# POSSIBLE MOTION

**I MOVE TO** award a professional services contract to Shannon & Wilson, Inc. for the Gary Paxton Industrial Park (GPIP) Debris Flow/Risk Analysis and Conceptual Design of Protective Works Project on a time and materials basis for a not to exceed amount of $68,505 utilizing GPIP Fund undesignated working capital.

# MEMORANDUM

**To:** Mayor McConnell and Assembly Members
Mark Gorman, Municipal Administrator

**From:** Michael Harmon, P.E., Public Works Director MH
Jay Sweeney, Chief Finance and Administrative Officer
Dan Tadic, P.E., Municipal Engineer DT

**Reviewed:** Robin Schmid, Municipal Attorney RS
Garry White, GPIP Director GW
Tori Fleming, Contract Coordinator TF

**Date:** March 31, 2016

**Subject:** Gary Paxton Industrial Park Debris Flow/Risk Analysis and Conceptual Design of Protective Works - Approval to Award Professional Services Contract

## Background

On August 18, 2015 a debris flow impacted the Gary Paxton Industrial Park (GPIP) Administration Building resulting in minor damage. The debris flow initiated on the steep slope to the north of the building. Other potential debris flow chutes are suspected to exist along that hillside. Private parties have expressed an interest in purchasing property from the City and Borough of Sitka (CBS) in this immediate vicinity, however CBS is cautious about property sales until issues regarding adjacent debris flow hazards are resolved. Staff recommends a hazard analysis be completed prior to any further action is taken on sales or new leases in this area. Staff has worked with Shannon & Wilson, Inc. (S&W) to develop a scope of work and fees for this work. The scope of this effort would be very similar to what was previously completed for South Kramer, however would also include conceptual design of protective works.

## Analysis

S&W was founded in 1954 as a geotechnical engineering firm. Today S&W provides services for the design and construction of transportation facilities, buildings, civil works structures, military facilities, industrial plants, infrastructure components, and energy generators in addition to geotechnical engineering services. S&W maintains offices in multiple states across the United States from Alaska to Florida.

William Laprade is an Engineering Geologist and is the Senior Vice President of S&W. He has extensive experience in the highly specialized field of landslide investigations and analysis. Mr. Laprade also previously completed the South Kramer Avenue Landslide report in February 2016 under an Administrator authorized emergency procurement. Chris Robertson, PE is a licensed professional engineer with expertise in the planning and design of protective works for mitigating landslide risk. The bulk of the work under this contract will be performed by these professionals. They would be assisted by other S&W professionals for debris flow and geographic information system analyses.

Procurement of consultant and technical services is exempt from competitive bidding requirements per SGC 3.16.060D. However, generally the City publishes in advance its requirements for Professional Services stating concisely the general scope and nature of the project and then makes a qualifications-based selection. Exceptions to this are allowable under the current Procurement Policy and Procedures upon review and recommendation of the Director of Finance subject to approval by the Assembly. Given the highly specialized technical nature of this work Staff recommends awarding this contract to S&W. The associated field work is anticipated to be completed in May 2016 with a final report in July 2016.

## Fiscal Note

The Gary Paxton Industrial Park Fund contains an undesignated working capital balance of approximately $914,000. Staff recommends that a portion of these funds be used to fund this study. The GPIP Board opposed this recommendation on a 2 (in favor) to 1 (opposed) vote during their regular Board Meeting on March 10, 2016.

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## Recommendation

Approve award of a Professional Services Contract to Shannon & Wilson, Inc. for the Gary Paxton Industrial Park Debris Flow/Risk Analysis and Conceptual Design of Protective Works project on a time and materials basis for a not to exceed amount of $68,505 utilizing GPIP Fund undesignated working capital. This will result in a follow-on supplemental budget being introduced to the Assembly to appropriate funds for the award.

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON
WASHINGTON DC METRO
WISCONSIN

March 3, 2016

Mr. Dan Tadic, PE
City and Borough of Sitka
100 Lincoln Street
Sitka, AK 99835

**RE: PROPOSAL FOR DEBRIS FLOW HAZARD/RISK ANALYSIS AND CONCEPTUAL DESIGN OF PROTECTIVE WORKS, GARY PAXTON INDUSTRIAL PARK, SITKA, ALASKA**

Dear Mr. Tadic:

This proposal presents our scope of services and related cost estimate to perform a debris flow hazard and risk analysis, and develop conceptual designs of protective works for structures and facilities at Gary Paxton Industrial Park (GPIP) in Sitka, Alaska. The limits of the study area are from Silver Bay Seafoods to the City and Borough of Sitka (CBS) scrapyard. The industrial park, primarily owned by the CBS, is located at Sawmill Cove, about 4 miles east of the downtown area. The GPIP contains several buildings, open-air storage areas, water treatment facilities, and old pulp process clarifiers repurposed as a bear sanctuary and scrapyard, respectively.

We understand that private parties have expressed an interest in purchasing the bear sanctuary and the Administration Building; however, CBS is cautious about property sales until issues regarding adjacent debris flow hazards are resolved. On August 18, 2015, following a torrential rain event, a debris flow initiated on the steep slope to the north of the Administration Building, flowed down the slope, across Sawmill Creek Road, and impacted the Administration Building. The building suffered minor damage. The debris has been removed, but reservations remain regarding the safety of the building.

Based on a cursory view of the slopes to the north of the GPIP, it appears that in addition to the August 18, 2015, debris flow chute, other potential debris flow chutes pose potential risk to the GPIP. The purposes of our services would be to identify the debris flow hazards on the slopes to the north of the GPIP, evaluate the risk to the GPIP, and provide concepts for protecting facilities that are at risk. These services would be accomplished in Phase 1. We understand that we would work closely and coordinate our work with you as the CBS supervisor. The bulk of our

400 NORTH 34TH STREET, SUITE 100
P.O. BOX 300303
SEATTLE, WASHINGTON 98103-8636
206-632-8200 FAX: 206-695-6777
www.shannonwilson.com

services will be performed by Chris Robertson, PE, and Bill Laprade. They would be assisted by other Shannon & Wilson, Inc. (Shannon & Wilson) professionals for debris flow and geographic information system analyses.

Phase 2 would consist of services to design the protective works that are chosen for the respective parts of the industrial park. No single type of protective measure is likely to apply to all of the different areas of the GPIP. The scope and cost of Phase 2 will depend on the conclusions of Phase 1 and the type of chosen protective works; therefore, we have not provided them in this proposal.

## PROPOSED SCOPE OF SERVICES FOR PHASE 1

We propose to perform this Phase 1 scope of services in four stages, completed over a two- to three- month period.

1. Desktop Studies
   - — Review existing topographic data and aerial photographs that may be available from CBS.
   - — Review historical aerial photographs that may be helpful in mapping debris flow chutes.
   - — Prepare hillshade and contour maps from existing light detection and ranging data for preliminary analysis and for field use.
   - — Review photographs of the August 18, 2015, debris flow at GPIP.
2. Field Reconnaissance
   - — Preparation and travel for fieldwork.
   - — Field reconnaissance at GPIP for two days for Chris Robertson and Bill Laprade.
   - — Meetings with CBS staff to report observations and preliminary results.
3. Analyses and Report
   - — Debris flow analyses.
   - — Risk Zonation
   - — Conceptual protective works, options analysis, and costs.
   - — Draft Report
   - — Final Report

4. CBS Presentation – Two-day visit to Sitka to make presentations of the report to CBS staff and Assembly (other groups, as required) and discuss Phase 2 preferences and services.

## PLANNING-LEVEL OPINION OF PROBABLE CONSTRUCTION COST

We will develop a planning-level opinion of probable construction cost for debris flow mitigation alternatives, which will be based on approximate unit costs and be presented with the results of our geotechnical studies described previously. The purpose of providing a planning level of probable construction cost is for the CBS to use in deciding whether to design and construct one or more of the alternatives we develop in our study.

Our approach for estimating planning-level probable costs to construct the work will be based solely upon our experience with construction on similar projects, and contractor and supplier information. Our estimates of probable construction costs will include a number of assumptions as to actual conditions that will be encountered. These assumptions include decisions that other design professionals and government agency personnel may make during design and permitting, the means and methods of construction the Contractor will employ, the Contractor's techniques in determining price and market conditions at the time, and other factors over which we have no control. Given the assumptions that must be made, Shannon & Wilson cannot guarantee the accuracy of the estimate of probable construction costs.

Shannon & Wilson is not a construction cost estimator or construction contractor, nor should our rendering of an opinion of probable construction costs be considered equivalent to the nature and extent of services a construction cost estimator or contractor would provide.

## SCHEDULE AND COST ESTIMATE

Based on our current workload, we can start this project within about two weeks of notice to proceed from CBS. We estimate that the above stages of the work will take the following approximate time periods, excluding review time by CBS:

- Desktop Studies – two weeks
- Field Verification – one week
- Analysis and Report – four weeks
- CBS Presentation – one week

We estimate the fee for our services presented above will be about $68,500. We will not exceed with your written permission.

## ADDITIONAL SERVICES

Our scope of service does not include the following:

- We assume you will secure permission for us to access the site for performing the reconnaissance and shallow subsurface explorations.
- Any environmental assessment or evaluation regarding the presence or absence of threatened or endangered species or wetlands. We have environmental engineers and scientists who could assist you with these services if required.
- Final design recommendations for debris flow mitigation measures.
- Permitting activities.
- Civil engineering, including surveying, grading plans, utility relocations, paving, etc.

## CLOSURE

We assume that you will issue a contract for our services. Please make this proposal part of that contract. Shannon & Wilson has prepared the enclosed, "Important Information About Your Geotechnical/Environmental Proposal," to assist you and other is in understanding the use and limitations of our proposals.

