the accuracy of inclinometer systems can lead to erroneous interpretations of the collected data. Two common problems are: (i) to leave systematic errors uncorrected, and (ii) to plot the data to exaggerated scales in the hope of detecting movement at the earliest opportunity. The author suggests that at least 0.15 inch (4mm) of simple shear displacement should be observed at the discrete shear zone to confirm the position of the slip surface.

Sin No. 4. Using a factor of safety in remedial design that is too high is counter-productive. It provides a remedial treatment that exceeds the need, or it may be concluded that stabilization of the landslide is not feasible at an acceptable cost. Since landslide stabilization design is based on a comparison of "before" and "after" analysis of the modeled cross-section, and knowing that the factor of safety is exactly 1.00 at the onset of movement, an experienced practitioner can use judgment to select a factor of safety between 1.15 and 1.50 that is appropriate for the project. Factors influencing this decision are listed on Table 1.

Sin No. 5. Be aware that temporary remedial work, especially trenches and lower slope excavations, may reactivate a landslide. It is recommended that the geotechnical practitioner mention (in technical reports) the need for temporary (short-term) slope support systems during remedial work. These may require retaining walls, sophisticated dewatering systems, closely-sequenced construction techniques, favorable time of year for construction, etc., depending on the site specifics.

Sin No. 6. Always pay special attention to artesian conditions encountered during a site investigation. Should a landslide remedial treatment require temporary excavations, there is a danger that a critical hydraulic gradient may develop between the artesian layer and the excavation face during construction, causing a flow slide. A proactive approach is to treat the possibility of instability as a *design* requirement rather than leaving it as temporary works at the discretion of the contractor. It usually requires the contractor to install a sophisticated dewatering system.

Sin No. 7. It is almost impossible to safely construct a substantial fill over soft sediments that are underlain by steeply-inclined bedrock. These conditions are encountered in fjords, where marine silts are being actively sedimented, and in glacially-formed lakes.

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Moore-Love, Karla

From: Dee White <deewhite1@mindspring.com>
Sent: Thursday, April 30, 2015 3:38 PM
To: Council Clerk – Testimony
Subject: Email 3 of 4 Comment on Type IV Demolition Review WA Park Reservoirs
Attachments: 2008_Huvaj-Sarihan 2008 published p1171-1178.pdf

Evaluation of the Rate of Movement of a Reactivated Slide 2008
By Nejan Huvaj-Sarihan

Evaluation of the rate of movement of a reactivated landslide

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ABSTRACT
Washington Park slide in Portland, Oregon, was first encountered in 1894 during the construction of the two water supply reservoirs. Thirty-three borings and 22 open-shafts revealed information about the subsoil conditions and the presence of a well-defined thin seam of blue clay along the surface of the bedrock. In this paper, the mechanism of the reactivated landslide is discussed, and the relation between the rainfall and observed movements is investigated.

RÉSUMÉ
Le premier cas de glissement à être enregistré dans le parc de Washington à Portland, dans l'Oregon, date de 1894 pendant la construction des deux réservoirs d'eau. 33 carottes et 22 puits ouverts ont ainsi pu donner des informations quant à l'état du sous-sol, révélant notamment la présence d'une fine couche d'argile bleue clairement définie le long de la surface du soubassement/du substrat rocheux. Dans cette étude, nous allons donc examiner les mécanismes de réactivation de glissements de terrain ainsi que la relation existant entre les précipitations enregistrées et les mouvements du sol.

1 INTRODUCTION

The landslide is located in the Central West Hills, west of downtown Portland in Oregon. The city of Portland constructed two water supply reservoirs in the 1890’s by excavating in a small narrow valley. This paper presents the background information about this landslide, the stratigraphy and material properties, observed movement through the years and correlation of stability with rainfall. The 3-D view of the terrain is shown in Figure 1.

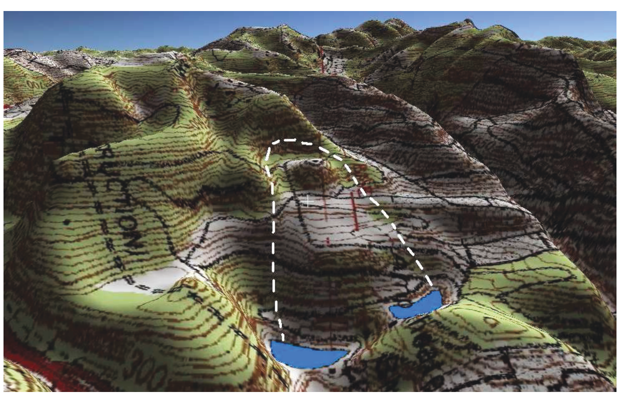

Figure 1. NASA World Wind 3-D view of the terrain in Washington Park Reservoir slide area looking northwest. White dash lines indicate the approximate boundary of the moving mass, the two reservoirs are shown toward the bottom of the figure with blue colour.

2 BACKGROUND INFORMATION

This is an extremely slow (< 16 mm/year) active landslide, where movements are concentrated within a narrow shear zone, above which the ground moves almost like a rigid body and movements are often controlled by rainfall-induced pore pressure fluctuations. These types of slides have been studied previously by various researchers such as Picarelli et al. 2004, Bonnard and Glastonbury 2005, Eshraghian et al. 2008, and Calvello et al. 2008. It is a good and historic example of a landslide moving at a long-term constant velocity.

On the West Hills of Portland, minor local instability was observed in the location of this landslide during the construction of a residential development upslope during 1891-1892. The reservoir construction for the City of Portland was started in October 1893 and completed in September 1894. In August 1894 engineers found a crack in the west wall of Reservoir 4 (the reservoir on the left in Figure 1) with movements of about 13 mm per day for several days. More indications of instability at the toe of the slope and bulging at the base of the reservoir in the concrete lining of Reservoir 3 were also observed. Continued movements were observed during the winter of 1894-95 at both reservoirs causing them to be out of service for about 10 years.

It should be noted here that there was a discussion in 1890’s about whether the slide started moving due to the toe excavation during reservoir construction or due to heavy rainfall. Some people argued that the large main slide was in a state of rest until 1894, up to the time when the cracks first appeared in the west slope of Reservoir No. 4 in August. Clarke (1904) gives ample evidence that the slide had been moving before the reservoir excavations were made. This was explained in detail due to lawsuit investigations at the time. It was concluded that the movements were taking place intermittently before the construction of the reservoirs had started.

In 1895 the head scrap of the landslide was found in a marshy depression 518 m upslope of the reservoirs (see Figure 2). The extent of the sliding mass was becoming apparent. The graben feature at the top of the slope was semicircular, 90 m long and 9-18 m wide. The main body of the slide was about 122 m wide near the head scarp and it was 335 m wide at the base near the toe. The volume of the moving mass has been estimated to be 2.6 million m^3 (Clarke 1904).

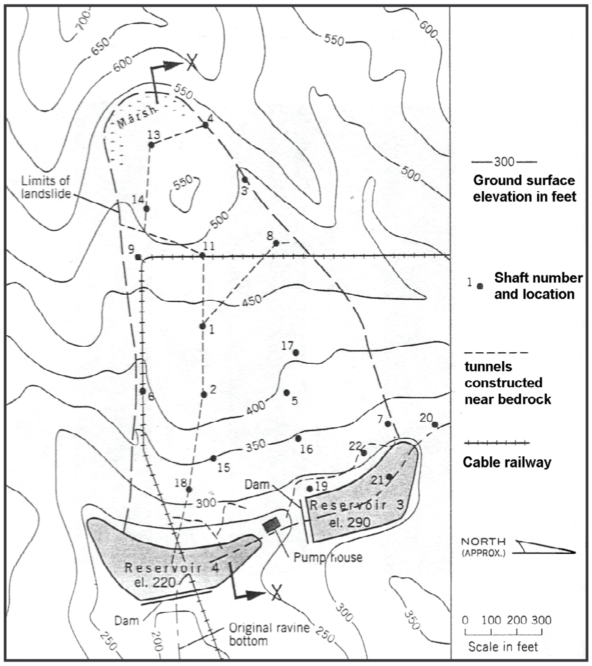

Figure 2. Washington Park reservoir slide (Clarke 1904, Cornforth 2005)

2.1 Geology and Stratigraphy

West Hills form the western boundary of the Portland Basin. They consist of uplifted, layered basalt flows of the Miocene age Columbia River Basalt Group with some Pleistocene to Pliocene age sedimentary deposits (Rice 1998, Myers et al. undated, Burns et al. 2006). Overburden materials are primarily wind-deposited silts called Portland Hills Silt Formation that covers most of the West Hills to depths ranging up to 13 m. These silt deposits are believed to be derived from glacial sediments of the Columbia River drainage system (Rice 1998, Burns et al. 2006) and sediments consist of intermixes of gravels, sands, silts, and clays. A multi-colored plastic clay deposit correlated with the Sandy River Mudstone of Miocene to Pleistocene age underlies the Portland Hills Silt and overlies the basalt. The upper basalt is highly weathered (Myers et al. undated).

During a landslide inventory study in Portland, it was discovered that most of the landslides (48%) surveyed in the study occurred in the West Hills within the Portland Hills Silt or loess (Burns et al. 1998). Earthflows and slumps were the typical type of slides observed in the region, making up 69% of all the landslides (Burns et al. 1998).

Related to Washington Park Reservoir slide, in early 1900's a subsurface investigation was carried out by 22 deep shafts and 9 wash-drill borings. The shafts were each 1 m square, dug by hand and dewatered by pumps. They were made during July 19, 1897 to January 24, 1899. In 16 shafts the base of the slide was reached and ranged from 15 to 34 m below the ground surface (average 24 m). With the help of shafts a seam of blue clay overlying the bedrock, forming the bed of the ancient slide, was identified (Clarke 1904). Location of these shafts is shown in Figure 2 with black dots and in Figure 3 with black lines. Borings were 10 cm diameter holes, cased with driven wrought-iron pipe.

From the shaft excavations, the general character of the materials forming the mass of the slide has been determined to be largely of broken rock of small size mixed with clay matrix. The detailed notes taken during the logging of shafts and reported by Clarke (1904) are very useful in identifying the materials involved, the depth and character of the slickensided slide surface. For example: Shaft 1: *"Blue sedimentary clay without any admixture of broken rock. Some pieces of clay having smooth upper faces. A plainly defined movement seam was uncovered, having 13 cm of dark blue clay above the line of cleavage, with fine broken rock between the clay and the solid bedrock"*, *"the line of cleavage in the stratum of clay was defined very clearly. The upper and lower portions of the stratum could be easily separated along the line of cleavage, and the faces, which had been in contact presented uniformly a smooth and glazed appearance."* From the descriptions of the other shafts, the thickness of the blue clay seam above the basalt bedrock and the exact location of the slide plane can be identified. For example, Shaft 2: *"dark blue clay, 30 cm thick, on top of the rock, the line of the slide was defined clearly near the bottom of the clay"* or Shaft 5: *"2.5 cm thick blue clay, the under face of which was smooth, next came 15 cm of mixed clay and rock fragments, below which the bedrock was found smooth and without fissures. The total thickness of the distinctly clay seam was about 8 cm, through which a line of cleavage, indicating the movement plane was defined clearly"* (Clarke 1904).

2.2 Material Properties

The red clays were quite plastic and contained little sand. At some locations, the material was coarse, containing grains and small fragments of the rock incorporated with the clay, but the finer materials were all of the same reddish or yellow color. The blue clay differed from the red. When found in thin seams near bedrock blue clay was tough and plastic but when found in considerable bodies at higher levels it contained quite a significant amount of fine sand. When dry it was hard to pick and a vertical bank would stand without support, when placed in water it soon crumbled into an incohesive mass. Clarke (1904) described it as "blue quicksandy clay".

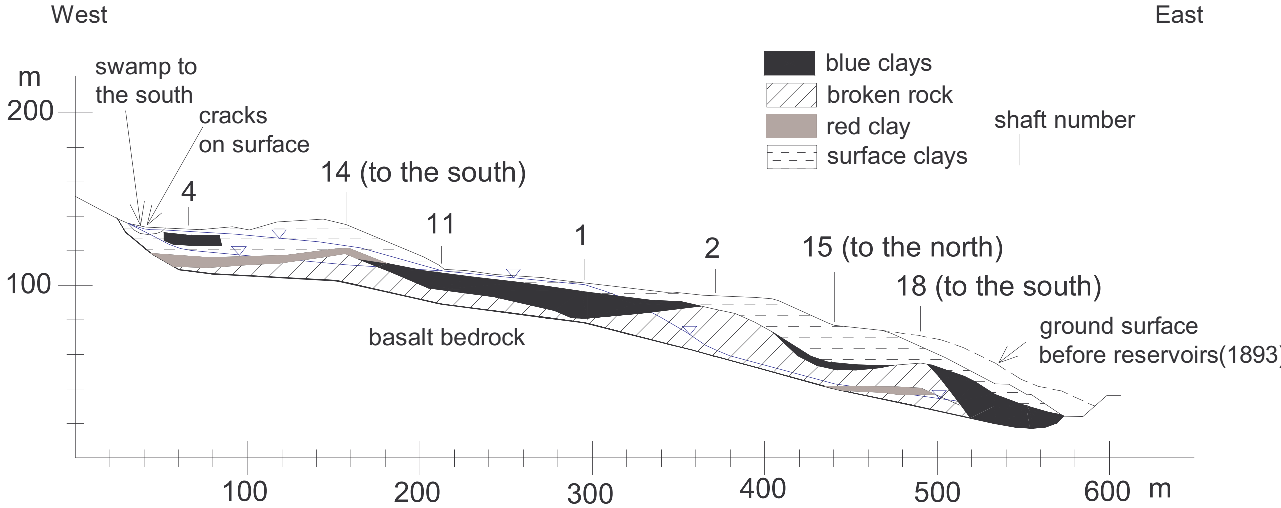

Figure 3. Cross section X-X in Figure 2 (modified from Clarke 1904 and Cornforth 2005)

Cornforth (2005) analyzed the Washington Park Reservoir slope and back-calculated a friction angle of 13.3 degrees. Unfortunately from 1900's no laboratory data is available on the weak blue clay that is causing the movements. But there was another landslide in late 1990's nearby (within 1.6 km distance) discovered during the construction of the Washington Park Station of the Westside Light Rail Project in Portland. The sliding materials were geologically similar (Cornforth 2007). Vessely and Cornforth (1998) took a block sample of the clay within the shear zone at the Washington Park Station slide at a depth of 18.3 m. The landslide was occurring within a layer of decomposed basalt near the contact with less-weathered basalt bedrock. It was moving with an average rate of 0.8 to 20 mm/year. The samples of decomposed basalt consisted of stiff to very stiff, mottled, gray-brown-red silty clay with scattered coarse sand-sized nodules. Samples were highly slickensided. The properties of the material were clay-size fraction of 30%, liquid limit of 85%, plastic limit of 59%, and plasticity index of 26% (Vessely and Cornforth 1998).

3 RATE OF MOVEMENT AND RELATION WITH RAINFALL

The surface movement data are recorded starting from December 1894 (Figure 4). Until December 1899, movement data is obtained from the average movement of 14 survey points established on the surface of the slope, along the central portion of the sliding ground, monitored monthly. Since December 1899 more points are installed for monitoring. The average of the readings at 51 of these points along a central belt 100 ft wide, is used in plotting the movement during 1900-1903. Although it is known that there had been movements before the reservoir excavations were made, it is not possible to know the amount of previous movements. Therefore the cumulative movement data plotted in this study (see Figures 4 and 5) starts from zero movement in December 1894.

To determine the depth of the moving mass, 2.5 cm diameter pipes (connected in 3 m segments) were inserted into the boreholes (Clarke 1904). In most of the borings, the movement was found to be taking place at or near the surface of the bedrock, and at depths varying between 15 and 34 m below the surface of the ground. In some of the borings water would rise in the casing after they were completed, indicating the presence of water pockets at various places in the sliding ground (Clarke 1904).

In this slide as well as in other slides in West Hills in Portland, it is observed that the rate of movement increased during the winter or rainy months of November to May, and decreased during the remaining months of the year when the rainfall was less (Clarke 1904, Cornforth 2005, Myers et al. undated, Burns et al. 2006). In spring 1897 it was understood that the water in underground springs fed by percolating water from the surface was a major factor. A comprehensive drainage system was planned (Clarke 1904). The effectiveness of reducing water pressures is shown (in Figure 4) by the decrease in the rate of movement between December 1897 and November 1898, during which period the underground reservoir connected with Shaft No.1 was drained by pumping.

When landslide movements are monitored the uniformity of the movement of the sliding mass with depth becomes important because the movements are monitored at the ground surface and the basal shear plane may or may not be experiencing the same amount of movements. In the landslide analyzed in this study, the movement at the surface and at bedrock level was found to be uniform. For example, in Shaft No.6, between October 25, 1897 and November 22, 1899 the total surface movement was 14.9 cm, while the movement at the bottom of the shaft was 14.3 cm during the same period (Clarke 1904).