We appreciate the opportunity to assist you with this project. Please call me 206-695-6891 if you have any questions about this proposal or if we may be of further service to you.

Sincerely,

**SHANNON & WILSON, INC.**

William T. Laprade
Senior Vice President

WTL:CAR/wtl

Enc: Cost Estimate (2 pages)
Important Information About Your Geotechnical/Environmental Proposal

SHANNON WILSON, INC.

## COST ESTIMATE

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Proposal No.: | | 21-2-62657 | | | |
| | | | | Project: | | GPIP Sitka | | | |
| | | | | Client: | | CBS | | | |
| | | | | By: | | WTL | | | 3/1/2016 |
| | | Rate | | Quantity | | Subtotal | | | Subtotal |
| GPIP HAZARD AND RISK ANALYSIS | | | | | | | | | |
| | | | | | | | | | |
| Desktop Studies | | | | | | | | | |
| | Principals | 245 | /hr | 30 | hr | $7,350 | | | |
| | GIS Analyst | 110 | /hr | 20 | hr | $2,200 | | | |
| | Word Processing | 95 | /hr | 2 | hr | $190 | | | |
| | Reproduction | 95 | /hr | 2 | hr | $190 | | | |
| Subtotal | | | | | | | | | $9,930 |
| | | | | | | | | | |
| Field Reconnaissance | Principals | 245 | /hr | 72 | hr | $17,640 | | | |
| Reimbursables | | | | | | | | | |
| | Air Fare | 800 | ea | 2 | ea | $1,600 | | | |
| | Vehicle Rental | 70 | /day | 4 | days | $280 | | | |
| | Hotel | 185 | /day | 6 | days | $1,110 | | | |
| | Parking | 30 | /day | 8 | days | $240 | | | |
| | Board | 60 | /day | 8 | days | $480 | | | |
| Subtotal | | | | | | | | | $21,350 |
| | | | | | | | | | |
| Analysis | | | | | | | | | |
| | Principals | 245 | /hr | 20 | hr | $4,900 | | | |
| | Sr. Geologist | 145 | /hr | 32 | hr | $4,640 | | | |
| | GIS Analyst | 110 | /hr | 20 | hr | $2,200 | | | |
| Subtotal | | | | | | | | | $11,740 |
| | | | | | | | | | |
| | | | | | | | | | |
| Draft Report | | | | | | | | | |
| | Principals | 245 | /hr | 30 | hr | $7,350 | | | |
| | Sr. Geologist | 145 | /hr | 10 | hr | $1,450 | | | |
| | GIS Analyst | 110 | /hr | 8 | hr | $880 | | | |
| | CAD | 100 | /hr | 4 | hr | $400 | | | |
| | Word Processing | 95 | /hr | 2 | hr | $190 | | | |
| | Reproduction | 95 | /hr | 2 | hr | $190 | | | |
| Subtotal | | | | | | | | | $10,460 |
| | | | | | | | | | |
| Final Report | | | | | | | | | |
| | Principal | 245 | /hr | 8 | hr | $1,960 | | | |
| | Geologist | 100 | /hr | 4 | hr | $400 | | | |
| | CAD | 100 | /hr | 2 | hr | $200 | | | |
| | Work Processing | 95 | /hr | 1 | hr | $95 | | | |
| | Reproduction | 95 | /hr | 2 | hr | $190 | | | |
| Subtotal | | | | | | | | | $2,845 |
| | | | | | | | | | |
| Sitka Presentation | | | | | | | | | |
| | Principals | 245 | /hr | 40 | hr | $9,800 | | | |

## COST ESTIMATE

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Proposal No.: | | 21-2-62657 | | |
| | | | | | Project: | | GPIP Sitka | | |
| | | | | | Client: | | CBS | | |
| | | | | | By: | | WTL | | 3/1/2016 |
| | | Rate | | | Quantity | | Subtotal | | Subtotal |
| Reimbursables | | | | | | | | | |
| | Air Fare | 800 | ea | | 2 | ea | $1,600 | | |
| | Vehicle Rental | 70 | /day | | 2 | days | $140 | | |
| | Hotel | 185 | /day | | 2 | days | $370 | | |
| | Parking | 30 | /day | | 3 | days | $90 | | |
| | Board | 60 | /day | | 3 | days | $180 | | |
| Subtotal | | | | | | | | | $12,180 |
| | | | | | | | | | |
| TOTAL | | | | | | | | | $68,505 |

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

Attachment to and part of Proposal 21-2-62657-001

Date: March 3, 2016
To: Mr. Dan Tadic, PE
City and Borough of Sitka

# IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL PROPOSAL

More construction problems are caused by site subsurface conditions than any other factor. The following suggestions and observations are offered to help you manage your risks.

## HAVE REALISTIC EXPECTATIONS.

If you have never before dealt with geotechnical or environmental issues, you should recognize that site exploration identifies actual subsurface conditions at those points where samples are taken, at the time they are taken. The data derived are extrapolated by the consultant, who then applies judgment to render an opinion about overall subsurface conditions; their reaction to construction activity; appropriate design of foundations, slopes, impoundments, and recovery wells; and other construction and/or remediation elements. Even under optimal circumstances, actual conditions may differ from those inferred to exist, because no consultant, no matter how qualified, and no subsurface program, no matter how comprehensive, can reveal what is hidden by earth, rock, and time.

## DEVELOP THE SUBSURFACE EXPLORATION PLAN WITH CARE.

The nature of subsurface explorations—the types, quantities, and locations of procedures used—in large measure determines the effectiveness of the geotechnical/environmental report and the design based upon it. The more comprehensive a subsurface exploration and testing program, the more information it provides to the consultant, helping to reduce the risk of unanticipated conditions and the attendant risk of costly delays and disputes. Even the cost of subsurface construction may be lowered.

Developing a proper subsurface exploration plan is a basic element of geotechnical/environmental design, which should be accomplished jointly by the consultant and the client (or designated professional representatives). This helps the parties involved recognize mutual concerns and makes the client aware of the technical options available. Clients who develop a subsurface exploration plan without the involvement and concurrence of a consultant may be required to assume responsibility and liability for the plan's adequacy.

## READ GENERAL CONDITIONS CAREFULLY.

Most consultants include standard general contract conditions in their proposals. One of the general conditions most commonly employed is to limit the consulting firm's liability. Known as a "risk allocation" or "limitation of liability," this approach helps prevent problems at the beginning and establishes a fair and reasonable framework for handling them, should they arise.

Various other elements of general conditions delineate your consultant's responsibilities. These are used to help eliminate confusion and misunderstandings, thereby helping all parties recognize who is responsible for different tasks. In all cases, read your consultant's general conditions carefully and ask any questions you may have.

## HAVE YOUR CONSULTANT WORK WITH OTHER DESIGN PROFESSIONALS.

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a consultant's report. To help avoid misinterpretations, retain your consultant to work with other project design professionals who are affected by the geotechnical/environmental report. This allows a consultant to explain report implications to design professionals affected by them, and to review their plans and specifications so that issues can be dealt with adequately. Although some other design professionals may be familiar with geotechnical/environmental concerns, none knows as much about them as a competent consultant.

**OBTAIN CONSTRUCTION MONITORING SERVICES.**

Most experienced clients also retain their consultant to serve during the construction phase of their projects. Involvement during the construction phase is particularly important because this permits the consultant to be on hand quickly to evaluate unanticipated conditions, to conduct additional tests if required, and when necessary, to recommend alternative solutions to problems. The consultant can also monitor the geotechnical/environmental work performed by contractors. It is essential to recognize that the construction recommendations included in a report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site.

Because actual subsurface conditions can be discerned only during earthwork and/or drilling, design consultants need to observe those conditions in order to provide their recommendations. Only the consultant who prepares the report is fully familiar with the background information needed to determine whether or not the report's recommendations are valid. The consultant submitting the report cannot assume responsibility or liability for the adequacy of preliminary recommendations if another party is retained to observe construction.

**REALIZE THAT ENVIRONMENTAL ISSUES MAY NOT HAVE BEEN ADDRESSED.**

If you have requested only a geotechnical engineering proposal, it will not include services needed to evaluate the likelihood of contamination by hazardous materials or other pollutants. Given the liabilities involved, it is prudent practice to always have a site reviewed from an environmental viewpoint. A consultant cannot be responsible for failing to detect contaminants when the services needed to perform that function are not being provided.

**ONE OF THE OBLIGATIONS OF YOUR CONSULTANT IS TO PROTECT THE SAFETY, PROPERTY, AND WELFARE OF THE PUBLIC.**

A geotechnical/environmental investigation will sometimes disclose the existence of conditions that may endanger the safety, health, property, or welfare of the public. Your consultant may be obligated under rules of professional conduct, or statutory or common law, to notify you and others of these conditions.

**RELY ON YOUR CONSULTANT FOR ADDITIONAL ASSISTANCE.**

Your consulting firm is familiar with several techniques and approaches that can be used to help reduce risk exposure for all parties to a construction project, from design through construction. Ask your consultant, not only about geotechnical and environmental issues, but others as well, to learn about approaches that may be of genuine benefit.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

# William T. Laprade, LEG | Senior Vice President

*ENGINEERING GEOLOGIST*

## EDUCATION

BS, Geological Sciences, University of Washington, 1981
MA, Geography, Arizona State University, 1973
BA, Geography, Clark University, 1967
Post-Graduate Studies, Engineering

## REGISTRATION

Certified Engineering Geologist, OR, E844, 1982
Licensed Engineering Geologist, WA, No. 111, 2001
Registered Geologist, KY, KY-2537, 2012
Professional Geologist, UT, 9671724-2250

## PROFESSIONAL SUMMARY

Bill Laprade has 42 years of experience in all phases of geotechnical consulting: geologic reconnaissance, field exploration planning, drilling operations and logging, feasibility studies, design, construction monitoring, and construction management. His years of experience in the Pacific Northwest have made him an expert on local geology and soil conditions. His specialties include interpretation of glacial stratigraphy for design of civil works projects, slope stability evaluations in a multitude of geologic conditions, timberland mass wasting in mountainous terrain, and the geotechnical aspects of hydroelectric facilities, including small and large diameter pipelines. He has also served as an expert consultant for the geologic aspects of construction claims and landslides. Bill was the principal investigator for a study that involved more than 1,400 landslides for the City of Seattle.