It can be seen from Figure 4 that with each recurring dry season there was a corresponding decrease in the movements and that with the beginning of winter rains the movement increased. It is also seen that a time lag of about one month elapsed between a change in the

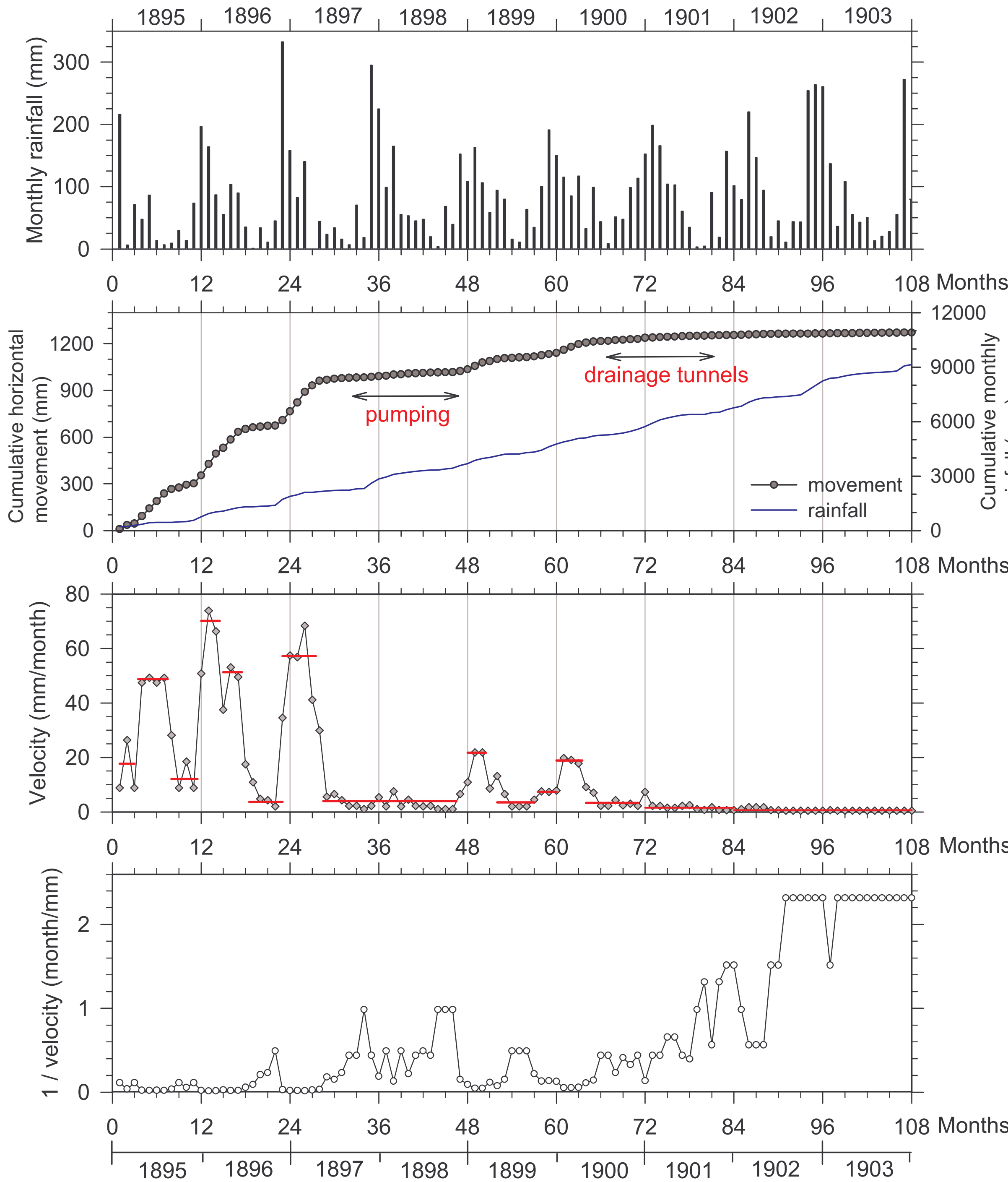

Figure 4. Measured rainfall, movements, and velocities for January 1895 – December 1903 period. Rainfall records are taken at 2.4 km distance from the slide location. Pumping from Shafts No.1, 11 and 18 was carried out during August 1897 – November 1898. Construction of drainage tunnels in progress from July 1900 to September 1901 (data from Clarke 1904).

volume of rainfall and the corresponding change in the rate of movement. When pumping from Shaft No.1 was in progress the movement didn't increase as rapidly during the winter months as it had during the former winter seasons. Decreased movement during 1898 was due in part to the pumping of water from Shaft No. 18 (July-

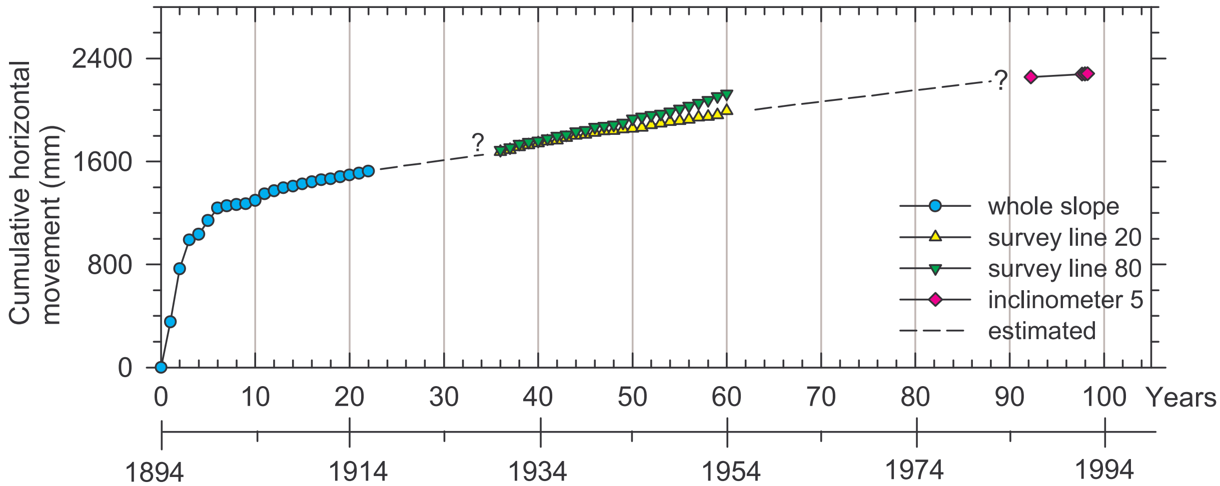

Figure 5. Cumulative movements of the slide between 1894 and 1993 (data from Clarke 1904, Clarke 1918, Cornforth 2005).

August) and No.11 (October-November), but it is believed to have been due principally to the drainage of the underground reservoir connected with Shaft No.1 (until January 1898) (Clarke 1904).

Slide was remediated with a system of drainage along bedrock. Drainage tunnels were completed in September 1901. It be can seen that the drainage tunnels have been very effective in draining away the water pockets and bringing a condition of stability in the sliding mass. In 1925-26, drainage tunnels damaged by landslide movements were repaired or replaced. Extensive surface drains were added (Cornforth 2005).

In movement data shown in Figure 5, survey line 80 is near the top of the slide (at about 550 ft ground elevation in Figure 2), and survey line 20 is near the toe of the slide close to the reservoirs. Both survey lines are stretching the width of the slide in approximately north-south alignment. Movements are average annual horizontal movements of all points within the slide boundaries on the specific survey line. Between 1930 and 1954 survey line 20 moved with a rate of 13 mm/year, and survey line 80 moved slightly faster, with movement rate 18 mm/year.

9 inclinometers were installed in 1987 near the toe of the slide close to the reservoirs at the ground surface elevations of about 250-300 ft to measure the rates of movement at the discrete shear zone more accurately than is possible from surface survey hubs. These inclinometers have been read at three-month intervals until 1993. Inclinometer SI-5 (located near Reservoir 4) shows long term creep movements on the order of 4.6 mm/year (Cornforth 2005).

4 STABILITY ANALYSES

Various researchers have proposed empirical correlations between the residual shear strength and index properties. However most of them have significant scatter (the reasons for which were explained by Mesri and Shahien 2003) decreasing their reliability and applicability to real life problems. The empirical correlation developed by Mesri and Shahien (2003) between the secant residual friction angle and the plasticity index is used in this study. In this method, for a given I_p, the secant residual friction angles at three different effective normal stresses, namely 50, 100 and 400 kPa, are estimated from the empirical information and used to establish a non-linear relationship between shear strength and effective normal stress for the material. The plasticity index of the blue clay in the shear zone above the bedrock is estimated to be 26% (Cornforth, 2007).

Before discussing the slope stability analyses, the difference between the high and low ground water levels should be noted in Figure 3. From the top of the slide to Shaft No.11 there are two blue lines, the higher one indicating the groundwater level before any pumping was carried out. The lower line indicates the groundwater level after pumping. From Shaft No.11 down to the toe of the slide, higher and lower groundwater levels join and are shown by the same blue line. Two-dimensional limit equilibrium slope stability analyses are carried out using Spencer’s method in UTEXAS3 computer program.

Considering that there were indications of instability and slope movements before the reservoirs were excavated, it is assumed that the slope was initially marginally stable, and the factor of safety (F.S.) was 1.00. Using the ground surface before the reservoir excavations (see Figure 3) and high groundwater level, the mobilized strength of the blue clay overlying the bedrock was back-calculated for a F.S. of 1.00. The results are shown in Figure 6 as secant friction angles and a non-linear relationship between shear strength and effective normal stress.

We can see that there is a significant nonlinearity to this relation indicated by decreasing secant friction angles with effective normal stress. We also see that the mobilized back-calculated strength in the slide is close to the residual strength of a material with I_p = 33% (instead of I_p=26%). This could be reasonable considering the effects of sample preparation on the measured plasticity index and the residual shear strength (Mesri and Shahien 2003). Also it should be recalled that I_p = 26% was reported from a nearby, geologically similar landslide (Vessely and Cornforth 1998), and not from the shear zone of the Washington Park Reservoir slide.

In the next slope stability analysis, the new ground surface (after the reservoir excavations) is used, and the F.S. is calculated using the back-calculated mobilized strength, and high groundwater levels. This would indicate the effect of the reservoir excavation on the stability of the slope. The F.S. is calculated to be 0.92 in the current study. For a slightly different water conditions, Cornforth (2005) calculated F.S. to be 0.95.

After reservoir excavations were made, and after pumping was carried out, the water levels in the shafts were given by Clarke (1904), that would indicate a lower groundwater level at the top of the slope as shown by the lower blue line. Using this condition, F.S. is calculated to be 1.01. This means that the lowering of the groundwater counteracted the drop in the factor of safety due to reservoir excavations. These groundwater levels reported in the literature may be approximate.

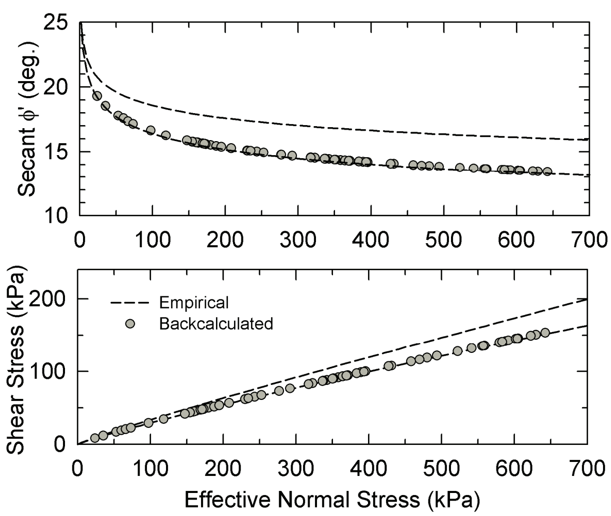

Figure 6. Back-calculated mobilized shear strength for blue clay together with residual shear strengths from Figure 2 of Mesri and Shahien (2003) shown by dashed lines (in both figures upper dashed lines are for I_p = 26%, lower dashed line I_p = 33%).

5 FAILURE TIME PREDICTION

The prediction of the failure time of a landslide is a very challenging and important subject in mitigating landslide hazards. Various researchers proposed methods to predict when a landslide would fail, such as Saito (1965) and Fukuzono (1985) among others.

The inverse-velocity method is used increasingly as it is a useful tool for estimating the failure time of a landslide from the measured rate of movements (Rose and Hungr 2007, Eberhardt 2008). The concept of inverse-velocity for predicting slope failure time was developed by Fukuzono (1985) based on laboratory simulations of accelerating creep conditions. The inverse of observed displacement time rate ("inverse-velocity") was plotted against time, the values approached zero as velocity increased towards failure. A trend line through values of inverse-velocity versus time could be extrapolated to zero value of inverse-velocity (where the velocity would be highest), predicting the approximate time of failure. Fukuzono (1985) presented three types of plots fitted to the laboratory data, concave (α<2), convex (α>2) and linear (α=2), defined by the following equation:

$$V^{-1} = [A(\alpha - 1)]^{1/\alpha - 1} (t_f - t)^{1/\alpha - 1} \qquad [1]$$

where t is time, A and α are constants and t_f is the time of failure. In the laboratory measurements preceding failure, α was found to range between 1.5-2.2. Fukuzono (1985) based on the laboratory simulations concluded that a linear trend fit through inverse-velocity data usually provided a reasonable estimate of failure time as supported by other researchers (Rose and Hungr 2007).

For Washington Park Reservoir slide the rate of movements and inverse-velocities are shown in Figure 4. It can be seen that the movement rate is decreasing and inverse-velocity is increasing with time, therefore it is not an accelerating creep type of movement and it is not possible to apply Fukuzono's inverse-velocity approach for the long-term measured data. Only small incremental time can be used where the inverse-velocity seems to decrease toward zero. If we use the data at months 1 and 2 and a linear relationship between inverse-velocity and time, we would predict a time of failure at 2.5 months. Since the velocities decrease and slide becomes stable with time, Fukuzono's method would not be very useful in this kind of non-accelerating movement data.

When we look at the movement data in terms of the long-term creep movement rates, Saito's method might be applicable. Saito's time to failure prediction method is also used commonly (Picarelli et al. 2004, Bonnard and Glastonbury 2005) and predicts the time to failure using this equation:

$$\log t_r = 2.33 - 0.916 \times \log \dot{\varepsilon} \pm 0.59 \qquad [2]$$

where the time to rupture (t_r) in minutes is obtained from the strain rate (in units of 10^{-4}/min) of the slope. To estimate a constant creep displacement rate we can look at typical slow constant rate movements, such as during 84-108 months where the displacement rate is 0.43 mm/month (5.2 mm/year). At inclinometer SI-5, which is located at about 300 feet ground surface elevation near the toe of the slide to the west of reservoir 4, the average creep rate was 4.6 mm/year between 1987-1993. Therefore the average creep rate of Washington Park Reservoir slide can be taken as about 5 mm/year. Also it can be noted that in Washington Park Station slide (within 1.6 km distance to Washington Park Reservoir slide) with similar geologic and environmental conditions the creep rates were 5.6 mm/year between 1975-1976 and 0.8-1.8 mm/year between 1987-1994 (Myers et al. undated).

As was done by Saito (1965) we can use the length of the slope (520 m) to convert measured horizontal deformation rate of 5 mm/year to a strain rate. Therefore creep strain rate of this slide is about $9.62x10^{-6}$/year. When used in Saito's equation in terms of the units required, average time to failure can be obtained as 604 years (with a range 155-2349 years) with the assumption that the slope will continue to deform at 5 mm/year constant creep rate without any change in other parameters influencing the stability of the slope. If we had used the highest deformation rate observed in the history of this slide (such as in month 13 in Figure 4) 74 mm/month, we would estimate a time to failure of 5 years (with a range of 1-20 years) if the slope had continued moving with this rate. Saito's method could be a useful tool for setting up threshold deformation rates and corresponding alert levels for landslide hazard mitigation.

Another way of looking at the deformation rates to estimate failure time could be in terms of the acceleration of the movements. Picarelli et al. 2004 presents a plot between the acceleration of the slope movements and the time to failure from slope failures in the literature. In Washington Park Reservoir slide, there have been relatively high accelerations at month 4 (39 mm/month^2) and at month 23 (33 mm/month^2). But the maximum acceleration occurred in month 12, and it was 42 mm/month^2 (or $4.7x10^{-5}$ m/day^2). That could be arguably the closest condition the slope came near failure. If the movements had continued with that acceleration, it would have lead to the failure in about 30-100 days (Picarelli et al. 2004 Fig.10). The acceleration decreased in the dry season following month 12. In the long-term, the drainage remedial measures prevented the slope from accelerating, and helped stabilize it at a constant velocity creep deformations. Estimating time to failure based on acceleration values could be a useful approach in establishing warning systems in landslide prone areas.

For active landslides with very slow (< 1.6 m/year) to extremely slow (< 16 mm/year) movements (IUGS 1995) concentrated within a narrow shear zone, where the rate of movement is more or less uniform with depth, the factor of safety of the slide is often in the range of 1.20-1.01 and movements are often controlled by rainfall-induced pore pressure fluctuations (Calvello et al. 2008, Bonnard and Glastonbury 2005, Eshraghian et al. 2008). Relating the displacement rate of a slope to the factor of safety has been an interest for geotechnical engineers, especially in the recent decade. For example, Calvello et al. 2008 proposed "R-u-F-v" approach where changes in the pore pressures (u) can be estimated from rainfall (R), and it is used to calculate factor of safety (F) at different times, and correlated with the displacement rates (v). In addition, they have successfully applied an optimization algorithm for calibrating the parameters used in the analysis. As emphasized by Calvello et al. 2008, this method needs a good understanding of the movement mechanism(s) of the slide, and considerable geotechnical engineering judgement as parameters are being calibrated. To be able to use "R-u-F-v" approach, one needs the pore pressures in the ground with time in addition to the movement rates. Since pore pressures in the ground were not measured at different times in the slide analyzed in this study, this promising method could not be applied.

Bonnard and Glastonbury (2005), based on Glastonbury and Fell (2002), presented relations between the F.S. and slide velocity for earthflows and debris slides from the literature (Figure 7). They used infinite slope analysis approach. Due to uncertainties in the calculated F.S., they present data in terms of "relative change in the F.S." For each slide, the condition of highest groundwater level (the least stable condition) was considered to represent a relative F.S. of 1.0. The other conditions are normalized against this value.

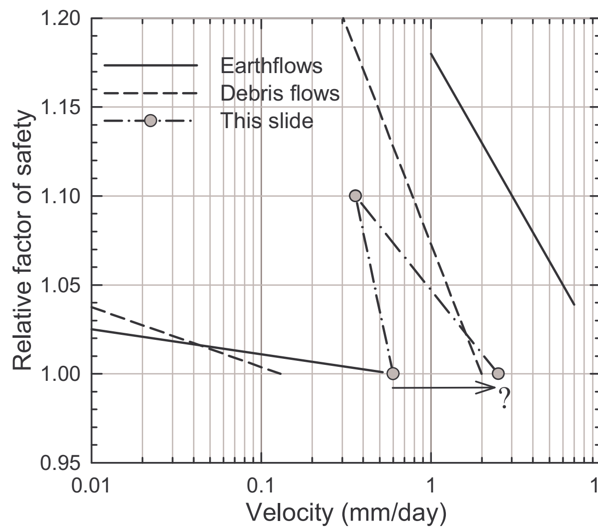

Figure 7. Relation between relative factor of safety for earthflows and debris slides taken from Bonnard and Glastonbury 2005, shown with estimates for the landslide in this study.

For earthflows where the majority of the movement is uniform between the ground surface and the basal sliding plane, the sensitivity of the slide to fluctuations in groundwater level is possibly related to velocity of movement of the earthflow. Therefore, Bonnard and Glastonbury (2005) calculated F.S. for changing groundwater conditions and related that to the movement rate of the slope. They present similar relations for debris slides, which are reported to have internal deformation (i.e. non-uniform movements on the ground surface and at depth), relating measured groundwater levels and calculated relative F.S. to observed slide velocities.

For Washington Park Reservoir slide, F.S. was calculated as 0.92 after the excavations were made for reservoir construction and the groundwater level was high. Slope stability analysis by Spencer's method and a nonlinear shear strength envelope is used in UTEXAS3. Although there is uncertainty in the time when the groundwater levels were this high and corresponding rate of movement, for the sake of reaching to an estimate, this time is assumed to be close to January-February 1895 where initial movements were being measured (average about 18 mm/month). The second case is after the reservoir excavations were made, and water level is lowered by pumping (in March 1899, cross-section and water levels reported by Clarke 1904) for which the F.S. is calculated to be 1.01. During that time, movement rates were slower (about 10 mm/month). These factor of safety values can be plotted in Figure 7 using a "relative factor of safety approach", whereby the values are normalized by the lowest one (F.S.=0.92). The highest movement rate of the slide, observed in January-February of 1896 in Figure 4, is also shown in Figure 7 for the possibility that the movements might have been the highest at that time. More information about the piezometric levels at different times and corresponding rate of movements for Washington Park Reservoir slide is needed to improve such an initial estimate. However, plotting even an initial estimate would help to compare with the typical range of velocities for other slides, and see the sensitivity of the slide to changes in groundwater levels.

6 SUMMARY AND CONCLUSIONS

Close relation exists between the rainfall and the movement of the slide. With each recurring dry season there was a corresponding cessation of movement, and with the beginning of winter rains the movements increased. The pumping and drainage tunnels were very effective in reducing the movement rates to extremely slow creep rates.

Mobilized shear strength in the slide was backcalculated. The empirical relation between plasticity index and the residual shear strength is found to be valuable especially when there is not enough laboratory investigation on the shear strength of the material.

Various failure time prediction methods are investigated and it is discussed that they can be very useful in establishing threshold values in warning systems.

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From: Dee White <deewhite1@mindspring.com>
Sent: Thursday, April 30, 2015 3:38 PM
To: Council Clerk – Testimony
Subject: Email 4 of 4 Comment on Type IV Demolition Review WA Park Reservoirs
Attachments: LCDC Landslide TRG July 2000.pdf

LCDC Landslide TRG (Technical Resource Guide)
July 2000

PLANNING FOR NATURAL HAZARDS:

Landslide TRG

July 2000

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Community Planning Workshop
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Table of Contents

Section 1: Introduction to the Landslide Technical Resource Guide

Landslides pose a significant threat to many communities in Oregon and create challenges to development in steep terrain, coastal regions and other landslide-prone areas. The purpose of this guide is to help planners, local decision-makers, and community leaders reduce risk to life and property from landslides. The guide is designed to help your local government address landslide hazard issues through effective comprehensive plan inventories, policies and implementing measures.

1.1 The Threat of Landslide Hazards to Oregon Communities

Landslides are a serious geologic hazard in almost every state in America. Nationally, landslides cause in excess of $1 billion in damages and 25 to 50 deaths each year.[1] Landslides threaten transportation corridors, fuel and energy conduits, and communication facilities.[2] In Oregon, a significant number of locations are at risk to dangerous landslides. While not all landslides result in property damage, many landslides impact roads and other infrastructure, and can pose a serious life-safety hazard. A rapidly moving landslide in Douglas County, for example, killed five people during the storms of 1996.

Growing population and the resultant increased demand for home ownership has caused development to occur more frequently in hazard areas. Landslide-prone areas are easily identified; they often exist in highly desirable locations, such as beachfront or hillside property. In planning for development, landowners and developers alike should be aware of the implications of siting and building homes and other structures and uses in landslide areas. The number of potential injuries and deaths is directly related to exposure — the more people in areas of known risk, the greater the risk of injury or death. Policies that regulate development in areas of identified risk are essential to reduce risk from landslide hazards. By regulating development in areas of known risk, communities can better protect life and property.

Sidebar

Organization of the Natural Hazards Technical Resource Guide

The Natural Hazard Technical Resource Guide consists of eight chapters. The three preliminary *Planning for Natural Hazards* chapters include hazard-related information on reviewing your comprehensive plan, the elements of a comprehensive plan, and legal issues. Reviewing your comprehensive plan gives your community an opportunity to assess the adequacy of its existing natural hazard inventories and policies. The five hazard-specific chapters then provide detailed information on flood, landslide, coastal, wildfire, and seismic hazards. Appendices include information on Goals 2, 7, 17 and 18, a resource directory and land use tools matrix for hazard mitigation.

1.2 How to Use the Landslide Technical Resource Guide:

The Landslide Technical Resource Guide provides information to help communities in Oregon plan for landslide hazards. Each section heading asks a specific question to help direct you through information related to strengthening your comprehensive plan's factual base, policies and implementing measures. This guide also contains numerous references and contacts for obtaining additional information about landslide hazards.

Section 2:
Is Your Community Threatened by Landslide Hazards?

Section 2 presents an overview of the causes and characteristics of landslides, and provides information to assist communities in landslide hazard identification.

Section 3:
What are the Laws in Oregon for Landslide Hazards?

Section 3 summarizes current laws that Oregon communities are required to address for landslide hazards.

Section 4:
How can Your Community Reduce Risk from Landslide Hazards?

Section 4 describes evaluation techniques for the development review process and hazard mitigation methods to help communities reduce risk from landslide hazards.

Section 5:
How are Oregon Communities Addressing Landslide Hazards?

Section 5 examines how several communities are implementing programs to reduce risk from landslide hazards. These examples illustrate plan policies and implementing measures for landslides.

Section 6:
Where can Your Community find Resources to Plan for Landslide Hazards?

Section 6 is a resource directory listing contacts, programs, and documents that planners, local governments and citizens can use to get more information on landslide hazards.

Section 2: Is Your Community Threatened by Landslide Hazards?

Landslide hazards can cause severe property damage and loss of life. Identifying hazard areas is a key step in developing effective plan policies and implementing measures. This section assists local planners and decision-makers in understanding how landslides may affect future and current development. An overview of the causes and characteristics of landslides is included, along with information on identifying landslide hazards in your community.

2.1 What is a Landslide Hazard?

Landslides are relatively common, naturally occurring events in some parts of Oregon. Landslides include any detached mass of soil, rock, or debris that moves down a slope or a stream channel.[3] Landslides are classified according to the type and rate of movement and the type of materials that are transported.[4] Landslides occur when earth materials fall, slide, or flow down a slope. Two types of forces are at work: (1) driving forces combine to cause a slope to move, and (2) friction forces and strength of materials act to stabilize the slope. When driving forces exceed resisting forces, landslides occur.[5]

2.2 Where do Landslides Occur?

Landslides occur as “on-site” hazards and “off-site” hazards, and should be distinguished to effectively plan for future hazard situations. Decision-makers who are familiar with “on-site” landslides often may not be aware of the effects that “off-site” hazards can have on homes and communities.

- “On-site” hazards occur on or near the development site and are typically the slower moving landslides that cause most of the property damage in urban areas. Most existing landslide hazard maps deal with “on-site” hazards. On-site landslide hazards include features called slumps, earthflows and block slides.[6]

- “Off-site” landslide hazards typically begin on steep slopes at a distance from homes or developments, and are often rapidly moving. Recent events highlight the importance of “off-site” landslide hazards. In 1996, “off-site” landslides in Douglas County began a long distance away from homes and roads, traveled at high velocity, killed five Oregonians and injured many others.[7]

Tip Box

Hazard Inventories

Oregon Statewide Planning Goal 2 requires cities and counties to develop a factual base (including inventories) as part of their comprehensive plans. Statewide Planning Goal 7 requires communities to inventory known hazards. Inventories contain facts about land use, natural resources, public facilities and development trends within the planning area, and provide the basis for comprehensive plan policies. Inventories must be periodically updated to reflect the best current information about resources, trends and local conditions that would affect plan decisions.

Tip Box

Steep Slope Ordinances

Many communities in Oregon address landslide hazards through ordinances regulating development on steep slopes and in steep ravines. Section 5 of this guide presents examples of several communities addressing steep slopes in their ordinances, including techniques to help calculate the percentage slope and degree of the hazard.

2.3 What are the Different Types of Landslides?

Landslides are classified by causal factors and conditions, and include falls, slides and flows, which are described below. A combination of characteristics can also contribute to an increased risk of landslide hazards.

2.3.1 Falls

Falls move through the air and land at the base of a slope. In falls, material is detached from a steep slope or cliff and descends through the air by free fall or by bouncing or rolling downslope. Rockfall, the most common type, is a fall of detached rock from an area of intact bedrock. Rockfalls are common along Oregon highways where the roads are cut through bedrock.

2.3.2 Slides

Slides move in contact with the underlying surface. Slides include rockslides – the downslope movement of a rock mass along a plane surface; and slumps – the sliding of material along a curved (rotational slide) or flat (translational slide) surface. Slow-moving landslides can occur on relatively gentle slopes, and can cause significant property damage, but are far less likely to result in serious injuries. Two examples of slow moving landslides are the subdivision landslide in Kelso, Washington and the slide occurrence in 1998 at The Capes development in Tillamook County.[8]

2.3.3 Flows

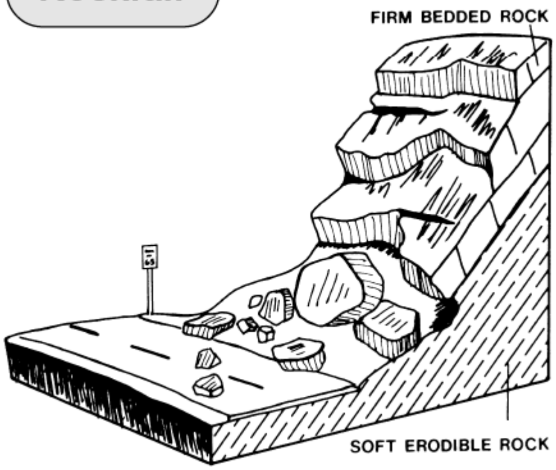
Flows are plastic or liquid movements in which mass (e.g., soil and rock) breaks up and flows during movement. Debris flows normally occur when a landslide moves downslope as a semi-fluid mass scouring, or partially scouring soils from the slope along its path. Flows are typically rapidly moving and also tend to increase in volume as they scour out the channel.[9]

Landslide Key

Section 6 of this guide provides references to documents that provide more detailed information on the nature and types of landslide hazards.

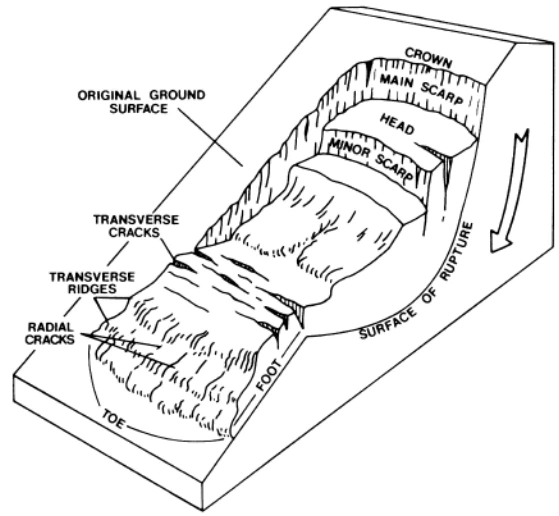
Types of Landslides: Earthflow, Rockfall, Rotational Landslide

Rockfall



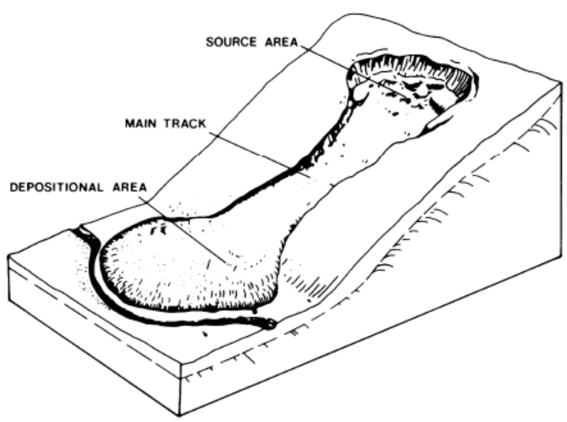
Source: *Federal Emergency Management Agency.* *FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 11.*

Rotational Landslide



Source: *Federal Emergency Management Agency.* *FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 12.*

Earthflow



Source: *Federal Emergency Management Agency.* *FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 15.*

Debris Flows in Oregon

Debris flows (also referred to as mudslides, mudflows, or debris avalanches) are a common type of rapidly moving landslide that generally occur during intense rainfall on previously saturated soil. *"Rapidly moving landslide" is the term used in Senate Bill 12 (1999 ORS section 195.250), Oregon's statewide policy applied to rapidly moving landslides.*

Debris flows commonly start on steep hillslopes as soil slumps or slides that liquefy, accelerate to speeds as great as 35 mph or more, and flow down hillslopes and channels onto gently sloping ground. Their consistency ranges from watery mud to thick, rocky, mud-like, wet cement — dense enough to carry boulders, trees and cars. Debris flows from different sources can combine in canyons and channels, where their destructive power can be greatly increased.[10]

The debris flows occurring during the 1996 Oregon storm events included mud, water, logs, and boulders up to 20 feet in diameter that traveled significant distances. Debris flows are difficult for persons to outrun or escape, and they present the greatest risk to human life. Debris flows have caused most of the landslide-related property damage in rural areas, and have caused most of the recent landslide-related injuries and deaths in Oregon.[11]

Based on Oregon Department of Forestry's (ODF) Storm Impacts Study,[12] the highest debris flow hazard occurs in steeply sloped areas in the Tyee geologic formation (or similar sedimentary rocks) in western Douglas County, Coos County, and western Lane County. The debris flow hazard is also high in much of eastern Tillamook County and the Columbia Gorge.

Most slopes steeper than 70 percent are at risk from debris flows.[13] While these types of debris flow hazards are usually not in located in developed areas, homes that lie in the path of the debris flow are at risk, even those on gentle slopes or those located a significant distance from the initiation point. Landslides can move long distances, sometimes as much as several miles. The Dodson debris flows in 1996 started high on Columbia Gorge cliffs, and traveled far down steep canyons to form debris fans at Dodson.[14] Slope alterations can also greatly affect the number of times channelized debris flows occur, and cause landslides in areas otherwise not susceptible to landslides.

Slide in the Portland Metro Area from the 1996-1997 Landslide Events

Photo: *Federal Emergency Management Agency*

Very large, high-velocity landslides are rare, though there is evidence that the Bonneville landslide was a rapidly moving landslide about 300 years ago. This landslide covered an area of several square miles, apparently damming the Columbia River and creating the "Bridge of the Gods" near Cascade Locks, Oregon.[15]

2.4 What are the Conditions that Affect Landslides?

Natural conditions and human activities can both play a role in causing landslides. Certain geologic formations are more susceptible to landslides than others. Locations with steep slopes are most susceptible to landslides. The landslides occurring on steep slopes tend to move rapidly and are therefore more dangerous than other landslides. Although landslides are a natural geologic process, the incidence of landslides and their impacts on people and property can be accelerated by human activities.[16] Developers who are uninformed about geological materials and processes may create conditions that trigger landslide activity or increase susceptibility to landslide hazards.[17] This subsection will describe four conditions affecting landslides: natural conditions, slope alterations, grading and drainage.