Bill Laprade is a certified Engineering Geologist in Oregon and a licensed Engineering Geologist in Washington. He has spent his entire professional career of 40 years with the Seattle office of Shannon & Wilson. He is presently a Senior Vice President of the firm.

Bill is also considered an expert in the identification and geologic interpretation of landslides and was the prime author of the Seattle Landslide Study for Seattle Public Utilities. In that study, 1,436 landslides were identified, categorized, and plotted. He then prioritized the 50 landslide areas in the city and provided preliminary cost estimates for abatement of the instability problems. He has worked on some of the largest slides in the western United States, in a multitude of geologic and hydrologic conditions. He works closely with geotechnical engineers to form remedial solutions for landslide stabilization.

## LANDSLIDES, ROCK SLIDES &SLOPE STABILITY

***North Dakota Department of Transportation, I-94 Painted Canyon Landslide, Billings County, ND.*** Project Geologist. Bill served as project geologist performing a geologic reconnaissance of the landslide, reviewing existing boring logs and soil sample, evaluating subsurface conditions and preparing a new subsurface exploration plan. After the completion of drilling of new borings, Bill reviewed soil samples, helped prepare the laboratory testing program and integrated geologic conditions for the landslide. He used in-situ instrumentation and geologic information to prepare subsurface interpretive profiles.

***Thurston County Roads Division, Sunrise Beach Landslide, Thurston County, WA.*** Bill was Project Manager for evaluating the geologic conditions for and the remediation of a large landslide that damaged a road and residential property along an inlet in southern Puget Sound. The 1,700-foot-wide landslide was explored with borings and reconnaissance, and then Shannon & Wilson designed deep trench drains, walls, and horizontal drains to stabilize the landslide.

***Kala Point Homeowners' Association, Kala Point Slope Stability Studies, Jefferson County, WA.*** Bill was Project Manager for a study of an unstable bluff comprised of glacial deposits that is about 1-mile-long and 200 feet high. Shannon & Wilson geologists (1) performed detailed reconnaissance mapping of the bluff, (2) reviewed historical documents, (3) evaluated the short- and long-term prognosis for the bluff, which has residential structures located close to the edge, and(4) provided recommendations for reducing the risk of landsliding. Bill presented the results at a meeting of the residents.

***BNSF Railway Company (BNSF), Landslides Along Puget Sound, Tacoma to Everett, WA.*** As a geologist, Bill has evaluated several landslides along the coastal bluff of Puget Sound for the BNSF. They include shallow, rapid landslides that act as debris avalanches; debris flows; and large, deep-seated landslides. The largest landslide occurred at Woodway, where a 500-foot-wide section of bluff collapsed onto the tracks and into Puget Sound, moving the top of the bluff back 50 to 75 feet.

***BNSF and Sound Transit, Slope Stability Study, Seattle to Everett, WA.*** A study was conducted to evaluate the relative risk of landslide impacts to a commuter rail route along an existing BNSF mainline route at the toe of steep bluffs on the east shore of Puget Sound. The study included review of literature and a time series of aerial photographs. Maps and data bases were prepared showing landslide characteristics, including type, size, geology, and dates. A statistical analysis was conducted to identify various levels of landslide risk to route segments. Information was used to develop potential mitigation measures and identify high risk sites where those measures would be implemented.

***City of Seattle Public Utilities, Seattle Landslide Study, Seattle, WA.*** As Project Manager, Bill managed this study, which involved the compilation of records for 1,436 landslides, field verification, geographic information system (GIS) presentation, generic engineering recommendations for remediation of instability, and revision of landslide-prone zones. Made presentations to City Council and staff meetings, and at public forums regarding the results of the study.

***Seattle Public Utilities, Landslide Prioritization Study, Seattle, WA.*** After completing the Seattle Landslide study, Shannon & Wilson, with Bill as Project Manager, created a prioritization methodology to rank the 50 landslide areas that were identified in the study, and calculated preliminary cost estimates for remediation. This prioritization allowed the public utility to plan capital expenditures for protection of facilities from landslide damage.

***City of Bellevue, Geologic Hazards Updates for Growth Management Act (GMA), Bellevue, WA.*** In 2002, Bill performed a review of geology and its relationship with hazards and erosion hazards. He collected all existing data, created hazard maps, provided recommendations for revisions to city codes, and presented the results to the committee for GMA update.

***Seattle Public Utilities, Atlas Place Drainage Improvements, Seattle, WA.*** Project Geologist for slope stability evaluation project in southwest Seattle. The goal of the project was to evaluate the risk to public utilities that traverse a known landslide area in a residential community. Subsurface explorations and geologic reconnaissance were performed and used in conjunction with previous explorations that had been performed the project area to evaluate geologic and hydrogeologic conditions. Slope stability analyses were performed and recommendations presented for protecting the utilities.

***King County Transportation, 1996 Emergency Auburn-Black Diamond Road Landslide Studies, King County, WA.*** This landslide remediation project was located at the 13800 block of Auburn-Black Diamond Road in King County. The project involved restoration of approximately 175 lineal feet of roadway that was threatened by landsliding on the downhill side of the roadway as a result of heavy rainfall. As Project Geologist, Bill provided recommendations for constructing a geotextile-reinforced wall on the downhill side of the road and installing an interceptor drain upslope of the roadway. He also assisted with developing plans and specifications and monitoring construction, and presented the results at public meetings.

***King County Transportation, 1997 Emergency Landslide Studies, King County, WA.*** Completed slide remediation studies at 23 sites in 1997 for King County following the 1996/1997 Holiday Storm. As Project Geologist, Bill conducted preliminary field evaluation and prepared exploration plans for landslides affecting roadways. He managed explorations and aided engineers in formulation of remedial measures.

***City of Seattle, Magnolia Bridge Slide, Seattle, WA.*** Seven residences were endangered and a major arterial bridge was partially destroyed from a 100-meter-wide landslide. As Project Geologist, Bill managed subsurface explorations, interpreted the geologic conditions causing instability, and met with residents to explain the geologic and stability conditions. He provided on-site monitoring during construction of remedial measures.

***City of Seattle, Garfield Street Slide, Seattle, WA.*** Bill was the Project Geologist for a two-stage stabilization of a seep seated landslide 250 meters wide and 50 meters high, that closed a bridge on-ramp at the toe, and threatened 10 residences at the top of the slope. His exploration program allowed interpretations of the subsurface conditions, and then the slide was stabilized with a combination of deep drainage trenches, retaining walls, vertical wells, horizontal wells, and horizontal directional drilling.

***City of Seattle Department of Parks and Recreation, Evaluation of 17 Landslides, Seattle, WA.*** As Project Manager, Bill guided City of Seattle Department of Parks and Recreation and Seattle Public Utilities during evaluation of 17 landslides in 1997. He performed initial reconnaissance (including initial temporary stabilizing recommendations), managed explorations, and interpreted geologic and stability conditions. In 1997, presented geologic/geotechnical conditions at four contentious public meetings. In 1998, made informational presentations at four public meetings for two public agencies on landslide-initiating conditions. (1997)

***City of Seattle Public Utilities, Landslide Prevention Public Information Meetings, Seattle, WA.*** In 1999, 2000, and 2001, Bill organized a group of geotechnical engineers and geologists to deliver three public informational meetings regarding landslide causes and prevention for three Seattle neighborhoods. He created a syllabus and then acted as presenter at public meetings.

***Seattle Public Utilities, Landslide Prevention Public Meetings, Seattle, WA.*** Beginning in 1999 and continuing to the present, Bill has helped organize and then present information to the public regarding causes and prevention of landslides with Seattle Public Utilities and Seattle Department of Planning and Development.

***City of Kelso, Three Rivers Estates, Kelso, WA.*** From 1998 through 2002, Bill worked as an Independent Geologic Reviewer for the City of Kelso for geotechnical/geologic work that was performed by other consultants for a large proposed residential subdivision that contained four landslides that were 50 to 100 meters wide and 300 to 400 meters long. Reviewed documents, met with City officials and the developer, and made recommendations about developer's geotechnical reports.

***Peru Ministry of Transportation, Central Highway Evaluation, Lima, Peru.*** In 1997, Bill served as Project Geologist and performed an evaluation of rock and soil stability for 200 kilometers of the Central Highway in the central Andes, east of Lima, Peru. His team created a modified ranking system for rock slopes and a new system for prioritizing landslides, and then performed reconnaissance and recommended remedial measures on the top 100 sites.

***Seattle Public Utilities, Spot Drainage Study, Seattle, WA.*** As Project Manager, Bill provided engineering recommendations, subsurface characterization. In 1999, Shannon & Wilson worked closely with R. W. Beck, Symonds Consulting Engineers, and Herrera Environmental to provided geotechnical services on 12 projects involving unstable slopes, ground settlement, erosion control, and subsurface drainage. Shannon & Wilson engineers and geologists provided subsurface characterization and design criteria to the design engineers for direct incorporation into project drainage.

***Seattle Public Utilities, Alki/Duwamish Head Landslide Stabilization, Seattle, WA.*** As Project Manager, Bill was responsible for landslide evaluation and providing stabilization measures for a 1,400-foot-wide landslide in glacial soils. Shannon & Wilson was retained to provide landslide evaluation and stabilization plans and specifications, and community involvement for this very large West Seattle landslide. A combination of deep interceptor drains and horizontal drains was used to stabilize the unstable slope.