Tip Box

Landslides and debris flows are triggered or accelerated by:

- Intense or prolonged rainfall, or rapid snow-melt;
- Undercutting of a slope or cliff by erosion or excavation;
- Seismic activity or shocks and vibrations from construction;
- Concentration of runoff onto slopes;
- Alternate freezing and thawing;
- Improper management of surface and ground water;
- Vegetation removal by fires, timber harvesting, or land clearing;
- Placing fill (weight) on steep slopes; and
- Any combination of these factors.

2.4.1 Natural Conditions

Natural processes can cause landslides or re-activate historical landslide sites. Rainfall-initiated landslides tend to be smaller, while earthquake-induced landslides may be very large, but less frequent. The removal of supporting material along waterbodies by currents and waves, or undercutting during construction at the base of a slope produces countless small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on gentle slopes above steep stream and river banks. Landslides are particularly common along stream banks, reservoir shorelines, large lakes and seacoasts. Concave-shaped slopes with larger drainage areas appear to be more susceptible to landslides than other landforms. Landslides associated with volcanic eruptions can include volumes approaching one cubic mile of material. All soil types can be affected by natural landslide triggering conditions.

2.4.2 Excavation and Grading

Slope excavation is generally needed in order to develop home sites or build roads on sloping terrain. Grading these slopes results in some slopes that are steeper than the pre-existing natural slopes. Since slope steepness is a major factor in landslides, these steeper slopes can be at increased risk for landslides. The added weight of fill placed on slopes can also result in an increased landslide hazard. Small landslides can be fairly common along roads, in either the road cut or the road fill. Road associated landslides are good indicators of the potential impacts of excavation on new construction.

2.4.3 Drainage and Groundwater Alterations

Water flowing through the ground is often the factor that finally triggers many landslides. Any activity that increases the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines can be especially problematic, as can water retention facilities that direct water onto slopes. However, even lawn irrigation and minor alterations to small streams in landslide prone locations can result in damaging landslides. Ineffective stormwater management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology of an area, but development that results in an increase in impervious surface will impair the ability of the land to absorb water.[18]

2.4.4 Changes in Vegetation

Removing vegetation from very steep slopes can increase landslide hazards. A recent study by the Oregon Department of Forestry found that landslide hazards in three out of four steeply sloped areas were highest for a period of 10 years after timber harvesting. Areas that have experienced wildfire and land clearing for development can be expected to have longer periods of increased landslide hazards than after timber harvesting because forest recovery may take a very long time, or may never occur. In addition, woody debris (both natural and logging slash) in stream channels may cause the impacts from debris flows to be more severe.

Tip Box

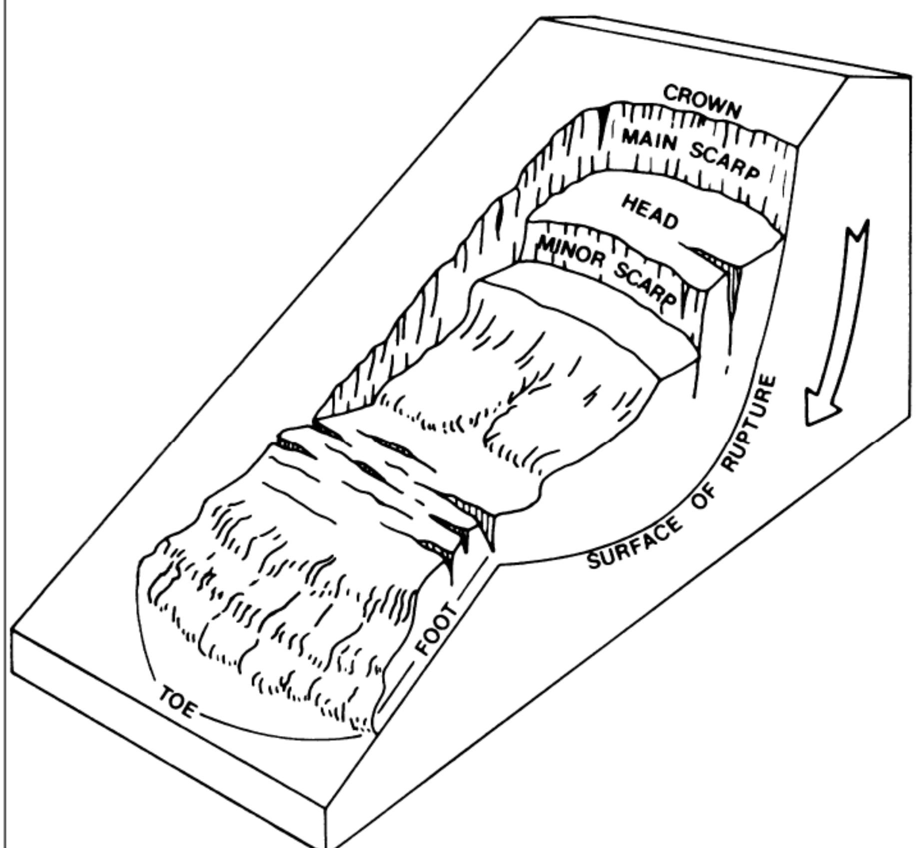
How is Landslide Severity Determined?[19]

Oregon Statewide Planning Goal 2 requires cities and counties to develop a factual base (including inventories) as part of their comprehensive plans. Statewide Planning Goal 7 requires communities to inventory known hazards. Inventories contain facts about land use, natural resources, public facilities and development trends within the planning area, and provide the basis for comprehensive plan policies. Inventories must be periodically updated to reflect the best current information about resources, trends and local conditions that would affect plan decisions.

Landslide Key

Refer to the discussion on evaluating site-specific development in Section 4 for further information on geotechnical reports.

Rotational Landslide Showing Scarps and Lobe-Shaped Deposits



Source: *Federal Emergency Management Agency. FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 12.*

2.5 How do Landslides Affect New and Existing Development?[20]

Landslides are a naturally occurring event and their effect on new and existing development in our communities can be devastating. Three conditions may put people and property at risk of landslide damage:

2.5.1 Creating Steeper Slopes

Excavation practices, sometimes aggravated by drainage, can reduce the stability of otherwise stable slopes. These failures commonly affect one or a few homes. Without these excavation practices, there is little risk of landslides in areas not prone to landslide movement.

2.5.2 Development on or Adjacent to Existing Landslides

Development on or adjacent to existing landslides is generally at risk of future movement regardless of excavation practices. Excavation and drainage practices can further increase risk of landslides, which can be very large. In many cases there are no development practices that can completely assure stability. Homeowners and communities in these situations accept some risk of future landslide movement. Slopes can be very gentle (under 10 percent) on some portions of existing landslides.

2.5.3 Development on Fairly Gentle Slopes

Development on fairly gentle slopes can be subject to landslides that begin a long distance from the development. The sites at greatest risk are against the base of very steep slopes, in confined stream channels (small canyons), and on fans (rises) at the mouth of these confined channels. Home siting practices do not cause these landslides, but rather put residents and property at grave risk of landslide impacts. The simplest mitigation measure for this situation is to locate the home out of the impact area, or construct debris flow diversions for homes that are at risk.

Landslide Alert and Hillside Drainage Problems

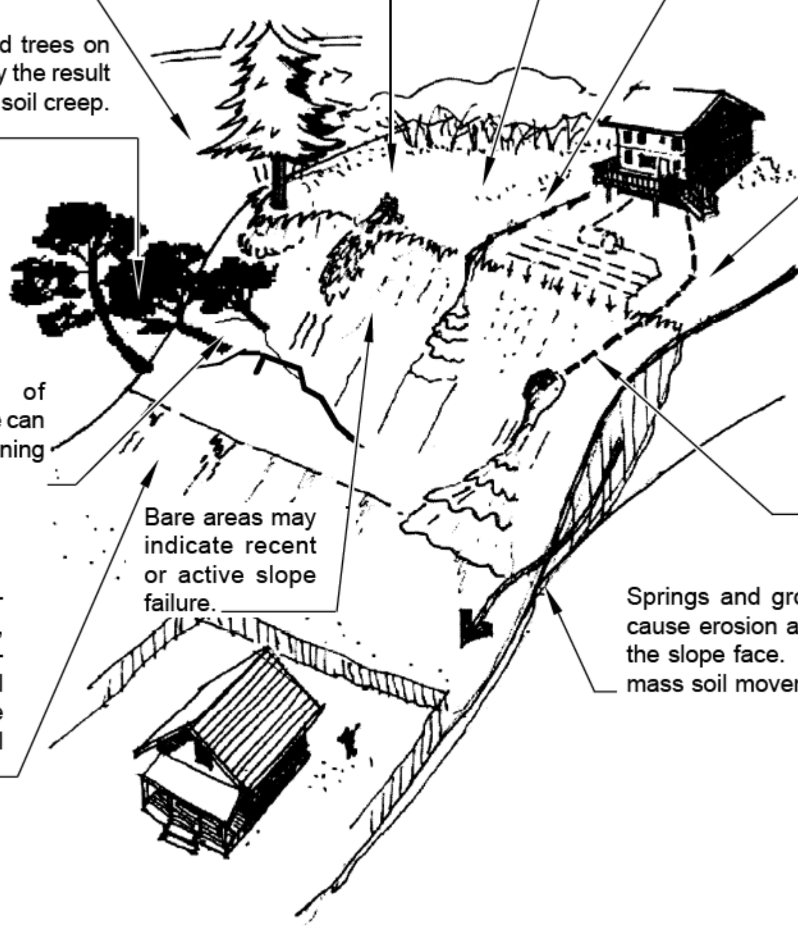
LANDSLIDE ALERT

AND HILLSIDE DRAINAGE PROBLEMS

Many landslides are triggered by improper drainage of water from different sources uphill from the slide. These sources can cause concentrations of extremely heavy saturated soils. When the saturated soils become heavier than the soils surrounding them, they can easily trigger a landslide.

Source: *Federal Emergency Management Agency. Hillside Drainage Flyer. Bothell, Wash.: FEMA Region 10 (2000).*

Seek the assistance of a geotechnical engineer for site specific design or consultation. Before undertaking any construction on your slope, check with your local permitting agency.



Hillside Drainage Flyer 3/12/97 **Federal Emergency Management Agency**

2.6 How can My Community Identify Landslide-Prone Locations?

Communities can identify landslide-prone locations by knowing the geologic and geographic factors of their environment, and through mapping and inventories.

2.6.1 Geologic and Geographic Factors

Geologic and geographic factors are important in identifying landslide-prone locations because of their influence on landslide processes. Stream channels, for example, have major influences on landslides, due to undercutting of slopes by stream erosion and long-term hillside processes.

Deep-seated landslide hazards are high in parts of Josephine and Curry Counties, and are fairly common in certain rock units of the western Cascade Mountains, and in fine-grained sedimentary rock units of the Coast Range. Infrequent, very large landslides and debris flows may occur in any of the larger mountains or in deep gorges in the Cascade, Wallowa, Elkhorn, or Siskiyou mountain ranges.[21]

The Oregon Department of Forestry (ODF) Storm Impacts Study, conducted after the 1996-97 landslide events, found the highest probability for the initiation of shallow, rapidly moving landslides was on slopes of over 70 percent to 80 percent steepness (depending on landform and geology). A moderate hazard of shallow rapid landslide initiation can exist on slopes of between 50 percent and 70 percent.[22]

In general, slopes over 25 percent, or a history of landslides in or very close to your community means there could be some level of landslide hazard within your jurisdiction. The steeper the slopes, or the greater the history of landslides, the more severe the landslide hazard. While some drier areas may not have hazards at slopes of 25 percent or greater, existing landslides at slopes under 15 percent may still be subject to movement. In otherwise gently sloped areas, landslides can occur along steep river and creek banks. At natural slopes of under 30 percent, most landslide hazards are related to excavation and drainage practices, or re-activation of preexisting landslide hazards.[23]

TRG Key

The first step of hazard assessment is hazard identification, estimating the geographic extent, intensity and occurrence of a hazard. More information on the three levels of hazard assessment can be found in Chapter 2: Elements of a Comprehensive Plan.

2.6.2 Soil Type

Soil type may, in some cases, be useful in identifying landslide-prone locations. The U.S. Natural Resources Conservation Service (NRCS) produces a number of useful soils map products including paper copy county soils reports and digital State Soil Geographic (STATSGO) and Soil Survey Geographic (SSURGO) databases. STATSGO soil surveys are more generalized statewide digital soils maps and the SSURGO data sets are typically more detailed (1:24,000 scale) and often follow county boundaries. Both STATSGO and SSURGO products can be incorporated into Geographic Information Systems (GIS). NRCS soils maps determine slope very roughly, and do not identify existing landslide hazards. The maps are based on agricultural soil properties and do not reflect underlying geology or engineering properties of the soils.[24]

Landslide Key

Contact information for the Natural Resources Conservation Service can be found in Section 6.

The STATSGO database is already available for Oregon and the NRCS is expanding the SSURGO coverage. Much of western Oregon has been completed or is within the certification process. Field mapping methods using national standards are used to construct the soil maps in the SSURGO database and they incorporate the most detailed level of soil mapping done by NRCS.[25] To utilize the full capabilities of this system, GIS software and expertise is required. NRCS is also developing a Soil Data Viewer to facilitate use of the technical soil information.[26]

2.6.3 Mapping and Inventories

Mapping of landslide hazards in Oregon began in the early 1970s when the Oregon Department of Geology and Mineral Industries (DOGAMI) mapped existing landslides in much of coastal Oregon. These maps are found in DOGAMI's Environmental Geology Bulletins. Particular types of landslides are mapped in portions of some counties, including most of the Oregon coast. The Oregon Department of Forestry (ODF) produced debris flow maps for Western Oregon that are accessible from the ODF website. DOGAMI began conducting field investigations in 2000 to further refine the ODF debris flow maps and determine "further review areas" to address rapidly moving landslides as required by Senate Bill 12, 1999 Oregon legislature.[29] Local planners and the public can access the Nature of the Northwest Information Center through the DOGAMI Website, or contact DOGAMI directly to find out whether or not landslide maps are available for their community.

Landslide Key

Refer to Section 6 of this guide for ODF and DOGAMI contact information.

Tip Box

Landslide and debris flow-prone locations can include:[28]

- V-shaped valleys, canyon bottoms, and steep stream channels
- Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons
- Areas with large boulders (2 to 20 feet diameter) perched on soil near fans or adjacent to creeks
- Steep hillslopes above a home or lot
- Logjams in stream above a home or lot
- Steepened roadcuts
- Areas that have been extensively disturbed by excavation into steep slopes
- Existing landslides or places of known historic landslides
- Moderately steep slopes that are exposed to high water flow

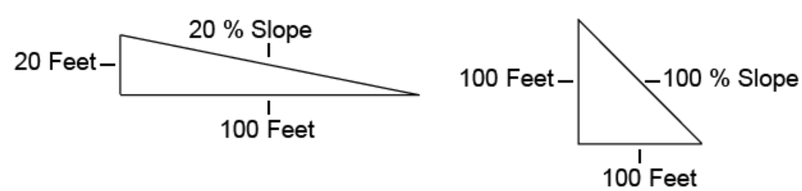
Tip Box

Calculating Percent Slope[27]

Engineers describe slope steepness using percent slope. This number is calculated by taking the vertical distance from the bottom to the top of the slope and dividing that distance by the horizontal distance from the bottom to the top of the slope. The result of this division is the slope. The slope is multiplied by 100 to give the percent slope.

An example would be a slope that rises 20 vertical feet over a horizontal distance (not distance along the slope surface) of 100 feet. The slope would be represented as 20 divided by 100 equals 0.20. Multiplying by 100 gives 20% slope.

A very steep slope that rises 100 vertical feet over 100-foot horizontal distance is 100 divided by 100 equals 1. Multiplying 1.00 by 100 gives a 100% slope, the same as a 45-degree angle slope.



Data collected on landslide occurrences associated with the severe storms of 1996 demonstrate the wide distribution of the landslide hazard, particularly in the western portion of the state. A three-year study by ODF took a close look at landslides that occurred in eight forestland study regions. Within the eight study sites (45.8 square miles total), ODF surveyed over 500 landslides. A study conducted by Portland State University showed that in the Portland metropolitan area, 17 homes were completely destroyed and 64 were badly damaged in over 700 landslides associated with the 1996 storms.

FEMA provided funds to generate a statewide inventory of known landslide occurrences associated with the major storm events of 1996 and 1997. DOGAMI collected evidence of over 9000 landslide and slope failure locations in the state. The study helped to gather and consolidate the available data on landslide occurrences from both public and private sources. The generation of the statewide landslide inventory is intended to provide a means for developing and verifying hazard models as well as to facilitate various efforts aimed at minimizing risk and damage in future storm events. The database includes a digital Geographic Information System (GIS) file with slide locations, a digital database with details on each slide, and an accompanying report. Communities need appropriate software and expertise to make full use of this GIS product. These products are available from DOGAMI by requesting: Database of Slope Failures in Oregon For Three 1996/97 Storm Events. Hofmeister, R.J., (2000) Oregon Department of Geology and Mineral Industries Special Paper. The database can also be accessed on the Internet at **http://sarvis.dogami.state.or.us/landslide/inventory/project.htm#Project.Summary.**

Tip Box

Maps only provide a general indication of a landslide hazard.

The ODF Storm Impacts Study found that forest canopy obscures the ability to identify or accurately measure landslide areas, specifically for debris flows, and that coarse-scale digital elevation models underestimate slope steepness, especially in areas with irregular, steep slopes. Ground-based investigation has provided the most reliable information on landslide occurrence and characteristics in the forests of Western Oregon.

Tip Box

Debris flow maps developed by the Oregon Department of Forestry can be accessed on the web at: **http://www.odf.state.or.us/gis/debris.html**, or by contacting ODF. ODF's Debris Flow Geographic Information System maps exist for the following counties: Benton, Clackamas, Columbia, Coos, Curry, Eastern Douglas County, Western Douglas County, Hood River, Jackson, Josephine, Eastern Lane County, Western Lane County, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington and Yamhill.

2.7 Summary: Resources to Help Your Community Identify Landslide Hazards

- ❒ *Landslide maps and identification of landslide-prone areas*, including the type, conditions, history and severity of landslide hazards, can help your community strengthen the factual base of your comprehensive plan.
- ❒ *Technical assistance*, including mapping, soil surveys, and calculating percent-slope, that can assist in identifying landslide-prone locations. DOGAMI and ODF are the principal state agencies providing technical assistance for identifying landslide-prone locations. Soil surveys provided by the Natural Resources Conservation Service can also provide limited assistance.
- ❒ *Local comprehensive plans* should include landslide identification and vulnerability assessment as a part of their inventory. Existing maps and information on historic slides can help you update the natural hazards component of your comprehensive plan.

Planning for Natural Hazards: Reviewing your Comprehensive Plan

The factual base of your community's comprehensive plan should reflect a current inventory of all natural hazards and a vulnerability assessment. The inventory should include a history of natural disasters, maps, current conditions and trends. A vulnerability assessment will examine identified hazards and the existing or planned property development, current population, and the types of development at risk. A vulnerability assessment will set the foundation for plan policies.

Your community should ask the following questions in determining whether or not its comprehensive plan has adequately inventoried landslide hazards.

- ❒ Are there landslide hazards in your community?
- ❒ Does your comprehensive plan hazard inventory describe landslides in terms of the geographical extent, the severity and the frequency of occurrence?
- ❒ Has your community conducted a community-wide vulnerability assessment?

Section 3: What are the Laws in Oregon for Landslide Hazards?

Oregon communities have a statutory mandate to develop comprehensive plans and implementing ordinances. As a part of the comprehensive planning process, cities and counties must address areas with "known" natural hazards. This section of the Landslide Guide presents laws that Oregon communities are required to address.

TRG Key

Information on Goal 7 can be found in Appendix A of the Natural Hazards Technical Resource Guide.

The state of Oregon passed landslide legislation in response to the property damage and fatalities from the 1996 flood and landslide events. The Debris Avalanche Action Plan, established by an Executive Order issued by Oregon Governor John Kitzhaber, March 4, 1997, was the initial state response.

The Governor's Debris Avalanche Action Plan included specific recommendations for state and local governments to reduce the occurrence of debris flows and reduce the risk to the public when debris flows occur.[30] The Executive Order calls for specific actions to be taken by state agencies, including Oregon Departments of Transportation, Forestry, Land Conservation and Development, Geology and Mineral Industries; Oregon State Police (OSP)-Office of Emergency Management (OEM); Building Codes Division; and the Governor's office. Outcomes from this action plan included development of ODF debris flow maps, brochures, forest practices deferral, the debris flow warning system (see the ODF Website), the 1998 review of Statewide Planning Goal 7, and creation of the Governor's Interagency Hazard Mitigation Team.

3.1 Oregon Laws Related to Landslide Hazards

3.1.1 Goal 7: Areas Subject to Natural Disasters and Hazards

Goal 7 is the Statewide Planning requirement that directs local governments to address natural hazards in their comprehensive plans. Goal 7 states that "Developments subject to damage or that could result in loss of life shall not be planned or located in known areas of natural disasters and hazards without appropriate safeguards. Plans shall be based on an inventory of known areas of natural disasters and hazards…"

3.1.2 Senate Bill 12 – Debris Flows

TRG Key

For information on Goal 17 and coastal shorelands, refer to Chapter 6: the Coastal Hazard Technical Resource Guide and Appendix A.

Following the flood and landslide events of 1996, legislation was drafted to reduce risk from future landslide hazards. The legislature passed Senate Bill 1211 in 1997, which dealt with rapidly moving landslide issues around steep forestlands, and not in typical urban or community settings. Senate Bill 1211 granted authority to the State Forester to prohibit forest operations in certain landslide-prone locations, and created the Interim Task Force on Landslides and Public Safety. SB 1211 charged the Interim Task Force with developing a comprehensive, practicable, and equitable solution to the problem of risks associated with landslides.[31]

The Interim Task Force developed the legislative concept that resulted in Senate Bill 12 in the 1999 session. Senate Bill 12 directs state and local governments to protect people from rapidly moving landslides. The bill has three major components affecting local governments: detailed mapping of areas potentially prone to debris flows (i.e., “further review area maps”); local government regulating authority; and funding for a model ordinance. The legislature allocated funding to the Department of Geology and Mineral Industries (DOGAMI) to prepare the “further review area maps,” and provided $50,000 for a grant to a local government to develop a model program to address rapidly moving landslides. *Senate Bill 12 applies only to rapidly moving landslides, which are uncommon in many communities, but are very dangerous in areas where they do occur.*

Local Government Responsibilities under Senate Bill 12

In order to reduce the risk of serious bodily injury or death resulting from rapidly moving landslides, Senate Bill 12 requires local governments to:[32]

- Exercise all available authority to protect the public during emergencies;
- Decide when to require a geotechnical report and, if a report is required, provide for a coordinated review of the geotechnical report by DOGAMI or ODF, as appropriate, before issuing a building permit for a site in a Further Review Area;
- Regulate through mitigation measures and site development standards the siting of dwellings and other structures designed for human occupancy in Further Review Areas where there is evidence of substantial risk for rapidly moving landslides; and
- Maintain a record, available to the public, of properties for which a geotechnical report has been prepared within the jurisdiction of the local government.[33]

Further Review Area Maps

Senate Bill 12 requires mapping of areas with potential for rapidly moving landslides. The language defines “Further Review Areas” as: an area of land within which further site specific review should occur before land management or building activities begin because either DOGAMI or ODF determines that the area reasonably could be expected to include sites that experience rapidly moving landslides as a result of excessive rainfall.[34]

DOGAMI will prepare further review area maps that include at a minimum all regions in Western Oregon mapped by ODF as high or extreme hazard debris flows by 2002. Communities can contact the Nature of the Northwest Information Center to access the DOGAMI maps or existing ODF maps (See contact information in Section 6 of this Guide). Developers may be required by local government to attain a geotechnical site report if the property is determined to be in a Further Review Area. However, local governments can request that a site report be prepared prior to granting a building permit, regardless of whether the site has been determined to be in a further review area. Local governments may need to include language in their ordinances requiring such site reports. Some of these "further review areas" may lie within Urban Growth Boundaries. Cities and counties may therefore need to modify their comprehensive plans and ordinances to meet requirements of Senate Bill 12 if DOGAMI maps show a landslide hazard in their community.

Forest Practices Public Safety Regulations

Senate Bill 12 requires the Oregon Board of Forestry to adopt regulations that reduce the risks associated with rapidly moving landslides which will replace the interim prohibition of certain forest operations. This bill also recognizes, however, that rapidly moving landslides can and do commonly occur on steep slopes regardless of past timber harvesting, therefore it will take the combined actions of homeowners, road users, forestland owners, and state and local government to protect the public.

Development of Model Ordinances

Senate Bill 12 also provided for a pilot program, under the guidance of the Department of Land Conservation and Development, to develop model ordinances, regulations and procedures for mitigation of hazards and for allowing the transfer of development rights. The grant of $50,000 for the pilot program was awarded to Douglas County. Douglas County began development of a model ordinance in February 2000 and can be contacted at (541) 440-4289 for more information.

Senate Bill 12 can be obtained online from the State of Oregon Home page at **http://www.leg.state.or.us/billsset.htm.**

3.1.3 Oregon State Building Codes Division - Landslides

The Oregon Building Codes Division adopts statewide standards for building construction that are administered by the state and local municipalities throughout Oregon. The One- and Two- Family Dwelling Code and the Structural Specialty Code contain provisions for lot grading and site preparation for the construction of building foundations.

Both codes contain requirements for cut, fill and sloping of the lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify foundation design requirements to accommodate the type of soils, the soil bearing pressure, and compaction and lateral loads from soil and ground water on sloped lots. The building official has the authority to require a soils analysis for any project where it appears the site conditions do not meet the requirements of the code or that special design considerations must be taken. ORS 455.447 and the Structural Code require a seismic site hazard report for projects that include essential facilities such as hospitals, fire and police stations and emergency response facilities, and special occupancy structures, such as large schools and prisons. This report includes consideration of any potentially unstable soils and landslides.

State building codes do not set standards for lot grading that is not associated with the construction of buildings. However, the state has recognized the Uniform Building Code Appendix Chapter 70 as an appropriate standard for excavation and fill of such properties. Local municipalities have the option of adopting this standard or their own to regulate lot grading in areas other than the building foundation. Many jurisdictions use these standards in conjunction with local planning ordinances. Building codes do not address "off-site" or deep-seated landslide hazards. Local governments can take the initiative to address these hazards.

3.2 Summary: Laws for Landslide Hazards

- ❒ Oregon Statewide Planning Goal 7: Areas Subject to Natural Hazards
- ❒ Senate Bill 12: Addressing Rapidly Moving Landslide Hazards in Oregon
- ❒ Oregon State Building Codes Division

Planning for Natural Hazards: Reviewing your Comprehensive Plan

Statewide Planning Goal 2 requires that comprehensive plan policies be supported by an adequate factual base. Section 3 of the Landslide Technical Resource Guide describes laws that communities are required to address in their comprehensive plans.

Your community should ask the following questions after identifying landslide hazards in your area:

- ❒ Does your community's comprehensive plan contain an inventory of landslide hazards, a vulnerability assessment and policies addressing landslide hazards?
- ❒ Has your community's comprehensive plan been updated to reflect the latest information on landslide hazards in your community, the current laws for rapidly moving landslides and the State Building Codes?
- ❒ Does your comprehensive plan have policies and implementing measures to reduce risk to existing and future development in landslide hazard areas?

Section 4:
How can Your Community Reduce Risk from Landslide Hazards?

Avoiding development in hazard areas is the most effective way to reduce risk. There are, however, many areas in Oregon where some degree of hazard is unavoidable, such as much of the Coast Range and the Cascade Mountains. Communities in vulnerable areas should manage and reduce their risk from landslide hazards if the risk cannot be completely eliminated.

TRG Key

For more information on specific hazards mitigation techniques see Appendix C: Land use Tools and Techniques in the Natural Hazards Technical Resource Guide.

Section 4 describes methods to evaluate site-specific development and other implementing measures to reduce risk from landslide hazards. Implementing measures are the ordinances and programs used to carry out decisions made in the comprehensive plan. They include zoning ordinances, development standards and other land use regulations, which directly regulate land use activities.

4.1 How can Your Community Plan for Landslide Hazards?

It is possible to plan, at least to some degree, for landslide hazards. The nature of your community's response will depend on the severity of the hazard. Avoiding, or significantly limiting development in landslide areas through zoning and careful planning lessens the need for other types of mitigation measures, and is the safest strategy for reducing risks to development in the most dangerous locations.

Landslide Key

Section 2 of this document provides information that can assist your community in identifying landslide hazards.

To successfully plan for a landslide hazard, consider the following steps:

✓ **Identify the hazard**
Hazard identification is the first phase of hazard assessment and is part of the foundation for developing plan policies and implementing measures for natural hazards.

✓ **Avoid the hazard**
Restrict development in hazard-prone areas. For landslide-prone areas with high density and potential for severe property damage or loss of life, this option should be followed.

✓ **Evaluate site-specific development**
Communities can require geotechnical reports to evaluate site-specific development in landslide areas. Techniques for evaluating these hazards during the land use and permitting process are described below.

✓ **Implement risk reduction measures through land use planning**
Minimizing development in hazard areas through low density and regulated development can reduce risk of property damage and loss of life. This section provides information on specific land use planning and zoning measures.

✓ **Implement non-regulatory measures**
Additional mitigation strategies and non-regulatory measures can further reduce risk from landslide hazards. These strategies are further explored in this section.

4.2 How is Development in Landslide-Prone Areas Evaluated?

Geotechnical reports can be required for development in locations that may have significant landslide hazards. Geotechnical reports are appropriate for new developments located on known landslides, and for areas where significant excavation may be required to develop the site. Other factors, such as the proposed construction activity may influence the decision to require a site report. For excavations, a combination of hillslope steepness and maximum cut and fill dimensions are generally appropriate criteria for determining when such a report is needed.

Tip Box

The Three Levels of Hazard Assessment

1. Hazard Identification
2. Vulnerability Assessment
3. Risk Analysis

If your community identifies landslide hazards through a hazard identification process or a vulnerability assessment, you should adopt a process to review individual development permits in those landslide-prone areas. For further description of the three levels of hazard assessment, refer to Chapter 2: Elements of a Comprehensive Plan.

Who can Prepare Geotechnical Reports?

Professional Engineers (PE) and Certified Engineering Geologists (CEG) regularly produce geotechnical reports. However, local governments may not be aware of the differences in the types of geotechnical professionals. Such specialists may have a Professional Engineers (PE) stamp or a Certified Engineering Geologist (CEG) stamp, but they must also be competent in the field within which they are practicing.[35]

"Procedures and capability of technical experts qualified to do site specific investigations should be clearly specified. Engineering geological registration and performance guidelines exist and are established by the State Board of Geologist Examiners, but geotechnical engineering certification and procedural guidelines have not yet been established. Qualified technical experts (PEs with geotechnical competency) are available, but not identified by registration."[36]

A *Certified Engineering Geologist* is an Oregon-registered professional geologist who has been trained and tested by the Oregon State Board of Geologist Examiners (OSBGE). An engineering geologist is a person who applies geologic data, principles, and interpretation to naturally occurring materials so that geologic factors affecting planning, design, and construction and maintenance of civil engineering works are properly recognized and utilized ORS 672.505(5).[37] An engineering geologist uses the knowledge of past and potential events to identify and characterize geotechnical problems that could affect the location, design, construction, and maintenance of structures and engineering works.[38] The Oregon Board of Geologist Examiners has adopted guidelines for engineering geologic reports.

A *professional engineer* is an Oregon-registered professional engineer. An engineer is defined as "…a person who has knowledge of mathematics, physical, chemical and other sciences and the principles and methods of engineering analysis and design acquired by engineering education and engineering experience" ORS 672.002(2).[39]

A *geotechnical engineer* is usually a civil engineer who considers the effects of earth materials and geologic processes on structures and engineering works. Geotechnical engineers often use information provided by engineering geologists in analyzing the effects of geologic conditions on proposed structures and in engineered designs to effectively address the geologic conditions. Thus, the geotechnical engineer accomplishes analyses and provides recommendations for geotechnical design, and completes an evaluation of the expected performance of the engineering work.[40]

After a geotechnical review is completed, local governments need to be sure the study has accountability (i.e. the PE or CEG stamp) and competency. Local governments should evaluate the study based on the qualifications of the geotechnical professional. The presence of a State of Oregon Stamp (PE or CEG) alone does not constitute competency. The "Boards" of registration (Oregon Board of Examiners for Engineering and Land Surveying - OSBEELS and the Oregon State Board of Geologist Examiners - OSBGE) can evaluate competency on a case-by-case basis.

There are several ways to ensure the competency of geotechnical studies. Peer review or internal review can help to ensure competency. Local governments can also consider sharing a qualified geotechnical engineer or engineering geologist between agencies to reduce cost, maximize expertise and ensure competency.[41] Private sector specialists can be found in the Yellow Pages.

The Board of Geologist Examiners has adopted guidelines for engineering geologic reports. There are no specific guidelines for Geotechnical Engineering Reports. ODF and DOGAMI plan to work with the Board of Examiners for Engineering and Land Surveying and the Board of Geologist Examiners to develop additional guidelines for rapidly moving landslides.

4.3 What Land Use Tools can be Used to Reduce Risk from Landslide Hazards?

Land use planning and zoning can assist local governments in regulating development and mitigating natural hazards. The following are land use tools communities can use to reduce risk from landslide hazards.

4.3.1 Overlay and Combining Zones

Overlay and combining zones are independent zones that co-exist with the base-zoning district. Development is usually regulated in accordance with the uses allowed by the base-zoning district. However, under certain conditions, the requirements of the overlay and combining zones can take precedence over the underlying zoning district. For example, a community could create an overlay-zone for landslide-prone areas and establish special review requirements for development in those areas.[42] Landslide mitigation requirements might include geotechnical reports for development proposals, or structural mitigation measures during construction.

Tip Box

Peer Review

Many of Oregon's local governments require geotechnical reports before they will allow a structure to be located in a landslide or steep slope hazard area. In some cases, local governments require the developer to pay for another engineer to review the geotechnical report. This "peer review" procedure allows the local government to get a "second opinion" regarding the substance of the geotechnical report and the potential risks associated with the proposed development. Marion County is in the process of adopting a new landslide/steep slope overlay zone. The following language regarding peer review is included in the draft ordinance: "All assessments and reports required by this chapter shall be reviewed by a qualified professional or professional firm…of the county's choice prior to acceptance of the development permit application. Such review shall include examination to ensure required elements or guidelines have been completed, report procedures and assumptions are generally accepted and all conclusions and recommendations are supported and reasonable." The proposed ordinance authorizes the county to require the developer to pay the cost of the "peer review."