***Seattle Public Utilities, Burke-Gilman Drainage Basin Studies, Seattle, WA.*** Project Manager and Geologist. Provided reconnaissance of steeply sloping drainage basin that is tributary to Lake Washington, and identified 20 potential landslide problem areas that may affect water supply, storm sewers, and sanitary sewers. Preliminary cost estimates were produced for remedial measures for each potential problem area.

***Burlington Northern Railroad, Index Slide, Index, WA.*** As Project Geologist, Bill performed explorations, geologic reconnaissance, and construction monitoring for the Index Slide on the Burlington Northern Railroad. The slide occurred in glacial lake clay that was interbedded with saturated sand lenses, causing periodic uplift of the mainline track. A row of vertical relief wells was installed to dissipate uplift pressure.

***Lummi Shore Road/Lummi Drive Roadway Repairs, Whatcom County, WA.*** Bill served as Project Manager and Geologist for shoreline protection and roadway repairs for Lummi Shore Road and Lummi Drive on Lummi Island Reservation. The scenic roadway had been unstable since its construction due to groundwater pressure and wave erosion in Bellingham Bay.

***Taiwan Ministry of Transportation, Alisan Highway 18, Taiwan.*** Bill was Consulting Engineering Geologist for a very large landslide on a key highway in central Taiwan. The slide is bounded by two active faults and triggered by torrential precipitation during typhoons. He provided advice to the federal ministry of transportation on the causes and remedial measures for the landslide.

***City of Issaquah, Issaquah Highlands Peer Review, Issaquah, WA.*** Bill was Principal-in-Charge of the peer review team that with the City of Issaquah to review the operation of stormwater infiltration systems as part of the stormwater management program for the Issaquah Highlands development. The City requested the review following the January 30, 2004, Camp Creek Landslide.

***Skagit County Public Works, South Fidalgo Island Stormwater Management Plan, Skagit County, WA.*** Bill worked with civil engineers and planners to evaluate the effects of surface stormwater on erosion and slope stability in a geologically and topographically complex area of increasing population density. He reviewed existing geologic information, performed detailed site reconnaissance, and proposed projects to reduce existing and potential erosion and stability problems owing to stormwater. He also presented preliminary and final results in public meetings.

***City of Bellevue, Bellevue Critical Areas, Bellevue, WA.*** As Principal-in-Charge and project geologist, Bill was responsible for coordinating and performing map studies (including field verification) to update faults and landslide prone areas and municipal code update for the City of Bellevue. He also attended a council meeting to present his findings and respond to questions about the critical areas.

***City of Woodinville, Woodinville Sensitive Areas Ordinance Update, Woodinville, WA.*** As Principal-in-Charge and project geologist, Bill was responsible for reviewing existing geologic and topographic information, performing field reconnaissance, analyzing city code, and developing draft regulations for the geologic hazards section of the municipal code of Woodinville.

EXPERT WITNESS

***US Navy, Indian Island Annex Road System, Port Townsend, WA.*** In December of 1984, Bill completed over a year of studies, made on behalf of the U.S. Navy, and related to a large construction claim on the earthwork portion of 7.5 miles of roadway. He provided witness services at the Armed Services Claims Review Board hearing in Arlington, Virginia.

***SR-82 Interchange, Goodfellow Bros. Construction v. State of Washington, Donald, WA.*** Bill was Project Geologist for the contractor for highway construction claims regarding an issue of borrow materials used for a new interchange for SR-82 just south of Yakima.

***Berg Construction v. U.S. Navy, Geologic Studies, Aleutian Islands, AK.*** Bill completed geologic studies for construction claim by a contractor in residual and glacial soils and basalt rock at Amchitka, near the western end of the Aleutian Island chain.

***Alki Slide Litigation, The Alki v. City of Seattle, City of Seattle Law Department, Seattle, WA.*** Bill provided geologic consulting for Seattle Law Department for defense against a homeowner's

suit against the City. Worked with an attorney to develop stability analysis and provide courtroom testimony.

***Testimony for Various Puget Sound Area Landslides, WA.*** Bill has consulted with and testified for numerous claimants and defendants regarding landslides in the Puget Sound area including the precedent-setting Alki Slide for Seattle Public Utilities, where an explanation of the geologic conditions was instrumental in winning the case.

***Jansen v. Easterday, Wallula, WA.*** Bill performed a review of legal and technical documents and a geologic reconnaissance, and then wrote a summary report of findings for defendants in a large pipe burst/washout on desert slopes above the Columbia River. His analysis and litigation aid helped the defendant reach an equitable settlement of the case.

***Curtis Road Improvement, Weber Construction v. Spokane County, WA.*** In 2001, Bill evaluated a changed conditions claim for a contractor who encountered unanticipated boulders in a rural road alignment. Geologic interpretation was one of the key points in the success of this case.

***Corporation of Delta v. BC Hydro, Delta, British Columbia.*** In 2006, Bill evaluated routes for a new electrical cable crossing of the Fraser Delta to Vancouver Island that was intended to go through Delta, BC. Bill worked with Delta's attorney to develop and defend alternative routes and testified in provincial hearings against BC Hydro's routes.

***Cain v. Highline Water District, Burien, WA.*** In 2005, Bill analyzed and presented testimony for the plaintiff in their claim against the Highline Water District, in which a water distribution on a steep hillside broke. The released water partially buried three houses at the bottom of the hillside.

***MacHugh v. South Columbia Basin Irrigation District, Pasco, WA.*** In 2007, Bill is working for an irrigation district in defense of a suit by an orchard owner at the toe of a steep slope that incurred a landslide in 2006 along the Columbia River.

***Widener v. King County, King County, WA.*** In 2009, Bill evaluated claims that an emergency landslide mitigation damaged residential property by construction vibration, increased surface water, and groundwater flows. The claim was that these changes caused slope instability and sinkhole development. Mr. Laprade testified in Federal Court for the County.

***Morton-Glenoma Landslides, Lewis County, WA.*** In 2009, a large and intense storm system caused landslides throughout eastern Lewis County, resulting in widespread slope instability. Particularly hard hit were the forest lands of Olympic Resource Management. Bill Worked with foresters and attorneys to determine causes and provide expert consultant services regarding claims against the timber company.

***Bachwitz v. City of Seattle, Seattle, WA.*** In 2010, Bill evaluated a landslide in the Magnolia neighborhood for the City. He provided consulting regarding the causes, and then managed the exploration, engineering and construction monitoring efforts to design remedial measure to stabilize the landslide.

***Webster Lake Drainage, Maple Valley, WA.*** Bill evaluated a landslide that severed a King County roadway near Maple Valley, WA. The landslide was caused by significant runoff from a

working sand and gravel mine. He provided expert testimony in King County Superior Court regarding the causes of the landslide.

***Crenna Landslide, Whidbey Island, WA.*** A landslide initiated on the outside edge of a road on a very steep hillside on the western shoreline of Whidbey Island in 2011, destroying a house close to the toe of the slope. Bill worked for the homeowner's attorney, gathering evidence, consulting with the attorney, and giving depositions. Eventually, the case was settled in favor of the homeowner.

***Harrison Ridge Greenbelt Landslide, Seattle, WA.*** Bill evaluated a landslide for the City of Seattle Attorney's Office that occurred on private property, on the edge of a City greenbelt area. The plaintiff claimed that revegetation activities in the park had caused destabilization of the hillside. Bill visited the site, reviewed historical documents, conferred with the defense attorney, and wrote an opinion report prior to the settlement of the case.

***Jackson v. City of Seattle, Kenmore, WA.*** In 2009, a landslide initiated from the edge of the City of Seattle's Tolt water supply pipeline right-of-way, and damaged a residence at the toe of the steep hillside. The homeowner plaintiff claimed that uncontrolled surface water flow and old fill associated with the pipeline construction in the 1960s had caused the landslide. Through document detective work and a site visit, Bill helped the defendent City of Seattle to come to a minor settlement, because the actual causes included actions taken by the homeowner.

***Panaview Landslide, Everett, WA.*** In 2011, a large landslide occurred on the edge of a steep hillside in the southeastern corner of Everett. Bill has provided field reconnaissance, planning of explorations, evaluation of landslide mechanics, analysis of subsurface data, and consultation with the defendant's attorneys.

FOREST LANDS

***Hampton Tree Farms, North Cascades, WA.*** Bill completed more than 30 reports on the suitability of road construction and timber harvesting on steep and sensitive slopes in the North Cascades, including recommendations for forest practices.

***ITT Rayonier, Mass-Wasting and Erosional Processes Evaluation, Forks, WA.*** As Project Geologist, Bill evaluated mass-wasting and erosional processes on a proposed timber cut for ITT Rayonier and wrote the earth section for the Draft Environmental Impact Statement.

***Weyerhaeuser, Watershed Analysis, Olympic Peninsula, WA.*** Bill performed mass-wasting and surface erosion modules of watershed analysis for the Weyerhaeuser Company in the McDonald Creek drainage basin on the eastern side of the Olympic Peninsula in preparation of timber cutting in the basin. He served as Project Manager.

***Weyerhaeuser, Watershed Analysis, Willapa Headwaters and Stillman Creek, WA.*** Bill completed the mass-wasting module for watershed analyses in the Willapa Headwaters and Stillman Creek watershed administrative units for the Weyerhaeuser Company. This involved analyzing aerial photographs and field reconnaissance to create a landslide inventory, writing the mass wasting module report, and participating in the synthesis, handoff, and prescription phases of the process. He served as Project Geologist.

***Plum Creek Timber Company, Harvest Unit Evaluation, Roslyn, WA.*** Bill has evaluated 15 proposed harvest units for their susceptibility to slope instability and erosion in volcanic and sedimentary rocks and alpine glacial soils in the Taneum, Yakima, Cooper, and Cle Elum drainages.

***Weyerhaeuser Company, North Cascade and Columbia River Tree Farms, WA.*** Since early 2014, Bill has been performing timber harvest and logging road evaluations in steep and unstable ground in the North Cascades and in the southeastern and southern forest lands. Thus far, this has included more than 35 sites. Additionally, he has been consulted and given opinions on the suitability for harvesting in areas on the suburban fringe.

***International Paper, Timber Harvest Units, South Fork Chehalis River, WA.*** As Project Geologist, Bill completed a comprehensive mass-wasting study of 31 proposed timber harvest units in the South Fork Chehalis River watershed, including mass-wasting module of watershed analysis and geotechnical review of road and harvesting plans.

***Hampton Tree Farms, Southwest WA.*** Bill has completed more than 40 timber harvest and road evaluations in steep, mountainous terrain in geologic conditions of mixed sedimentary and volcanic rocks in southwest Washington; and 20 evaluations in the metamorphic, sedimentary soils and glacial sediments of the North Cascades.

***Longview Timber Corporation, Cascade Mountains, WA.*** Bill performed 35 evaluations of harvest units and logging roads, from the Columbia Gorge to the North Cascades to support Forest Practice Applications.

## HIGHWAYS, STREETS & ROADS

***Grays Harbor County, Wishkah Road, Grays Harbor County, WA.*** As Project Geologist, Bill performed engineering geologic reconnaissance, managed the exploration program, and completed rock-slope stability analyses for a widened roadway cut into a 100-foot-high sedimentary rock bluff of the Montesano Formation with existing stability difficulties at Wishkah Road, Grays Harbor County, Washington.

***Montana Dept. of Transportation (MDT), Beartooth Highway Debris Flow Damage Emergency Repairs, Carbon County, MT.*** Bill Laprade is the co-Principal-in-Charge for Shannon & Wilson's work on the Beartooth Highway repair project. The day after notice-to-proceed was received, Bill was on the mountain evaluating the damage and mapping geologic conditions necessary for engineering decisions. Prior to ground surveying being completed, he prepared field sketches of the geologic conditions and morphology of the two debris flows, Bradshaw and Strecker. Using these annotated sketches and his evaluation of the relative condition of the slopes, preliminary decisions were made regarding project schedule, types of remedial measures, and personnel necessary to perform the geotechnical aspects of the project. He also worked with hydrologists to plan preliminary drainage improvements in the upper drainage basin to reduce the risk of future debris flows caused by rain-on-snow events.

***Seattle Department of Transportation, Golden Gardens Drive NW, Seattle, WA.*** Bill is Project Manager and Engineering Geologist for a washout that severed a 50-foot section of a main arterial. He performed a geologic reconnaissance, supervised exploratory drilling, interpreted geologic conditions, and managed engineering studies. Through an expedited alternatives

evaluation, the design team chose a preferred alternative, and the project will be constructed by October 2008.

***King County Roads and Engineering Division, Auburn-Black Diamond Road Landslide, Wynaco, WA.*** As Project Geologist and Principal-in-Charge, Bill evaluated the geologic conditions, planned the subsurface explorations, and determined the slide plane for an 800-meter wide deep-seated landslide in glacially overridden soils. His observations, working with geotechnical engineers, led to the stabilization of the large landslide that blocked a major road for several months.

***Utah Department of Transportation, Provo Canyon SR-189 Widening, Provo, UT.*** As Project Geologist, Bill accomplished engineering geologic reconnaissance for a 20-mile long corridor and wrote a technical report and geologic portion of the Environmental Impact Statement (EIS) for a large highway realignment in a mountain canyon for the Provo Canyon SR-189 Widening.

***Utah Department of Transportation, Provo Canyon Environmental Impact Analysis, Provo, UT.*** Bill served as Project Geologist and performed reconnaissance of Interstate I-72 corridor, made preliminary recommendations for landslide and rock slide stabilization, and presented the results at three public forums.

***FHWA, Coffman Cove Road, Prince Of Wales Island, AK.*** Project Manager for geologic site reconnaissance and assistance with the bid document preparation for the Coffman Cove Road upgrade. The project would upgrade a 4.8 km (3.0 mi) segment of single lane logging road to a double-lane public highway and improve access to the town of Coffman Cove and the surrounding Tongass National Forest.

***FHWA Ward Lake Road, Ketchikan, AK.*** Bill managed geotechnical explorations and engineering for two miles of new road and bridges in rugged terrain in glacial soils and metamorphic rock, and two miles of upgraded existing gravel road for Ward Lake Road in Ketchikan. He served as Project Geologist.

***FHWA Pioneer Mountains Scenic Byway in Polaris, MT.*** This project included 16 miles of new and upgraded road in valley bottom alluvium and steep mountainous terrain with glacial deposits and metamorphic rocks. Bill served as Project Manager and Geologist.

***City of Bellevue, Lakemont Boulevard, Bellevue, WA.*** Provided geotechnical recommendations for the 1.8-mile-long Lakemont Boulevard in Bellevue with a mixture of landslide deposits, glacial deposits, and Blakely Formation sandstone. Considerations included a steep-sided, landslide-prone canyon and 1,000-foot-long bridge. Bill served as Project Manager and Geologist.

***FHWA 17-Mile Council-Cuprum Road Upgrades, Council, ID.*** As Project Manager and Geologist, Bill evaluated 17 miles of two-lane forest road that would be paved in mountainous terrain near Council. Work included a geologic reconnaissance, excavation of 50 test pits, evaluation of subgrade soils for pavement, pavement design, design of a 40-foot embankment, and bridge foundation design.

***HDR, Mahoney Lake Hydroelectric Project, Ketchikan, AK.*** Bill completed geologic reconnaissance and a Geologic and Soils Report for FERC license application for Mahoney Lake Hydroelectric Project near Ketchikan where hornfelsed shale underlay the project in extremely precipitous topography.

## PROFESSIONAL ASSOCIATIONS

Association of Engineering Geologists
Geological Society of America, Fellow
Northwest Geological Society, Past-President
American Water Works Association
Washington State Geologist Licensing Board, Past Member

## YEAR JOINED FIRM

September 1973

## PUBLICATIONS

"Surface Mine Spoil Stability Evaluation, Interior Coal Province," by R.P. Miller, P.M. Douglass, R.A. Robinson, D.A. Roberts, and W.T. Laprade, U.S. Bureau of Mines, 1979, 737 p. (available from National Technical Information Service, PB 80-211113 and PB 80-211121).

"Geologic Implications of Pre-Consolidation Pressure Values, Lawton Clay, Seattle, Washington," by W.T. Laprade, Proceedings, 19th Annual Symposium on Engineering Geology and Soils Engineering, Pocatello, Idaho, 1982.

"Building Codes for Construction on Steep Slopes in Western Washington," by W.T. Laprade, Engineering Geology in Washington, Washington Division of Geology and Earth Resources Bulletin 78, Vol. I, 1989, p. 151-156.

"Engineering Geology in Urban Areas: Introduction," by W.T. Laprade, Engineering Geology in Washington, Washington Division of Geology and Earth Resources Bulletin 78, Vol. II, 1989, p. 637-638.

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"Engineering Geology of the Downtown Seattle Transit Project," by W.T. Laprade and S.R. Thompson, Engineering Geology in Washington, Washington Division of Geology and Earth Resources Bulletin 78, Vol. II, 1989, p. 667-680.

"Geology of Seattle, Washington, United States of America," by R.W. Galster and W.T. Laprade, Bulletin of the Association of Engineering Geologists, Vol. 28, No. 3, 1991, p. 235-302.

"The Geology of Queen Anne Hill," by W.T. Laprade, Queen Anne: Community on the Hill, K.F. Reinartz, ed., Queen Anne Historical Society, Seattle, Washington, 1993, p. 1-6.

"Engineering Geology of Seattle and Vicinity," by R.W. Galster, W.T. Laprade, and B.R. Beaman, Geologic Field Trips in the Pacific Northwest, D.A. Swenson and R.A. Haugerud, eds., Geological Society of America, 1994, Vol. 2, p. 2D1-16.

"Use of Geoscience Information by the Consulting Geoscientist Community," by William T. Laprade, in The Costs and Values of Geoscience Information, by Connie J. Manson, ed., Proceedings, 32nd Meeting of the Geoscience Information Society, Salt Lake City, 1997, Vol. 28 p. 5-13.

"Woodway Landslide – A Reminder and an Opportunity," by W. Laprade, W. Gilbert, and W. Hultman, Landslides in the Puget Sound Region, American Society of Civil Engineers, Seattle Section, Geotechnical Group, April 4, 1998.

"Sliding in Seattle: Test of a Model of Shallow Landsliding Potential in an Urban Environmental," by D.R. Montgomery, H.M. Greenberg, W.T. Laprade, and W.D. Nashem, in Land Use and Watersheds: Human Influence on Hydrology and Geomorphology in Urban and Forest Areas, edited by M.S. Wigmosta and S.J. Burges, American Geophysical Union Water Resources Monograph, 2001, p. 59-73.

"Probabilistic Assessment of Precipitation-Triggered Landslides Using Historical Records of Landslide Occurrence, Seattle, Washington," by J.A. Coe, J.A. Michael, R.A., Crovelli, W.Z. Savage, W.T. Laprade, and W.D. Nashem, Vol. x, No. 2, Environmental & Engineering Geoscience, 2004, p. 103-122.

"Effects of Urbanization and Development on Mass Wasting," by W.T. Laprade, in Landslides and Society, edited by A.K. Turner and R.L. Schuster, Proceedings of the First North American Conference on Landslides, The Association of Environmental and Engineering Geologists, 2007, p. 367-384.