4.3.2 Incentive Zoning

Incentive zoning requires developers to exceed limitations imposed upon them by regulations, in exchange for specific concessions. For example, if developers avoid developing in landslide-prone areas, the local government might allow them to build on other portions of their land at a higher density than is allowed by the current zoning designation.[43]

4.3.3 Performance Zoning

Performance zoning sets standards that allow for a certain level of impact on the environment from development activities. This technique is usually used in conjunction with traditional zoning. The standards typically address specific environmental conditions, and can include stormwater runoff.[44]

4.3.4 Incorporating Landslide Mitigation Requirements into Subdivision Regulations

Subdivision regulations govern the division of land for sale or development. Additional requirements may be incorporated into these types of regulations. Developers wanting to subdivide a property located in a high landslide-prone area could be required to pay exactions, impact fees or other system development charges.[45] This type of regulation combined with a fee exaction can serve to discourage development in landslide-prone areas. Three mitigation approaches that can be included in subdivision regulations include cluster development, performance bonds and site plans, which are described below.

4.4 What are Additional Methods for Reducing Risk from Landslides?

Some of the techniques listed below are regulatory measures used by local governments. Others are non-regulatory in nature and can be implemented by local government officials, developers and private citizens alike.

4.4.1 Drainage Practices

Ineffective stormwater management and excess runoff can cause erosion and increase the potential for landslides. Drainage can be affected naturally by the geology of an area, but can be exacerbated by the construction of large impervious surfaces (e.g., parking lots). These impervious surfaces impair the natural absorption of water and can adversely concentrate flow onto marginal slopes.[46] Special construction standards can be used to control water runoff, including mulching and seeding disturbed areas, which directs runoff away from potentially hazardous downslope areas.

4.4.2 Soil conservation and Steep Slope Stabilization

Soil conservation and steep slope stabilization are measures that can be implemented by placing restrictions on the grading of hillsides and establishing development limits on landslide-prone slopes. It is possible to reduce erosion and stabilize slopes using non-invasive structural measures. Activities related to slope stabilization and soil conservation include erosion prevention through regulations that limit development on severe slopes, or through proper site design. These measures can also help avoid costly stabilization work.

4.4.3 Lower Density in Residential Lots

Lower density in landslide-prone areas can result in fewer people and structures being at risk and can also reduce the potential for landslides by reducing the number of cuts and fills for driveways and house pads. Density in hazard areas can also be minimized through the voluntary dedication of land for open space or public parks, which can reduce potential development on those lands.

4.4.4 Development Standards

Development that fits the terrain and does not use extensive excavation and drainage alterations will reduce risk from landslide hazards. Specifying maximum cuts and fills and compaction standards can further reduce risk. Locating the structure on a part of the property not prone to landslides is another strategy to reduce risk of property damage from landslides.

Special hillside development standards applied to slopes calculated to be high risk can reduce cross-slope cuts and fills. These standards include reduced street widths, hammerheads rather than cul-de-sac bulbs and sidewalks on only one side.

4.4.5 Cluster Development

Cluster development is the concentration of structures on one part of a lot to preserve the remainder of the property for open space. Cluster development usually is permitted only under planned unit development procedures. Clustering offers the potential for savings in some areas: the sewer and water lines and streets needed to serve a cluster may be much shorter than those necessary for a traditional subdivision of comparable density.[47] Cluster development provides the opportunity to avoid developing in hazard areas by maximizing development structures on non-hazard areas.

4.4.6 Performance Bonds

Performance bonds are bonds required of a subdivider or developer to ensure that specified improvements will be carried out after approval for the development is given by the local government. Performance bonds are widely used for a broad range of improvements – such as sidewalks, streets, curbs, storm sewers, street lighting, etc. They are one type in a broader category known as surety bonds.[48] Performance bonds can be used to improve drainage practices or implement other mitigation techniques.

Tip Box

Process for Evaluating Development in Landslide-Prone Areas

Communities can use a regulatory process to assist in evaluating development in landslide-prone areas. For example, when a developer submits a site development plan, local planning officials will apply local hazards regulations. If the site is located within the boundary of a known hazard area, the developer can be required by local regulations to retain a professional to evaluate the level of risk and provide recommendations on mitigation measures. This requirement pertains to the proposed structure, to the construction methods, and natural conditions proposed to be altered on and around the site. During the review of the site development plan, planners must rely on detailed technical information and professionals to obtain the most accurate evaluation.

TRG Key

For a brief discussion on Transfer of Development Rights refer to Chapter 3 of the Natural Hazards Technical Resource Guide: the Legal Issues Guide.

4.4.7 Site Plans

A site plan is a large-scale map of a proposed development site. Most zoning and subdivision ordinances require that a site plan accompany any application for a partition, variance, conditional use, zone change, or other quasi-judicial action. The standards for the drafting of such maps are not high, but each drawing should have a consistent scale (described on the plan), a north arrow, and a title or legend, and should show property lines, the locations of buildings, and the presence of roads, streams, and other major features of the landscape.[49] If a landslide hazard is present, you can use the site plan to determine the location of the permitted development and to avoid the hazard area.

4.4.8 Restrictions on Uses and Facilities

There can be restrictions made on the types of uses and facilities that can be built in mapped landslide areas. A city or county may decide that critical facilities or large assembly places such as a college, hospital, convention center, or church should not be allowed in an extreme landslide hazard area.

4.4.9 Prohibition

Where supported by the factual base, a community may decide that the landslide hazard is severe enough that development should be prohibited. There may be legal issues with such prohibitions.

4.4.10 Structural Practices

Structural mitigation practices can include those that deflect landslide movement (typically for debris flows) and those that can physically arrest or control landslide movement. These measures should be required at the time the development is approved by the local government.

4.4.11 Vegetation

Limiting or regulating the amount of vegetation cleared off a hillside lot reduces the risk of increasing the number of landslide-prone areas in a community. Planting vegetation or maintaining slope terraces can also reduce slope-runoff.[50]

4.5 What are Examples of Plan Policies and Ordinances that Regulate Development in Landslide-Prone Areas?

Oregon cities of Bend and Salem provide examples of landslide policies and ordinances used by communities to regulate development in areas of steep slope and landslide-prone areas. For further information on the Salem ordinance refer to Section 5 of this guide.

4.5.1 Bend General Plan[52]

The Bend general plan establishes performance standards for development in steep slope areas. Bend's plan allows the city to reduce minimum residential density where slopes are greater than 20 percent.

1. The City shall require development on slopes in excess of 10 percent to employ measures to minimize the hillside cuts and fills for streets and driveways.
2. The location and design of streets, structures and other development features on slopes in excess of 10 percent shall give full consideration to the natural contours, drainage patterns, and vegetative features of the site to protect against temporary and long-term erosion.
3. In areas where the natural slope exceeds 20 percent, the city may reduce the minimum residential density (allow larger lots) or alternatively, may require cluster development through the PUD process to preserve the natural topography and vegetation, and improve fire protection.

TRG Key

Refer to the Legal Issues Guide for further information.

4.5.2 Salem Ordinance Chapter 68 Section 68.010 Intent and Purpose

The Salem draft ordinance contains a good example of a statement of intent that could be included in a local landslide ordinance. Section (e) clearly indicates the City's position that they cannot completely eliminate the landslide risk in their community.

The intent and purpose of the provisions of this chapter are:

(a) To implement the Geologic Hazards goals and policies of the Scenic and Historic Areas, Natural Resources and Hazards section of the Salem Area Comprehensive Plan;
(b) To review development applications for properties within landslide hazards areas;
(c) To assess the risk that a proposed use or activity will adversely affect the stability and slide susceptibility of an area;
(d) To establish standards and requirements for the use of lands within landslide hazards areas;
(e) To mitigate risk within landslide hazards areas, not to act as a guarantee that the hazard risk will be eliminated, nor as a guarantee that there is a higher risk of hazard at any location. Unless otherwise provided, the landslide hazard regulations are in addition to generally applicable standards provided elsewhere in this code.

4.6 Summary: Reducing Your Community's Risk from Landslide Hazards

❒ **Avoid the hazard** if possible, since risk reduction techniques can be very expensive or may not be feasible in areas prone to rapidly moving landslides or near a very large landslide.

❒ **Reduce the level of risk** in hazard-prone areas by minimizing development, reducing density, or implementing mitigation measures if developing in hazard-prone locations is unavoidable.

❒ **Evaluate development** in landslide-prone locations. Evaluation can be required through local government regulations and by understanding the geology of the area. Technical

Sidebar

Hazard Mitigation Grant Project[51]

The City of Rufus along the Columbia River is bisected by Gerking Canyon which drains a watershed largely comprised of dry land wheat fields. Heavy rainfall associated with summer thunderstorms or rapid snowmelt can cause significant runoff that carries water and rocky debris through town impacting roads, bridges, housing and the community well system. To address this hazard, the upland wheat growers constructed a series of catchment basins designed to control runoff before it reaches town by detaining water and soil. Not only are peak runoff flows reduced, soil erosion in the fields is controlled and the detained water is given a chance to percolate into the ground to improve soil moisture. This project involved the Natural Resources Conservation Service, the Sherman County Soil and Water Conservation District, and funding from FEMA's Hazard Mitigation Grant Program.

assistance from state agencies such as DOGAMI and ODF can assist in hazard mapping and assessment. Section 2 provides information on resources and technical assistance for landslide hazard identification.

- ❒ **Require geotechnical investigations** for development in locations that may have significant landslide hazards. Geotechnical reports are commonly used in evaluating development proposals and must be conducted by professional engineers or certified engineering geologists.
- ❒ **Adopt land use policies and enact regulations**, including overlay zones, incentive zoning, performance zoning, and subdivision regulations. Other useful regulatory strategies include excavation and grading standards, stormwater management, hillside development standards, restrictions on the types of uses of landslide-prone areas, density limits, and regulating vegetation on hillside lots.
- ❒ **Consider non-regulatory strategies** such as soil conservation, slope stabilization, and dedication of land for open space useful to a variety of community organizations for reducing risk from landslide hazards.
- ❒ **Provide public outreach** and information sessions for residents and potential residents living in landslide-prone terrain regarding the hazard and steps residents can take to protect themselves.
- ❒ **Assess the level of risk** for rapidly moving "off-site" landslide hazards, as they pose the highest threat to public safety and can cause loss of human life.

Planning for Natural Hazards: Reviewing your Comprehensive Plan

Implementing measures tied to specific actions are essential to carrying out plan policies in a comprehensive plan. Your local government should ask the following questions in assessing the adequacy of your comprehensive plan in addressing the landslide hazard:

- ❒ Do your comprehensive plan policies authorize lower density zoning provisions for areas of high vulnerability to natural hazards in general?
- ❒ Has your community implemented a process for evaluating site-specific development?
- ❒ Does your community have an approach to reduce risk from landslide hazards through a combination of regulatory and non-regulatory measures?
- ❒ Do the implementing measures carry out your comprehensive plan's policies related to landslides in your community?
- ❒ Does your community require site-specific evaluations and geotechnical reports for proposed developments in landslide hazard areas?

Section 5:
How are Oregon Communities Addressing Landslide Hazards?

This section describes how several Oregon communities are addressing landslide hazards through a regulatory process. These examples describe development of plan policies, and implementation of the communities' landslide hazard ordinances.

5.1 A Collaborative Planning Approach - Salem & Marion County, Oregon

Salem and Marion County used federal hazard mitigation funding after the 1996 flood and landslide events to reduce risk to life and property through mapping of landslide hazards and development of landslide hazard ordinances.

Background

Salem and Marion County initiated the development of their landslide hazard ordinances in 1996, after heavy rains and flooding resulted in landslide activity. Funding was secured from Federal Emergency Management Agency (FEMA) presidentially declared disaster funds. Funds were provided to the state through the Hazard Mitigation Grant Program, administered by the OSP-Office of Emergency Management (OEM). The city, county, and the Oregon Department of Geology and Mineral Industries (DOGAMI) worked together to produce a landslide hazard study of the South Salem Hills. This project was expanded to include a similar study of the Eola Hills in Polk County after additional grant funds became available.

The study included landslide mapping and characterization of the Salem Hills and Eola Hills project areas coordinated by DOGAMI, the formulation of landslide hazard ordinances by the city and county, and development of a technical reference manual on mitigating geologic hazards in Oregon. The Department of Land Conservation and Development (DLCD) and OEM provided technical support for the study and ordinance development. FEMA funded 75 percent of the study and DOGAMI, Salem, and Marion County contributed the remaining 25 percent of project costs.

The approach taken by city and county staff was a key aspect in developing these ordinances. Collaboration among local government, project participants, and a broad group of stakeholders resulted in a citizen advisory committee. Project staff, together with the citizen advisory committee, agreed upon and adopted a set of principles for the development of the ordinances. With these principles in mind, staff collected, reviewed and summarized for the committee, hillside development ordinances and resource/reference materials from around the country but primarily from the northwest and California. A matrix was developed outlining these resource materials to assist staff and the committee.

Tip Box

Protecting Life and Property in Oregon – Public Education and Response

Oregon residents in landslide-prone areas can obtain additional information on landslides, from the "Oregon Landslide Brochure." Communities can develop an emergency response plan for areas prone to rapidly moving landslides. This plan should include evacuation routes that expose residents to the least hazards. Communities should also consider structural controls along essential evacuation routes, especially if these routes are at high or extreme hazard for rapidly moving landslides. Provisions in the land development code can provide access to landslide hazard areas (such as roads) to ensure emergency vehicle access and resident evacuation. Communities can develop regulations to ensure that homes are not located in the potential paths of rapidly moving landslides.

(The brochure is available by contacting DOGAMI - refer to Section 6 of this guide for contact information.)

TRG Key

Refer to the Comprehensive Plan Evaluation Guide Chapter 2 for more information on developing inventories and a listing of critical facilities.

The Draft Ordinance

The draft Salem ordinance for landslide hazards developed in 2000 requires the preparation and approval of a geological assessment before development occurs in areas identified with a moderate degree of hazard. These areas then undergo a preliminary review of geologic conditions. The ordinance requires staff to determine if a geotechnical report requiring more information and detail than the geological assessment is necessary. This approach ensures adequate review of proposed development on private property where potentially greater risk requires more detailed information to fully identify and address the hazard. Current mapping for landslide susceptibility in Salem covers portions of the Salem Hills and Eola Hills. The city is also incorporating the DOGAMI earthquake hazards maps for the Salem area to further assist in determining the degree of landslide risk for site-specific development. There are no existing city regulations on grading activities, though proposals for this kind of review are being considered.

The citizen advisory committee, city and county public works staff, building inspection staff, and legal counsel reviewed the draft ordinance in spring 2000. The State Board of Geologist Examiners and Engineering and Land Surveying Examiners Board were also asked for input on the draft ordinance. Revisions made the draft more specific to identified hazard areas, simpler to understand, easier to implement, and more clear and objective. The consensus process and collaboration between project staff, the advisory committee, and other interests participating in the study were beneficial to the public hearing process. The advisory committee presented and approved the draft landslide hazard ordinance. Respective city and county decision-makers were considering the draft ordinance at the time of publication of this document.

Landslide Key

Contact the City of Salem and Marion County Community Development Departments for the status of the ordinances. The summary of this section provides information on how to contact these local agencies.

The landslide hazard study resulted in two separate, but similar ordinance proposals. Salem will apply its ordinance to mapped landslide areas within the city limits and the county to mapped geological hazard areas and identified excessive slope areas. A Graduated Response Table, a key element of the Salem landslide ordinance, provides the mechanism that will be used to evaluate future development sites. The table factors the degree of hazard at a site with the level of proposed development activity to determine the extent of geological study needed before development can occur on the site.

The city and county ordinances establish a provision for independent review to ensure compliance with the criteria for a geological assessment or geotechnical report. Geotechnical studies will undergo an independent review process to ensure compliance with the ordinance and ensure that recommended mitigation measures provide for safe development. Prior to development, a declaratory statement indicating the property is within an identified hazard area needs to be recorded on the property deed. Compliance with the ordinance will be required as part of any land use permit and building permit for regulated activities within identified hazard areas.

DRAFT Ordinance – City of Salem - Chapter 68 – Landslide Hazards

(Ordinance under review in May 2000. Final language may be different.)

The following sections of ordinance language are considered ordinance provisions from the Salem Ordinance Chapter 68 Landslide Hazards. For more information or to obtain the draft ordinance in its entirety, contact the Salem Community Development Department.

68.010 INTENT AND PURPOSE

The intent and purpose of the provisions of this chapter are:

a) To implement the Geologic Hazards goals and policies of the Scenic and Historic Areas, Natural Resources and Hazards section of the Salem Area Comprehensive Plan;
b) To review development applications for properties within landslide hazards areas;
c) To assess the risk that a proposed use or activity will adversely affect the stability and slide susceptibility of an area;
d) To establish standards and requirements for the use of lands within landslide hazards areas;
e) To mitigate risk within landslide hazards areas, not to act as a guarantee that the hazard risk will be eliminated, nor as a guarantee that there is a higher risk of hazard at any location. Unless otherwise provided, the landslide hazard regulations are in addition to generally applicable standards provided elsewhere in this code.