"Landslide Mapping in Seattle," by W.T. Laprade and D.W. Tubbs, in *Landslides and Engineering Geology of the Seattle, Washington, Area*, edited by R.L. Baum, J.W. Godt and L.M. Highland, The Geological Society of America, Reviews in Engineering Geology XX, 2008, p. 37 – 54.

"Seattle Landslide Study: 12 Years Later," by W.T. Laprade and J.J. Lee, in Landslide and Engineered Slopes; Protecting Society through Improved Understanding, edited by E. Eberhardt, C. Froese, A.K. Turner, and S. Leroueil, 2012, p. 251-255.

"Challenging Soils in Seattle, Washington," by W.T. Laprade, in Geo-Strata, v. 16, no. 6, 2012, p. 24-30

# Christopher A. Robertson, PE, LEG | Vice President

## EDUCATION

MS, Civil Engineering, University of California at Berkeley, 1991
MS, Geology, University of Washington, 1981
BS, Geology, University of Washington, 1976

## REGISTRATION

Registered Professional Engineer, WA, 30636, 1993
Registered Professional Engineer, AK, 11845, 2007
Registered Professional Geotechnical Engineer, CA, GE 2471, 1999
Certified/Licensed Engineering Geologist, OR, E1117, 1993

## PROFESSIONAL SUMMARY

## TECHNICAL EXPERIENCE

Chris Robertson has considerable expertise in evaluating debris flow and debris torrent hazards and their mitigation alternatives. Recently, Chris provided recommendations for debris torrent mitigation measures along the Beartooth Highway in Montana. His recommendations included flexible debris flow barriers and diversion berms. For a series of large debris torrents that blocked a three-mile stretch of Interstate Highway I-84 in Oregon, he recommended alternatives to protect the highway, railroad and residents from future debris torrents. The area is in the Columbia River National Scenic Area, which imposed severe limitations on the types of works that could be built. In Peru, He mapped and evaluated about 50 debris torrent areas that affect the Central Highway. Based on this work, Chris prioritized the hazard sites in the extent of the hazard, likely recurrence, and suitability of the site for remedial measures. For two sites, he designed bypass channels to convey the debris over the highway. During Holiday Storm in Seattle, Washington, Chris made recommendations to homeowners regarding the risks to their homes from future debris flows, and alternatives for reducing the hazard, including slope stabilization, walls and diversion structures.

## DEBRIS FLOW EXPERIENCE

***Snohomish County, Preliminary Geotechnical Study for Index Galena Road Milepost 6.4 to 6.9 Flood Repairs Project, Near Index, WA.*** Geotechnical Principal-in-Charge. After completing feasibility studies, Chris developed a subsurface exploration program that included borings drilled using helicopter-transported remote-access drilling rigs, and seismic refraction surveys. Using the new subsurface data, Chris led geotechnical engineering studies to develop preliminary geotechnical engineering recommendations. He made recommendations for a new roadway alignment that would be about 1,800 feet shorter, and would avoid geotechnical hazard areas. His design recommendations included debris flow hazard mitigation, slope stability improvements, and earthwork, retaining wall and rockfall hazard mitigation recommendations. Chris' team is now completing final design studies.

***Chelan County Department of Public Works, Whispering Pines, Chelan County, WA.*** Debris flows affected lots in the Whispering Pines subdivision near Lake Wenatchee several times in the past few decades. At least one house was destroyed. Chris mapped debris flow hazard areas for the County to use for land use planning.

***Union Pacific Railroad, Emergency Cleanup, Dodson, OR.*** The Dodson landslides and debris flows occurred during the flood of 1996 burying Interstate I-84, the UPRR, and several houses. The total volume of debris was between 1 and 1.5 million cubic yards. Chris represented UPRR on a multi-agency technical task group evaluating the causes of the landslides, the risk of similar future landslides, and mitigation alternatives. The task group included representatives of the US Forest Service, the Oregon Department of Transportation and the Dodson School. He assisted the other team members in mapping the extent of the debris flows and resulting damage, evaluating the causes, likely recurrence and risk. He was responsible for evaluating and recommending conceptual designs for mitigation alternatives. His work included delineating hazard zones, evaluating the amount of warning time in event of future debris flows, and determining design parameters for the debris flows, including size and velocity. The task group produced a report that is being used by Multnomah County, the Columbia Gorge National Scenic Area Commission, and other agencies for hazard management and land use planning. Chris made presentations regarding hazard mitigation alternatives at Multnomah County hearings about the damage and future hazards to residences and travelers.

***Montana Department of Transportation (MDT), Beartooth Highway Debris Flow Damage Emergency Repairs, Carbon County, MT.*** Project consultant. Two large debris flows damaged the Beartooth highway in 13 locations as they scoured the mountainside and crossed multiple switchbacks. Chris provided expertise in debris flow evaluation, mitigation alternatives and design. The newly scoured channels are more prone to debris flows because of steep unstable sidewalls and shallow loose debris over bedrock. Using empirical models and a probabilistic study, he estimated debris flow magnitude, recurrence, and design parameters such as peak debris flow discharge, velocity and surge volume. Chris then developed conceptual alternatives including, doing nothing, armoring the roadway, debris catchment fences, diversion berms, catchment walls, bypass chutes and debris sheds. He provided MDT with guidance for selecting appropriate hazard mitigation alternatives that balanced risk and cost, and then directed design for the selected alternatives. The flexible debris flow barriers, which are the tallest in North America, are combined with excavations in soil and rock to provide larger catchment storage volume and confinement of the debris flows to the protected areas. Chris provided guidelines for making the new cut slopes including location, depth and cut slope angles. 8-2005 CAR:CLW

***Black & Veatch, City of Bellingham Middle Fork Nooksack River Diversion Dam and Intake, Whatcom County, WA.*** Chris participated in a Value Engineering study for a project to remove an existing concrete gravity dam, and replace it with a damless intake for the City of Bellingham water supply. The existing dam, which was built in the 1950s has deteriorated and blocks fish passage. The proposed scheme would use concrete abutments to constrict the mountainous stream, creating a deep pool for the intake. However, the proposed scheme, had a high construction cost and would have created a 50-foot high, nearly 20 percent slope that likely would not have improved fish passage. Therefore, the VE team recommended moving the intake structure 400 to500 feet upstream, which would flatten the stream grade, and eliminate costly deep excavations required for the pipe conveying water to an existing conveyance tunnel. Chris provided conceptual geotechnical design recommendations for the proposed new site. Following the VE study, Chris led geotechnical design studies to develop alternatives with an intake downstream from the dam. These included lowering the 9,000-foot long tunnel invert, constructing a new tunnel, and constructing a siphon to deliver water into the tunnel. He developed preliminary geotechnical recommendations for making rock excavations for an intake structure, debris torrent projection measures, foundations, modifications to the tunnel portals, and for a new pipeline downstream from the tunnel.

***Ministry of Transportation, Central Highway Improvements, Peru.*** Chris was responsible for evaluating debris flow hazards along the highway. He identified 50 sites where debris flows were likely or had occurred historically and then prioritized these sites in terms of potential hazard to the highway and made recommendations for improvements to reduce highway closures. At two sites, he recommended constructing a bypass channel that will intercept the debris flow upstream from the highway. From there a chute will convey the debris flow over the road discharge it into a stream that will naturally disperse the debris. His chute design was based on peak debris flow rates calculated using superelevated erosion scars on curves in the natural channel. The bypass chute design specified a cross-section and slope that should prevent deposition from occurring in the chute before it discharges into the river downstream. At one of the sites, he also recommended riprap protection for the natural stream channel to prevent channel migration away from the discharge point of the bypass channel. Chris supervised the civil design of these bypass structures and development of plans for the bid documents.

***HW Lochner, SR 542 North Fork Nooksack River Glacier and Gallop Creek Conceptual Foundation Studies, WSDOT Northwest Region, Mount Baker Area, Whatcom County, WA..*** Chris was the Geotechnical Principal-in-Charge for two Chronic Environmental Deficiency in and Glacier Washington. Debris flows affect the Gallop and Glacier Rivers in town, depositing and accreting cobbly and bouldery sediment. Therefore, the rivers are subject to frequent flooding and debris flows that could breach the existing channel banks and affect the existing bridges. Chris provided type, size and location recommendations for the conceptual design of new bridges over the Glacier and Gallop Rivers.

***Washington State Department of Natural Resources (DNR), Tiger Mountain Lower High Point Trail Footbridge, King County, WA.*** Principal-in-charge for this project to replace a trail footbridge in Tiger Mountain State Forest. In 2009, the existing High Point Creek trail footbridge was damaged from flooding and debris flow. The DNR wanted to replace the damaged footbridge with a 200-foot-long bridge constructed at a higher elevation to accommodate debris flows and flooding. We provided foundation recommendations for a single-span cable suspension bridge and for a three span truss bridge. We performed a geologic reconnaissance and three hand borings to evaluate the subsurface conditions and geologic hazards. Because the site cannot be accessed by vehicle, construction equipment and materials would need to be carried 1.2 miles to the site or flown to the site via helicopter.