68.030 REGULATED ACTIVITIES; PERMIT & APPROVAL REQUIREMENTS; APPLICABILITY

Except as may be exempted under SRC 68.040, no person shall engage in the following regulated activities on geological hazard areas, maps of which are adopted under this chapter, without first obtaining permits or approvals as required by this chapter:

1) Excavations;
2) Fills;
3) Installation or construction of an accessory structure greater than 500 square feet in area;
4) Construction, reconstruction, structural alteration, relocation or enlargement of any building or structure for which permission may be require pursuant to this code;
5) Land division, planned unit development, manufactured dwelling park development;
6) Tree removal on slopes greater than 60 percent.

68.050 MAP ADOPTION: AMENDMENT

The approximate location and extent of geological hazard areas are shown on Landslide Hazard Susceptibility Maps, which shall be adopted by council and shown on the official zoning map of the city. The Landslide Hazard Susceptibility Maps have been developed to indicate the general location of areas of low, moderate, and high susceptibility to landslides, and areas of known landslide hazards. These maps are based on the best

Tip Box

The Salem draft ordinance contains a number of provisions that other communities might consider adopting to address development in their jurisdiction's landslide hazard area:

1. Intent and purpose statement – purpose is clear and tied to the identified risk.
2. Clear statement of where ordinance applies and to what activities.
3. The ordinance is based on mapping of the risk. The factual base clearly supports the implementing measures.
4. The classification criteria provide clear and objective review standards.

available information and may be amended based upon the receipt of corrected, updated or refined data or the revision of studies upon which the maps were initially based.

68.060 CLASSIFICATION CRITERIA AND REVIEW REQUIREMENTS.

The Graduated Response Table 68-1 shall be used by city staff to determine the level of site investigation for various types of regulated activity on property any portion of which is shown on Landslide Hazard Susceptibility Maps. Using a rating system, slope and physiographic conditions at the site are evaluated in relationship to a proposed activity. If a rating meets or exceeds quantified thresholds provided in the table, a geologic assessment or geotechnical report or both shall be provided by the applicant and action specified therein undertaken or insured before any regulated activity may be permitted, approved, or processed. Where any portion of the subject property on which regulated activities are proposed is identified under two slope conditions, or two or more categories, the highest condition or category will apply.

Table 68-1: Graduated Response – Draft July 2000

Graduated Response Table Note:

Select one assigned value from PARTS (I or II, and III and IV) and proceed to PART V.

PART I.

Reference: **Public Works Slope Contour Map**	**Slope Ratings Environmental Constraints Category**			
	Low	**Moderate**	**High**	**Assigned Value**
Slope Conditions	1	2	3	
Regulated Slopes Less Than 10%	N.A.	N.A.	N.A.	
Regulated Slopes between 10%-15% but Not Including 15% (N/A to Category 5 on GMS 105)	X			
Regulated Slopes between 15%-25% and Including 25% (N/A to Category 5 on GMS 105		X		
Regulated Slopes over 25% (N/A to Category 5 on GMS 105)			X	
Score				* Points

PART II.

Reference: **Geologic Map Series (GMS/105)**	**Earthquake-Induced Landslide Susceptibility Ratings Environmental Constraints Category**			
	Low	**Moderate**	**High**	**Assigned Value**
Physiographic and Geologic Categories	1	2	3	
Property Identified under Categories 1, 2, 3 or 4 on GMS/105 Reports	N.A.	N.A.	N.A.	
Property Identified under Category 5 on GMS/105 Report			X	
Score				** Points

PART III.

Reference: **Interpretive Map Series (IMS-5), Interpretive Map Series (IMS-6), Geological Map Series (GMS/105), and Public Works Slope Contour Map**	**Water-Induced Landslide Susceptibility Ratings Environmental Constraints Category**			
	Low	**Moderate**	**High**	**Assigned Value**
Physiographic and Geologic Categories	1	2	3	
Property Identified under Category 1 on IMS-5 & IMS-6 Reports	N.A.	N.A.	N.A.	
Property Identified under Categories 1, 2, 3 or 4 on GMS/105 Reports	N.A.	N.A.	N.A.	
Property Outside GMS/105 and IMS-6 and Greater Than 15%		X		
Property Identified under Categories 2 or 3 on IMS-5 & IMS-6 Reports		X		
Property Identified under Categories 4, 5a, 5b or 6 on IMS-5 & IMS-6 Reports			X	
Score				*** Points

Table 68-1: Graduated Response cont. – Draft July 2000

PART IV.

Type of Activity	Activity Ratings for Potential Site Impact Land Use Category: Low 1	Moderate 2	High 3	Assigned Value
Installation or Construction of an Accessory Structure Greater Than 500 Square Feet	X			
Single Family, Manufactured Dwelling Building Permit (Structural Expansion/Remodel)	X			
Multiple Family Building Permits (Structural Expansion/Remodel)		X		
Partition		X		
Grading (as Independent Activity)			X	
Subdivision, Planned Unit Development, Manufactured Dwelling Park			X	
Schools, Hospital and Public Building Permits (Structural Expansion/Remodel)			X	
Commercial and Industrial Building Permits (Structural Expansion/Remodel)			X	
Tree Removal on Regulated Slopes Greater than 60% (as Independent Activity)			X	
Score				**** Points
Add scores from PART I or II, and III and IV. Proceed to PART V.				*****Points

PART V.

*See Adopted Requirements for Geologic Assessments and Geotechical Reports in the City of Salem Public Works Design Stadards	Total Risk Assessment Policy Provision	
Category 1- Low Landslide Risk Assessments	Category 2 – Moderate Landslide Risk Assessments	Category 3 – High Landslide Risk Assessments
(4 points or less)	(5-8 points)	(9 points or greater)
No Requirements	Grading Permit, Geologic Assessment* *If the Geologic Assessment indicates landslide hazards on the site, the director of public works or building and safety administrator may specify the requirements of High Landslide Risk Assessments.	Grading Permit, Geotechnical Report* *The director of public works and building and safety administrator may require a qualified independent review of a geotechical report.

5.2 Applying Land Use Tools in Myrtle Creek, Oregon

The Myrtle Creek Zoning ordinances regulate development in steep-slope and landslide-prone areas.

Background

Myrtle Creek's 1990 Comprehensive Plan states that over 300 acres of buildable land within the Myrtle Creek urban growth boundary are designated "Steep Slope Residential." These areas of steep slope are determined suitable for residential development, recognizing that actual development densities will vary according to the degree of the slope. Since hillsides present a potential hazard to life and property from the mass movement of underlying soils, the city developed, and continues to update, its steep slope ordinances. Policies within the comprehensive plan (Chapter 5: Natural Disasters & Chapter 14 Land Use and Urbanization) require a mandatory evaluation of proposed development in areas affected by steep slopes to ensure proper consideration of all potential hazards.

Myrtle Creek has jurisdiction within the city limits and the northern portion of the Urban Growth Area (UGA) (urban growth boundary), while Douglas County (through an Urban Growth Management Agreement) has planning jurisdiction over the southern half of the Myrtle Creek UGA. This southern portion of the UGA is known as Tri City and is an Urban-Unincorporated community. County regulations are enforced through Article IX of the Douglas County Zoning Ordinance.

Local implementation of the Myrtle Creek Zoning Ordinance has shown that the ordinance does a good job of regulating hillside developments. The language in the ordinance is specific enough to make clear and objective interpretations while remaining flexible enough to deal with site-specific issues. The strength of the ordinance is its comprehensiveness.

Myrtle Creek Zoning Ordinance No. 508

The following excerpts of ordinance language are from the Myrtle Creek Zoning Ordinance pertaining to steep slopes and landslides. For more information or to obtain the ordinance in its entirety, contact the Myrtle Creek Planning Office.

Section 1.03.0 Intent

> The intent of these regulations is to provide a means of ensuring that land uses of the community are properly situated in relation to one another; and that development is sufficiently open to provide light, air and privacy; that adequate space is available for each type of development; that density of development in each area is held at a level which can be properly serviced by such governmental facilities as the street, fire protection, school, recreation, and utility systems; and in general, to promote the public health, safety, order, convenience, prosperity and welfare of the people living in the community.

Tip Box

How to Use a Graduated Response Table

The advantage of the graduated response table is that it links development review standards to the degree of risk. For example: Development on slopes of 10-15% would have 1 point; if it is located on an area of relatively low risk of earthquake-induced landslides (category 1,2,3,or 4), the development would be assessed no additional points, a rating of 2 and 3 on the water-induced landslide report would add 3 points. If the activity is a subdivision, an additional 3 points would be assessed for a total of 7 points requiring a grading permit and geologic assessment.

Tip Box

Myrtle Creek

Local governments might want to adopt language like Myrtle Creek's. The ordinance has a clear statement of intent, clear and objective standards for site review, and a requirement to address both the major causes of landslides (e.g., slopes; drainage..) and the effects on surrounding properties. The required elements of a site investigation report are beneficial, and the ordinance includes the following tools to address hazard areas: density limits, open space requirements and performance standards.

Section 5.01.1 Site Review Criteria

The site review will be conducted in accordance with the criteria set forth herein. Any development proposal, which deviates from the established criteria, shall be referred to the Planning Commission for determination. The Planning Commission shall have the power to impose any or all of the supplemental conditions set forth in Section 5.01.2 in making their determination.

(1) Identify areas of potential natural hazards where area protection requirements shall be imposed and which shall include, but are not limited to, the following:

- a) Areas of mass movement and areas of greater than 25% slope shall require a written Site Investigation Report (Section 5.02.0) prior to any excavation or change in topography.
- b) Areas of potential flooding hazards where the floodplain site criteria of the Flood Hazard Area (SD-FHA) shall apply.
- c) Areas of lesser hazard where the imposition of supplemental conditions may be appropriate.

(8) Establish the adequacy of the grading and drainage plan for the collection and transmission of storm and ground water in order that the drainage from the proposed development will not adversely affect adjoining properties of public rights of way.

(9) Consider the effects of slope alteration (cut and fill) on erosion and run-off for surrounding properties and impose restrictions when appropriate.

(11) Establish where the retention of existing vegetation and natural topographic features will be beneficial as a soil stabilizer or is of scenic significance and impose restrictions where appropriate.

Section 5.02.0 Site Investigation Report

A site investigation report shall be submitted as part of the site review process when the proposed development involves identified mass movement hazard areas or areas of greater than 25 % slope. Also, the Planning Commission may require a site investigation report to be submitted for development in other areas of potential natural hazards based on the recommendation of the City Engineer for just cause. The Site Investigation Report provides information on the site of development adjacent land that is likely to be affected by the proposed development. Unless the City Engineer determines that certain specifications are not required, the Report shall include the information described in Subsection (1) through (6) herein, together with appropriate identification of information sources the date of information the methods use in the investigation and approximate man-hours spent on site.

(1) Qualifications To Conduct a Site Investigation Report

The Site Investigation Report shall be prepared by an engineering geologist or an engineer who certifies he is qualified to evaluate soils for stability or a person or team of persons qualified by experience and training to assemble and analyze physical conditions in flood or slope hazard areas. The person or team shall be employed by the applicant but shall be subject to approval as to qualifications by the City Administrator.

(2) Background Data in Report

The Site Investigation Report shall contain the following information:

a) A general analysis of the local and regional topography and geology including the faults, folds, geologic and engineering geologic units and any soil, rock and structural details important to engineering or geologic interpretations.
b) A history of problems on and adjacent to the site, which may be derived from discussions with local residents and officials and the study of old photographs, reports and newspaper files.
c) The extent of the surface soil formation and its relationship to the vegetation of the site, the activity of the landform and the location of the site.
d) Ground photographs of the site with information showing the scale and date of the photographs and their relationship to the topographic map and profiles. The photographs will include a view of the general area, the site of the proposed development and unusual natural features, which are important to the interpretation of the hazard potential of the site, including all sites of erosion or accretion.

(3) Topography Map
(4) Subsurface Analysis
(5) Development Proposal
(6) Conclusions

The following conclusions should be stated:

a) Whether the intended use of the land is or is not compatible with the conditions.
b) Any existing or potential hazards noted during the investigation.
c) The manner for achieving compliance with the ordinance and other requirements.
d) Mitigating recommendations for specific areas of concern and the degree to which they mitigate the concerns.

Section 5.04.0 Protection Standards for Natural Features

All development shall be preceded by the identification of any environmental or natural feature described in Section 5.04.1 through 5.04.6 below and shall meet the environmental protection standards applicable to each natural resource identified therein. Reference in this Section to “open space” is intended to mean the term as it is defined in Article II.

Section 5.04.1 Steep Slopes

In areas of steep slope, the following standards shall apply:

1) Twelve to less than 16% slope: Nor more than 40% of such areas shall be developed and/or regraded or stripped of vegetation.
2) Sixteen to 25% slope: No more than 30% of such areas shall be developed and/or regraded or stripped of vegetation, with the exception that no more than 20% of such areas may be disturbed in the case of poor soil suitability.
3) More than 25% slope: Not more than 15% of such areas shall be developed and/or regraded or stripped of vegetation, with the exception that no more than 5% of such areas may be disturbed in the case of poor soil suitability.
4) All erodible slopes shall be protected in accordance with the control standards contained in Section 5.04.6.

Section 5.04.3 Ravines and Ravine Buffers

1) At least 98% of all ravines shall remain in permanent open space. At least 80% of all ravine buffers shall remain in permanent open space. No uses or improvements other than those permitted herein shall be permitted in any area consisting of ravines or ravine buffers as defined by this ordinance.
2) Ravines shall not be the site of any land use or development, with the exception that access to other areas may be provided in ravine areas. In this event, an environmental assessment (or Site Investigation Report) shall provide the basis for location of such access. Minimum damage to the area shall be the guide in location of the access. The protected areas of ravine buffers shall be used only for passive recreation.
3) All erodible slopes shall be protected in accordance with the control standards contained in Section 5.04.6.

Section 5.04.6 Soil Erosion and Sedimentation Control

1) SESC Plan
   In order to prevent both soil erosion and sedimentation, a soil erosions and sedimentation control plan shall be required as part of an application for development whenever any land located in a stream, stream channel or body of water is disturbed and whenever a development will involve any clearing, grading, transporting, or other form of disturbing land by removal of earth, including the mining of minerals, sand, and gravel provided that any one of the following descriptions applies to said movement of land:

   a) Excavation, fill, or any combination thereof will exceed 500 cubic yards.
   b) Fill will exceed three feet in vertical depth at its deepest point as measured from the natural ground surface.
   c) Excavation will exceed four feet in vertical depth at its deepest point as measured from the natural ground surface.

d) Excavation, fill, or any combination thereof will exceed an area of 5000 square feet.
e) Plant and/or tree cover is to be removed from an area exceeding 5000 square feet on any parcel of land.

(Note: Specifically exempted from the requirement of a soil erosion and sedimentation control plan are agricultural uses.)

5.3 Summary: Lessons from Oregon Communities Addressing Landslide Hazards

- The development of the **Salem** and **Marion County** Landslide ordinances began with updated inventory information, which included landslide mapping and characterization of the project areas. After adoption by their respective governing bodies, city and county staff will be able to implement the ordinances. For more information on the Salem and Marion County Landslide hazard ordinances, contact:

  Marion County Planning Division
  P.O. Box 14500
  3150 Lancaster Drive NE, Suite B
  Salem, Oregon 97309
  Website: **www.open.org/mcplann**
  (information on the study/ordinance)
  Phone: (503) 588-5038
  Fax: (503) 589-3284

  City of Salem
  555 Liberty St. SE/Room 305
  Salem, OR 97301-3503
  Phone: (503) 588-6211
  Fax: (503) 588-6005

- The **Myrtle Creek Zoning Ordinance** is another good example of regulating development in steep-slope and landslide-prone areas. For more information on the Myrtle Creek Zoning Ordinance, contact:

  City of Myrtle Creek
  P.O. Box 940
  207 Pleasant St.
  Myrtle Creek, OR 97457
  (541) 863-3171

- Communities interested in developing a steep-slope or landslide ordinance can contact DOGAMI and DLCD for additional technical assistance.

Planning for Natural Hazards: Reviewing your Comprehensive Plan

Your comprehensive plan should be coordinated with and reflect other comprehensive plans and implementing measures of other communities within your region. Natural hazards do not respect community boundaries making it important to coordinate with other jurisdictions in your area. In reviewing your comprehensive plan, your community should ask the following questions in developing plan policies for landslide hazards:

- ❐ What plan policies should be added or amended to assist your community in dealing with landslide hazards?
- ❐ Are there communities that face similar landslide threats that have developed ordinances or non-regulatory programs that could be adopted by your community ?
- ❐ Is your comprehensive plan consistent with plans or actions of other jurisdictions and regional plans and policies (such as school, utilities, fire, park, and transportation districts?)

Section 6:
Where can Your Community find Resources to Plan for Landslide Hazards?

This section is a resource directory including contacts, programs, documents and internet resources to assist planners, local governments and citizens in obtaining further information on landslide hazards.

TRG Key

For more information on public agency coordination refer to the discussion on coordination in Chapter 2: Elements of a Comprehensive Plan.

6.1 State Agency Resources

Oregon Department of Geology and Mineral Industries (DOGAMI)

DOGAMI is an important agency in landslide mitigation activities in the state of Oregon. Some key functions of DOGAMI include development of geologic data for Oregon, producing maps, and acting as a lead regulator for mining and drilling for geological resources. The agency also provides technical assistance to communities and provides public education on geologic hazards. DOGAMI provides data and geologic information to local, state and federal natural resource agencies, industry and other private sector groups.