## OTHER SLOPE STABILITY EXPERIENCE

***Alyeska Pipeline Service Company, Main Line Refrigeration Unit 2, Trans Alaska Pipeline System (TAPS) Milepost 653, AK.*** A buried section of TAPS that is about 200 miles south of Fairbanks is actively refrigerated to maintain thaw-unstable permafrost. Alyeska observed cracking in the ground surface above the pipeline, indicating that the embankment may be moving. Ground temperature and inclinometer data indicate that the ground around the pipeline is not frozen and the embankment is moving toward the pond. As principal-in-Charge, Chris is directing analyses and developing design recommendations performing analyses and developing design recommendations to protect the pipeline from the slope movement. ***2015 – ongoing***

***Alyeska Pipeline Service Company, Jim River Pingo, Trans Alaska Pipeline System (TAPS) Milepost 271, AK.*** Near Pipeline Milepost 271, TAPS crosses over an open-system pingo (a mound of earth covered ice). The size of the pingo has changed since the pipeline construction causing vertical that support the pipe to tilt and, in some cases, jack out of the ground. Chris is the principal-in-charge responsible for exploring the site with two 100-foot deep borings, and

installing thermistor strings and vibrating wire piezometers to collect subsurface information that will be used to design new foundations at two bents. (2015)

***Bonneville Power Administration, Raymond-Cosmopolis, Grays County, WA.*** BPA is replaced an 18-mile long 115-kV transmission line supported on old steel lattice pole towers with new steel pole single-circuit towers directly embedded in the ground. Additional right-of-way clearing was required in an area that is managed for timber production. Chris managed geotechnical and forest practice act studies for the tower replacement project. The geotechnical studies provided BPA with design recommendations for the tower foundations with emphasis on the angle towers, which have large lateral loads. The forest practice studies concentrated on areas underlain by soil identified by the Washington DNR as having high erosion and/or landslide potential. The forest practice study provided recommendations for reducing erosion and landslide hazard associated with the clearing.

***HW Lochner, SR 542 North Fork Nooksack River, MP 37.67 Chronic Environmental Deficiency Site – Tension Cracks, WSDOT Northwest Region, Mount Baker Area, Whatcom County, WA.*** Principal-in-Charge. At a site east of Glacier, the highway is on a bench cut in a 45-degree, 60-foot high slope directly above the Nooksack River. The roadway has been slumping and settling for years. Chris' team explored the subsurface conditions, installed instruments to monitor groundwater levels and ground movement. The subsurface explorations showed the settling roadway sections are underlain by poorly compacted sidecast fills. Chris provided recommendations for alternatives to mitigate the ongoing settlement, including overexcavating and replacing the sidecast fill with densely compacted structural fill, moving the highway into the hillside so it is on a full bench cut section, and several retain wall options.

***Interwest Construction, Seattle City Light Ross Lake Barge Landing Rockfall Barrier and MSE Wall, Ross Lake, WA.*** Chris directed foundation studies for an anchored, flexible rockfall barrier and an MSE wall. The barrier protects the barge landing that was reconstructed after a it was demolished by a large rock landslide. The barrier foundations are constructed in loose talus from the recent rock landslide. Chris provided alternatives for two rockfall barriers that Interwest proposed, including. (S&W services and construction completed in 2016)

***Snohomish County, Jackson Gulch Road Landslide Repair, Snohomish Co., WA.*** Principal-in-charge. Slope movement has occurred at the Jackson Gulch site since before 1990. Repairs over the years have included soil excavation and replacement, drainage improvements, road realignment, and a soldier pile wall. In June 2011, the slope moved again, damaging the existing roadway. Chris proposed using spiral nails to reinforce the slope, because they could be installed from the roadway without disturbing a nearby wetland. A test program was implemented to demonstrate constructability and to evaluate pullout capacity for design. Chris oversaw the spiral nail design, 60, 90, and bid set plans and specifications, and prepared a spiral nail cost estimate for the project. (2014 to present)

***Snohomish County, Miller Road at Pioneer Highway Landslide Repair, Snohomish Co., WA.*** Principal-in-charge. In 2010 and 2011, slope movement in the Miller Road embankment near the intersection with Pioneer Highway, closed Miller Road. The landslide scarp extends 280 feet along Miller Road, and downslope 70 feet to the base of the embankment fill. The County closed Miller Road, but wanted to protect Pioneer Highway from progressive landslide movement. Excavating and grading Miller Road alone would not meet stability requirements and would require a shoreline permit. Therefore, Chris proposed using spiral nails to reinforce the slope between Miller Road and Pioneer Highway. A test program demonstrated the approach was

constructible and the pullout capacity for design. Chris oversaw the spiral nail design, the 60, 90, and bid set plans and specifications, and spiral nail cost estimate for the project. (2014 to present)

***Alyeska Pipeline Service Company (APSC), Thompson Pass Subsurface Drainage System, Trans Alaska Pipeline System (TAPS), AK.*** APSC installed a subsurface drainage system consisting of horizontal drains, collection galleries and piezometers to improve stability of fills placed on steep slopes south of Thompson Pass. The system has been operating but not maintained since the late-1970s. Chris performed an initial site reconnaissance to locate and evaluate the system component conditions. The area has overgrown with slide alder and other vegetation. The next project phase will include reviewing historical data and measuring system performance. With that information, Chris will develop recommendations for APSC for the need for continued system operation and maintenance. (2014 to present)

***City of Seattle Parks and Recreation, 8400 Block of Golden Gardens Drive NW and 3800 Block of Lake Washington Boulevard S. Landslide Repairs, Seattle, WA.*** Principal-in-charge. Heavy rain during the winter of 2010 triggered landslides at the 8400 Block of Golden Gardens Drive NW and the 3800 Block of Lake Washington Boulevard S. Chris developed repair concepts and then oversaw the geotechnical explorations and design. The Golden Gardens landside stabilization consisted of subsurface drainage and grading to improve surface water runoff. The subsurface drains consisted of parallel trenches along the fall line that were backfilled with pervious aggregate and a perforated collector pipe. The Lake Washington Boulevard high bluff peel off landslide did not require stabilization, but measures to prevent debris runout onto the road. Chris' design included regarding the slope with a berm to prevent debris runout. Construction was completed in 2014. 2013-2014.

***Lummi Nation, Skookum Creek Fish Hatchery, Intake structure Landslides, Acme, WA.*** Chris reviewed a series of landslides that occurred in a steep creek valley during road and pipeline construction for a hatchery water supply. The creek valley was marginally unstable without construction activities. The road and pipeline excavations triggered landsliding in colluvium and weak rock that dipped towards the creek. Chris provided conclusions and recommendations to assist the project insurer respond to a claim.

***City of Los Angeles, White Point Landslide, San Pedro, CA.*** Chris was the geotechnical principal-in-charge for exploring a large landslide, and preparing recommendations to maintain stability, protect adjacent properties, and restore City infrastructure. The landslide failed catastrophically in fall 2011, mobilizing about 250,000 cubic yard, destroying the road and utilities and threatening nearby properties. Chris' team explored the site on an emergency basis, using geologic mapping of the surface exposures and with wireline and bucket auger drilling. They installed instrumentation to measure ground movement and to characterize a complex hydrogeologic system. Their recommendations included dewatering using directional drilling, regrading, and high strength tieback anchors. Chris' team designed stabilization measures for the bluff between the landslide and seaside residences. The stabilization measures included grading the landslide to promote surface water runoff, directionally drilled subsurface drains, and ground anchors. The subsurface drains were installed using directional drilling to reduce shoreline impacts and permitting requirements. To our knowledge, they were the first directionally drilled subsurface drains in southern California. Chris' team developed plans and specifications, and provided continuous construction observation. Construction was completed in 2014.

***City of Seattle, Regional Landslide Study, Seattle, WA.*** Following the numerous landslides that occurred during and after the 1997 New Year's storm, the City of Seattle retained Shannon & Wilson, Inc. to conduct a regional landslide study. The purpose of the study was to determine where landslides have occurred in Seattle and determine slope stability improvements that the City could construct to reduce future damage to their property. Chris recommended and assisted with a study that included assembling a GIS database containing all of the landslides in the City records, Shannon & Wilson, Inc. records (with the clients permission) and other published records. Using this database, the landslides were characterized by type, geology, slope, size and other characteristics. The study provides general engineering recommendations for repairing and preventing landslides. It provides detailed descriptions of the landslide history and setting in three study areas: West Seattle, Madrona and Queen Anne/Magnolia. In 25 selected type areas, the study determined types of slope stability improvements that could be made to protect City property and their approximate cost. Based on this study, the City is beginning several programs to reduce landsliding in Seattle. These include a drainage study, redefining the existing mapped landslide hazard zones and homeowner education for residences living and landslide-prone areas. Follow up included prioritizing and budgeting for stability improvements.

***Pacific County, Monohon Landing Road Landslide, Raymond, WA.*** Pacific County maintains Monohon Landing Road, which extends across two landslide zones that are separated by about 500 feet. The landslides have had measurable movements since the roadway was built in the early 1900's. As principal-in-charge, evaluated the subsurface conditions, directed slope stability analyses to back-calculate the landslide strength properties, and analyze the static stability of the landslides. He provided slope stability remediation recommendations and quantity estimates to improve the roadway. (2009)

***Seattle Park Department, Kinnear Park Landslide Repair, Seattle, WA.*** Chris was responsible for preparing construction documents for landslide repairs, which included a deep subsurface drain, grading, and landscaping.

***Fischer & Sons, Oyster Creek Inn Stabilization, Skagit County, WA.*** The 70-year old Oyster Creek Inn was built on steep unengineered fill overlying weak weathered serpentinite bedrock. Slow deep-seated landslide movement has affected the Inn since it was built. As part of a design build team, Chris directed the engineering studies, design, plan development and environmental permitting to improve the slope stability and restore the restaurant. Access to the slope below the restaurant was limited to foot traffic and using a crane to lift equipment over the Inn. Chris' design used tieback anchors that transfer load from a reaction beam cast-in-place to the underlying bedrock. The lowest foundation wall was underpinned and reinforced. The work was accomplished without disturbing to Oyster Creek, which was less than 20 feet down a 45-degree slope from the reaction block. The project won excellence awards from American Society of Civil Engineers and the Associated General Contractors of Washington.

***Big Creek Hydro, Hyampom, CA.*** A penstock leak caused a landslide below a reaction block, which was on a remote ridge. Chris designed stabilization measures, including underpinning the reaction block, surface drainage measures, a shear key in the mobilized landslide block and regarding. Construction was completed with small equipment because of the access difficulties.

***L'Amourita Cooperative, Landslide Stabilization, Seattle, WA.*** The 1996-1997 storms remobilized a landslide that extends under a 10 to 15-foot high concrete retaining wall that was built in the early 1900's. The resulting movement damaged garages, stair access to the buildings, pavements, and threatened two apartment buildings and a historical residential cooperative

located upslope from the old wall. Based on borings drilled at the site, Chris concluded that the landslide failure surface was about 15 feet below the old retaining wall. He recommended constructing a soldier pile wall with tiebacks and using the existing concrete wall for lagging between the soldier piles. The new wall design accounts for the active forces exerted on the existing wall and the landslide forces both above and below the existing wall. Because of limited access to the site, helical anchors were used for the tiebacks. By using the existing concrete wall as lagging, the landslide was stabilized without disturbing the existing buildings and at a much lower cost than if the wall had been replaced. It also allowed construction during the wet season.

***King County, Landslide Evaluation, Vashon Island, WA.*** The 1997 New Year's storm reactivated a large landslide on the south end of the island. The landslide was actively moving for several months, damaging or destroying several houses and requiring frequent regrading and resurfacing of the King County road. The landslide is about 1700 feet wide and 500 feet long, with the main slide surface extending about 100 feet below the landslide mass. Chris evaluated the subsurface soil and groundwater conditions, landslide geometry and movement rates using seven borings, inclinometers, piezometers, field mapping, surveying and aerial photographs. Based on the subsurface information, he provided King County with alternatives and associated cost estimates for repairing the landslide. The alternatives included road maintenance, dewatering, constructing a toe buttress and regrading.

***King County, Landslide Stabilization, King County, WA.*** The 1997 New Year's storm caused a landslide that reduced 500 feet of the Whitney Hill Road to one lane. Chris assisted King County prepare Plans and Specifications to repair the landslide with a large counterweight berm and subsurface drainage. During construction, he provided recommendations regarding materials and for constructing subsurface trench subdrains and for constructing the counterweight berm on the steep slopes that remained following the landslide.

***King County, Landslide Stabilization, Kirkland, WA.*** Chris designed repairs for a landslide that affected the shoulder of Juanita Drive. He provided the County with alternatives to repair the landslide, including stormwater runoff improvements, subsurface drainage with trench subdrains, a drained toe buttress and a gabion retaining wall. The County constructed a drained quarry spall toe buttress, combined with stormwater runoff improvements.

***King County Landslide Evaluations, King County, WA.*** Project Manager. The 1997 New Year's storm caused numerous landslides in the Pacific Northwest. Chris evaluated numerous landslides that affected residences and King County roads. He provided owners and insurance companies with a professional opinion regarding the causes, remaining hazards of the landslides and possible repairs alternatives. Many of the residences had been "yellow tagged" by the City of Seattle, which required the owners to retain a professional engineer to evaluate the hazard before resuming full-time occupancy. He designed repairs for seven of the landslides. The repairs include underpinning, regaining walls, surface and subsurface drainage, toe buttresses and a large counterweight toe berm.

***Beachcrest Community Association, Slide Mitigation Study, Seattle, WA.*** The February 1996 storms caused several landslides that affected access roads to Puget Sound in the Beachcrest Community. Chris mapped areas that were prone to landsliding, evaluated the causes of the landslide and the effectiveness of an existing "curtain" drainage system. He conducted subsurface explorations to evaluate the subsurface conditions for two of the landslide that had the potential to block the main beach access road. Based on this work, Chris made recommendations

for repairing several landslides and improving drainage to improve stability in other high-risk areas.

***Burlington Northern Railroad Santa Fe Railroad (BNSF), Landslide Evaluation, Seattle to Portland, WA.*** Project Manager for a landslide evaluation and remedial design along the Burlington Northern Santa Fe mainline tracks. The landslide movement was crushing an existing timber soldier pile wall with rakers that was adjacent to the tracks. The explorations showed that the toe of the landslide does not extend under the track. Therefore, the primary hazard would be from landslide debris blocking the track. Chris designed landslide repairs that included subsurface drainage, regrading to promote runoff, and replacing the existing timber pile wall with a new braced steel H-pile wall.

***Burlington Northern Railroad Santa Fe Railroad (BNSF), Track Repairs, OR.*** Project Manager assisting BNSF with repairs to track segments that are subject to frequent rock fall along the Oregon Trunk. The rockfall occurs from nearly vertical basalt cliffs adjacent to the track that were cut in the early 1900's. Chris assisted BNSF in soliciting bids, evaluating the bids, selecting the contractor and scheduling the work.

***Harding Lawson Associates, Tacoma Eastern Railroad Storm Damage Repair Project, Tacoma, WA.*** Project Manager of geotechnical design. The project involved more than 50 landslides, track washouts, and two bridge replacements. Chris conducted the field reconnaissance, directed subsurface explorations, and designed landslide repairs. The landslide repairs included quarry spall fills, regrading, drainage, and soldier pile retaining walls. New pile foundations were driven for the two new bridge foundations. He prepared the plans and wrote the specifications for earthwork, pile foundations, subsurface drainage, and soldier pile walls.

***Harding Lawson Associates, Landslide Repairs, Portland to Tillamook, OR.*** More than 100 landslides occurred in the coastal mountains between Portland and Tillamook. Chris assisted with the initial plans and specifications for landslide, trackbed washout, revetment, retaining wall, and tunnel portal repairs. In a later phase, he directed field explorations at one repair site to replace an overturned gravity retaining wall. He recommended installing a small diameter soldier pile wall that could be installed without affecting fish habitat, and that could be drilled through the heterogeneous sidecast fill material and into the underlying bedrock. He provided design recommendations including lateral earth pressures for designing rock-socketed piles.

***Washington State Department of Transportation, Highway Repair, Mercer Island, WA.*** Movement of the temporary shoring system during construction of the Mercer Island lid over Interstate Highway I-90 resulted in ground cracks that could cause motion further upslope. Chris was a Project Engineer responsible for construction monitoring during grouting of open cracks. The grouting was accomplished to fill the ground cracks and thereby reduce future upslope movement. By mapping the position of grout takes in the inclined holes, Chris was able to map ground cracks that were not exposed at the surface. His mapping clearly showed the presence and distribution of ground cracks allowing the State to evaluate other properties that could be at risk. With this information, Shannon & Wilson provided an opinion about the likelihood of future movements and assisted the State with condemnation proceedings to acquire property affected by landsliding.

***Residential Slide Evaluation, Myrtle Creek, OR.*** Evaluated the potential for damaging floods that could result if landslides blocked a creek upstream from a residence in Myrtle Creek. Two landslides are active about 300 to 500 feet upstream from the residence. Based on field

reconnaissance mapping, Chris estimated likely landslide dam heights, and then used published empirical relations for dam breach flood routing to estimate possible flooding near the residence. He also provided recommendations for reducing the flood hazard to the residence by improving the creek channel and constructing low berms to divert flow away from the residence.

***City of Vader, Water Supply Project, Vader, WA.*** The city water supply is pumped from a 6-foot-diameter shallow infiltration gallery adjacent to the Cowlitz River. The infiltration gallery and over one mile of the pipeline are located on a large active landslide that regularly disrupts service. While employed at Squier Associates, Chris mapped the landslide with aerial photographs and field mapping. He identified several alternate intake sites and pipeline routes that avoid active landslide areas.

***Oregon Department of Transportation, Osweg Landslide Analysis, Washington County, OR.*** While employed at Squier Associates as Project Engineer, Chris evaluated the causes of recent movement on a landslide that has moved 10 to 30 feet over the past 50 years. Homeowners alleged that recent landslide repairs caused movement, loss or property value, and damage to homes. Survey and instrumentation data showed no movement adjacent to the recent landslide repair.

***City of Cherry Grove, Slow Sand Filter, Washington County, OR.*** An ancient landslide reactivated following initial construction of gravity water filtration tanks on a bench that was partially excavated into the slope and partially formed on structural fill material. The movement disrupted the pipeline upslope from the tanks and caused minor deformation in the tanks. As Project Engineer employed at Squire Associates, Chris designed a shear key to protect the structure using field survey and inclinometer data and laboratory strength test confirmed by back-calculated strengths.

***Judge Velure, Capes Litigation, Oregon Coast Landslide, Tillamook OR.*** Chris provided independent expert witness services to assist mediation of a large landslide along the Oregon Coast. The mediators were an Oregon Circuit Court Judge and a federal U.S. District Court Judge who have extensive experience mediating cases where the party's experts provide conflicting and widely divergent opinions. These judges commonly use their own experts mediating such cases. The landslide was threatening numerous expensive townhouses in a gated community that were constructed near the crest of a steep ocean bluff. The ancient landslide was remobilized by erosion along the beach. We evaluated the defendant's and plaintiff's experts studies and recommendations, and then performed additional subsurface explorations. We evaluated the landslide mechanism and causation, house set-back limits, the consultants' proposed "fixes", and probability of damage to the townhouses near the bluff. We then made recommendations to increase stability of the slope and protect the townhouses and developed and opinion of probable construction costs. Chris made presentations to all parties involved, which the judges then used to move the mediation forward. With our third party expert witness studies and presentations the judges successfully mediated the dispute.

## PUBLICATIONS/PRESENTATIONS

"Beartooth Highway Debris Flow Mitigation," by C.A. Robertson, W.J. Perkins, and T.W. Hopkins, presented to American Society of Engineering Geologists, Seattle, Wa, 2006.

"Flujo de Escombros Análisis y Diseño de Estabiliz a ción," presented to Colegio de Ingenieros, June 1997, Lima, Peru.