Contact: DOGAMI
Address: 800 NE Oregon St., Suite 965
Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: http://sarvis.dogami.state.or.us/homepage/mission.html
Deputy State Geologist: (503) 731-4100 ext. 228
Earthquake Team Leader: (503) 731-4100 ext. 226
Coastal Team Leader: (541) 574-6642

The Nature of the Northwest Information Center

The Nature of the Northwest Information Center is operated jointly by the Oregon Department of Geology and Mineral Industries and the USDA Forest Service. It offers a selection of maps and publications from state, federal and private agencies.

Contact: The Nature of the Northwest Information Center
Address: 800 NE Oregon Street # 5, Suite 177
Portland, OR 97232
Phone: (503) 872-2750
Fax: (503) 731-4066
Hours: 9am to 5pm Monday through Friday
E-mail: Nature.of.NW@state.or.us
Website: http://www.naturenw.org/

Oregon Department of Forestry

In addition to its other functions, ODF regulates forest operations to reduce the risk of serious bodily injury or death from rapidly moving landslides directly related to forest operations, and assists local governments in the siting review of permanent dwellings on and adjacent to forestlands in further review areas.

Contact: Geotechnical Specialist, Eastern Oregon, Policy Issues
Address: 2600 State Street
Salem, Oregon 97310
Phone: (503) 945-7481
Fax: (503) 945-7490
Website: http://www.odf.state.or.us

Contact: Geotechnical Specialist, Linn and Lane County, Southern Oregon
Address: 1785 NE Airport Road
Roseburg, Oregon 97470-1499
Phone: (541) 440-3412

Contact: Geotechnical Specialist, Northwest Oregon
Address: 801 Gales Creek Road
Forest Grove, Oregon 97116-1199
Phone: (503) 359-7448

Oregon Department of Forestry Debris Flow Warning Page

The ODF debris flow-warning page provides communities with up-to-date access to information regarding potential debris flows. The ODF warning system is triggered by rainfall and monitored in areas that have been determined high hazard for debris flows. As the lead agency, ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows. Advisories and warnings are issued as appropriate. Information is broadcast over NOAA weather radio, and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media that convey the information to the interested public. ODOT also provides warnings to motorists during periods determined to be of highest risk for rapidly moving landslides along areas on state highways with a history of being most vulnerable.

Contact: ODF Debris Flow Warning Page
Website: http://www.odf.state.or.us

Sidebar

The Governor's Interagency Hazard Mitigation Team (GIHMT) is an important organization for interagency coordination, formalized by Governor Kitzhaber after the 1996-97 flood and landslide events. One of the most important roles of the GIHMT is to provide a forum for resolving issues regarding hazard mitigation goals, policies and programs. The team's strategies to mitigate loss of life, property and natural resources are reflected in the state's *Natural Hazards Mitigation Plan*. This plan is dubbed the "409 plan" since it is required by section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (P.L. 93-288). The GIHMT reviews policies and plans and makes recommendations with an emphasis on mitigation and education. Representatives from Oregon Emergency Management staff the GIHMT.

Department of Land Conservation and Development (DLCD)

Oregon's Department of Land Conservation and Development (DLCD) administers a natural hazards program to assist local governments in meeting Statewide Planning Goal 7: Areas Subject to Natural Disasters and Hazards. Activities relating to landslide mitigation include:

- Distribution of model ordinances through which hazards can be mitigated. DLCD advises local governments on which ordinance best meets their needs;
- Review of local land use plan amendments for consistency with state landslide programs and regulations and providing direct technical assistance;
- Provides liaison between pertinent local, state, and federal agencies. DLCD representatives serve on a variety of commissions and ad hoc committees which deal with natural hazards;
- Adopts and amends Statewide Planning Goals and Administrative rules relating to natural hazards.

Contact: Department of Land Conservation and Development
Address: 635 Capitol Street NE, Suite 150
Salem, OR 97301
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: http://www.lcd.state.or.us/

Oregon Department of Consumer and Business Services

The Building Codes Division (BCD) of the Oregon Department of Consumer and Business Services sets statewide standards for design, construction and alteration of buildings that include standards for grading, excavation and fill in the area surrounding the building foundation. The Structural Code also contains requirements for site evaluation of soil and seismic hazard conditions that impact landslides.

Contact: Building Codes Division
Address: 1535 Edgewater ST. NW, P.O. Box 14470
Salem, OR 97309
Phone: (503) 378-4133
Fax: (503) 378-2322
Website: http://www.cbs.state.or.us/external/bcd

Oregon Department of Transportation (ODOT)

Under Senate Bill 12, ODOT provides warnings to motorists during periods determined to be of highest risk of rapidly moving landslides along state highways with a history of being most vulnerable to rapidly moving landslides.

Contact: ODOT Transportation Building
Address: 355 Capitol St. NE
Salem, OR 97310
Phone: 888-275-6368
Website: http://www.odot.state.or.us/

Oregon State Police (OSP)-Office of Emergency Management (OEM)

In relation to Senate Bill 12 and rapidly moving landslide hazards, OEM coordinates state resources for rapid and effective response to landslide-related emergencies. The Oregon Emergency Response System (OERS) of OEM is a key player in the dissemination of debris flow advisories and warnings. OEM chairs the GIHMT, a body which develops landslide hazard mitigation strategies and measures. OEM administers the FEMA Hazard Mitigation Grant Program, which provides a source of funding for implementing hazard mitigation projects. OEM works with other state agencies to develop information for local governments and the public on landslide hazards.

Contact: OEM
Address: 595 Cottage Street NE
Salem, OR 97301
Phone: (503) 378-2911
Fax: (503) 588-1378
OEM State Hazard Mitigation Officer: (503) 378-2911 ext.247
Recovery and Mitigation Specialist: (503) 378-2911 ext.240
Website: http://www.osp.state.or.us/oem/

Department of Geology, Portland State University

Portland State University conducts research and prepares inventories and reports for communities throughout Oregon. Research and projects conducted through the Department of Geology at Portland State University includes an inventory of landslides for the Portland metropolitan region after the 1996 and 1997 floods and a subsequent susceptibility report and planning document for Metro in Portland.

Contact: Portland State University, Department of Geology
Address: 17 Cramer Hall; 1721 SW Broadway
PO Box 751
Portland, OR 97207
Phone: (503) 725-3389
Website: http://www.geol.pdx.edu

6.2 Federal Agency Resources

Federal Emergency Management Agency (FEMA)

FEMA Region 10 serves the northwestern states of Alaska, Idaho, Oregon and Washington. The Federal Regional Center (FRC) for Region 10 is located in Bothell, Washington. FEMA is an agency of the federal government whose purpose is to reduce risks, strengthen support systems, and help people and their communities prepare for and cope with disasters regardless of the cause. FEMA's mission is to "reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based emergency management program of mitigation, preparedness, response and recovery."

Contact: Federal Regional Center, Region 10
Address: 130-228th St. SW
Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: www.fema.gov

Natural Resource Conservation Service (NRCS)

The NRCS produces soil surveys. These may be useful to local governments who are assessing areas with potential development limitations including steep slopes and soil types. The NRCS is "a federal agency that works in partnership with the American people to conserve and sustain our natural resources."[55] Their mission is to "provide leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and environment."[56] They operate many programs dealing with the protection of these resources.

Contact: Natural Resource Conservation Service, Oregon State Branch
Address: 101 S.W. Main Street, Suite 1300
Portland, OR 97204-3221
Phone: (503) 414-3200
Fax: (503) 414-3103
Website: http://www.or.nrcs.usda.gov/Welcome.html

Contact: Federal Natural Resources Conservation Service
Address: 14th and Independence Ave.
Washington, DC 20250
Website: http://www.nrcs.usda.gov/

Sidebar

Project Impact: Building Disaster Resistant Communities

FEMA's Project Impact is a nationwide initiative that operates on a common sense damage reduction approach, basing its work and planning on three simple principles:

1. Preventive actions must be decided at the local level;
2. Private sector participation is vital; and
3. Long-term efforts and investments in prevention measures are essential.

Project Impact began in October of 1997 when FEMA formed partnerships with seven pilot communities across the country. FEMA offered expertise and technical assistance from the national and regional level and used all the available mechanisms to get the latest technology and mitigation practices into the hands of the local communities. FEMA has enlisted the partnership of all fifty states and U.S. Territories, including nearly 200 Project Impact communities, as well as over 1,100 businesses.[53]

Benton, Deschutes, and Tillamook counties, and Multnomah County with the city of Portland are the Oregon communities currently participating in this initiative to build disaster resistant communities. Application for participation in the program in Oregon is through the OSP-Office of Emergency Management in Salem.[54] For more information about Project Impact visit http://www.fema.gov or (http://www.fema.gov/impact/impact00.htm), or contact the OSP-Office of Emergency Management.

6.3 Recommended Landslide Publications

The following documents provide information on a particular aspect of landslide hazard mitigation. These documents represent the principal resources communities can use to better plan for landslide hazards. They are key tools for reducing the risks associated with landslide-prone areas.

Geologic Hazards: Reducing Oregon's Losses, Special Paper 32. Beaulieu, J.D. and Olmstead, D.O. (1999) Dept. of Geology and Mineral Industries

Characterization of geologic hazards, specific multi-hazard considerations and the interrelationships of geologic hazards, and geologic hazard risk reduction. Outlines the responsibilities and limitations of state agencies including OEM, DLCD, ODF, Building Codes, local agencies, and DOGAMI's coordination role in risk reduction activities. Provides a matrix on strategies to reduce risk and legal considerations.

To obtain this resource contact: DOGAMI (see State Resources for contact information).

Joint Interim Task Force on Landslides and Public Safety - Report to the 70th Legislative Assembly (1998).

Glossary of key terms and relationship to the Statewide Planning Goals – specifically Goal 7. Discussion on forest practices and landslides, best management practices and the authority of ORS 527.630. Discusses non-forest area slides and case studies (West Hills area in Portland) and provides a summary of insurance issues.

To obtain this resource contact: The state library in Salem.

Landslide Loss Reduction: A Guide for State and Local Government Planning. World, Robert L & Jochim, Candace L., FEMA, Colorado Division of Disaster Emergency Services and Colorado Geological Survey

Comprehensive information on landslide related issues. Addresses the benefits of mitigation, planning as a means of loss reduction, local government roles, causes and types of landslides and the relationships between landslides and floods, and landslides and seismic activities. The journal also looks at the planning process, an inventory of landslide costs, and evaluation of mitigation projects and techniques.

To obtain this resource contact: FEMA (see Federal Resources for contact information).

Landslides in Oregon Brochure, Oregon Department of Forestry, Oregon Department of Geology and Mineral Industries, Department of Consumer and Business Services, OSP-Office of Emergency Management

Oregon-specific information on landslides and debris flows. Provides, pictures and graphics, and information on state agencies and their roles in landslide mitigation activities.

To obtain this resource contact: DOGAMI (see State Resources for contact information).

Landslides Investigation and Mitigation, Special Report 247. Turner, Keith A., Schuster, Robert L. (Editors)(1996) Transportation Research Board, National Research Council, National Academy Press, Washington DC.

Mitigating Geologic Hazards in Oregon: A Technical Reference Manual, Special Paper 31. Beaulieu, J.D., and Olmstead, D.O. (1999) Department of Geology and Mineral Industries

To obtain this resource contact: DOGAMI (see State Resources for contact information).

Planning for Hillside Development. Olshansky, Robert B. (1996) American Planning Association Planning Advisory Service Report Number 466

This document describes the history, purpose and functions of hillside development and regulation, the role of planning, and provides excerpts from hillside plans, ordinances and guidelines from communities throughout the U.S.

To obtain this resource: Check your local library or contact the American Planning Association.

Regulation of Hillside Development in the United States. Olshansky, Robert B. (1998) In Environmental Management (Vol. 22, No.3, pp 383-392)

Provides a history of hillside development and the differing views on how and why regulations are developed. Discussion regarding the purpose of hillside regulation including aesthetics, natural phenomena, health, safety and general welfare, natural resources, geologic hazards, fire protection and access.

To obtain this resource: Check your local library.

State of Oregon - Natural Hazards Mitigation Plan. The Interagency Hazards Mitigation Team, (2000) OSP-Office of Emergency Management

To obtain this resource contact: Oregon Emergency Management (see State Agency Resources for contact infor mation).

Unstable Ground: Landslide Policy in the United States. Olshansky, Robert B. and Rogers, J. David (1987) Ecology Law Quarterly pg.939

To obtain this resource: Check your local library.

USGS Landslide Program Brochure. National Landslide Information Center (NLIC), United States Geologic Survey

Good, general information in simple terminology. Information on the importance of landslide studies and a list of databases, outreach and exhibits maintained by the NLIC. The brochure also includes information on types and causes of landslides, falls and flows, features that may indicate catastrophic landslide movement.

To obtain this resource contact:

USGS - MS 966, Box 25046
Denver Federal Center
Denver, CO 80225
Tel. (800) 654-4966
Fax (303) 273-8600
Email: highland@gldvxa.cr.usgs.gov
Web: http://geohazards.cr.usgs.gov/

Database of Slope Failures in Oregon For Three 1996/97 Storm Events. Hofmeister, R.J., (2000) Oregon Department of Geology and Mineral Industries, Special Paper.

To obtain this resource contact: DOGAMI (see State Resources for contact information).

Storm Impacts and Landslides of 1996 Final Report. (1999) Oregon Department of Forestry.

This 145-page technical document contains the findings of a three-year monitoring project to evaluate the effects of the extreme storms that struck Oregon in 1996. This ground-based study sought to determine the accuracy and precision of remote sensing data in identifying landslides, stream channel impacts and landslide-prone areas. The study reports on landslide frequency and channel impacts, particularly as they relate to forest practices. The study also evaluated different timber harvesting, road construction and road drainage practices.

To obtain this resource contact: Oregon Department of Forestry, Forest Practices Section, (503) 945-7470.

6.4 Internet Resources

DOGAMI

http://www.sarvis.dogami.state.or.us
The DOGAMI web page includes information on landslide databases, coastal programs, earthquakes, an oil and gas page, a list of publications and access to the Nature of the Northwest Information Center. There is also a mined-land reclamation section and contact information for the Salem headquarters and other field offices.

Oregon Department of Forestry – Debris Flow

http://www.odf.state.or.us/gis/debris.html
This website provides a listing and access to Geographic Information System maps for counties in Western Oregon that have been mapped by Oregon Department of Forestry for debris flow hazards.

Landslide Web Page - U.S. Geological Survey

http://landslides.usgs.gov/
The landslide web page of the U.S. Geological Survey and the website for the National Landslide Information Center (NLIC) offers compehensive landslide information, as well as indexes to landslide publications available both in hard copy and on-line. The first site describes the National Landslide Hazards Program, lists landslide program publications and current projects, and describes recent landslide events. The NLIC site provides “real-time” monitoring of an active landslide in California, San Francisco Bay area landslide maps, links to landslide information for each state, landslide images, other useful links, a virtual fieldtrip of a Colorado landslide, and access to a new on-line bibliographic database.

Natural Hazards Research and Applications Information Center

http://www.colorado.edu/hazards
Publisher of Natural Hazards Observer newsletter, containing articles on hazards mitigation and listings of other hazard websites.

The International Landslide Research Group

http://ilrg.gndci.pg.cnr.it/
The International Landslide Research Group (ILRG) is an informal group of individuals concerned about mass earth movement and interested in sharing information on landslide research. The ILRG website currently provides all back issues of the group’s newsletter, with information about landslide programs, new initiatives, meetings and publications, and the experiences of people engaged in landslide research.

Federal Emergency Management Agency (FEMA)

http://www.fema.gov/pte/prep.htm
The Federal Emergency Management Agency (FEMA) website provides “fact sheets” - including preparedness tips - concerning most natural and technological hazards. A fact sheet on landslides is available at http://www.fema.gov/library/landslif.htm.

Planning for Natural Hazards: Reviewing your Comprehensive Plan

Coordination and consistency is essential to implementing plan policies that reduce landslide risk within your community. Your community should ask the following questions in reviewing your comprehensive plan to assist you in identifying resources to strengthen plan policies and implementing regulations:

- ❒ Have you made use of technical information and assistance provided by Oregon agencies to assist your community in planning for landslide hazards?
- ❒ What documents or technical assistance does your community need to find to further understanding of landslide hazards and begin the process of assessing community risk from landslide hazards?

Landslide Endnotes:

[1] Disasters by Design: A Reassessment of Natural Hazards in the United States Mileti, Dennis S. (1999) Joseph Henry Press, Washington D.C.

[2] USGS Landslide Program Brochure. National Landslide Information Center (NLIC), United States Geologic Survey

[3] State Hazard Mitigation Plan Draft. The Interagency Hazards Mitigation Team, (2000) OSP-Office of Emergency Management

[4] USGS Landslide Program Brochure. National Landslide Information Center (NLIC), United States Geologic Survey

[5] Homeowner's Landslide Guide For Hillside flooding, Debris Flows, Erosion and landslide control. – OEM/FEMA Region 10

[6] Local Government Landslide Guidance. Mills, Keith, (2000)

[7] (ibid.)

[8] State Hazard Mitigation Plan. The Interagency Hazards Mitigation Team, (2000) Oregon State Police - Office of Emergency Management.

[9] (ibid.)

[10] Debris-Flow Hazards in the San Francisco Bay Region. US Department of the Interior, USGS

[11] State Hazard Mitigation Plan. The Interagency Hazards Mitigation Team, (2000) Oregon State Police - Office of Emergency Management.

[12] Storm Impacts and Landslides of 1996 Final Report. (1999) Oregon Department of Forestry

[13] State Hazard Mitigation Plan. The Interagency Hazards Mitigation Team, (2000) Oregon State Police - Office of Emergency Management.

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