Slopes on Puget Sound

The Geology of Landslides

SHORELINE & COASTAL PLANNERS GROUP

October 5, 2017
Lacey Community Center

Sponsored by:

DEPARTMENT OF ECOLOGY
State of Washington

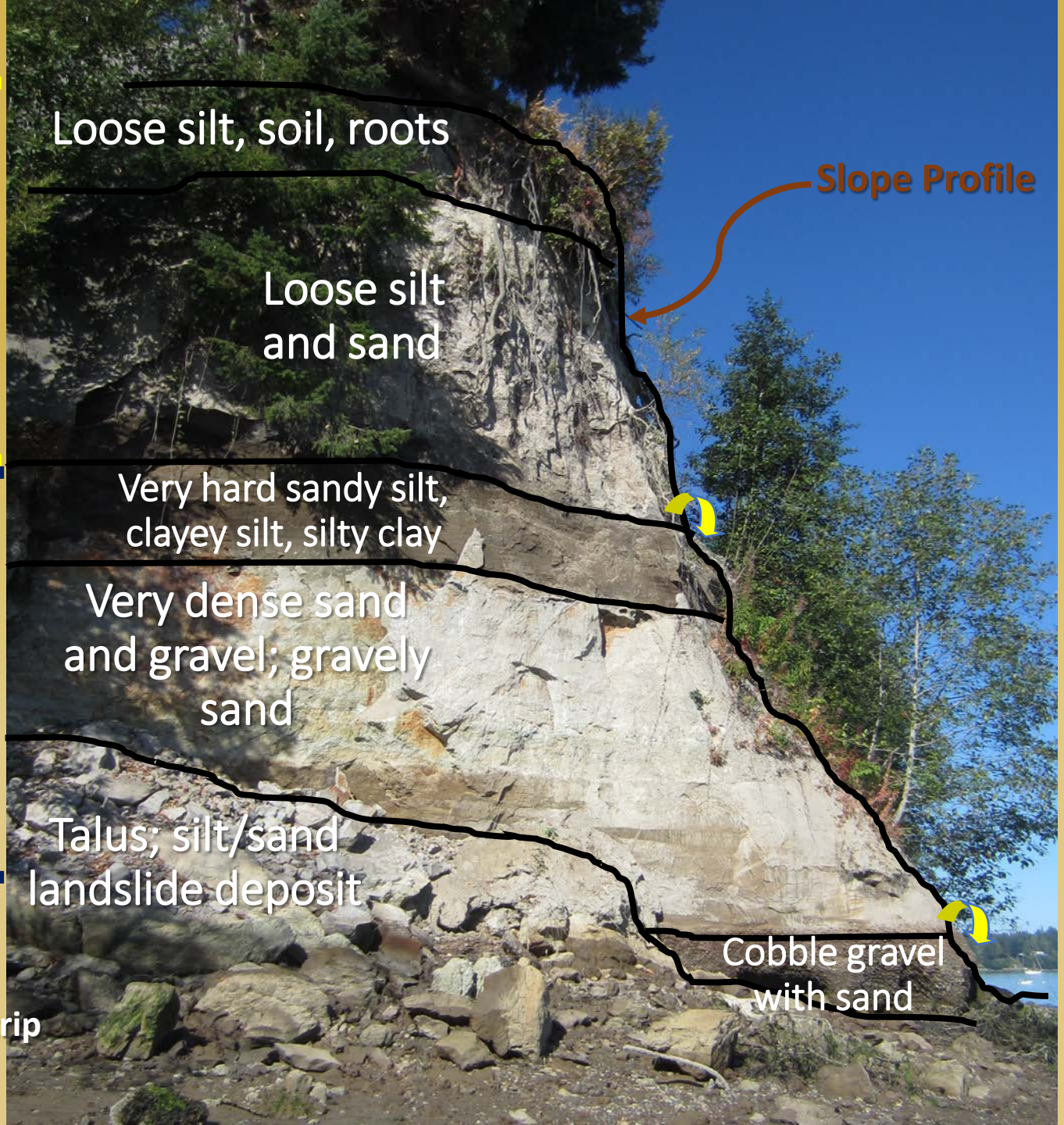
Sea Grant Washington

Presented by:
Wendy J Gerstel
Qwg Applied Geology
Olympia, WA

Field trip Focus Areas #1 (left) and #2 (right)
Tolmie SP east to Butterball Cove, Thurston Co

WA Dept of Ecology shoreline obliqu

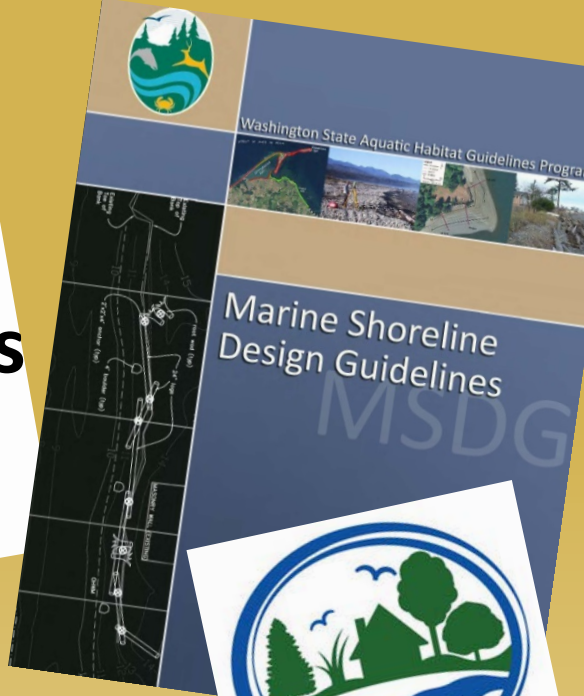
Morning field trip Focus Area #1 – note bulkhead visible in 1998, since buried by landslide deposits



Morning field trip
Focus Area #1

Guidance documents

- **Marine Shoreline Design Guidelines**
- **Shore Friendly Program**
- **Green Shores for Homes Program**
- **SMPs**
- **Other – BC, Maine…**
- **Governor's Joint SR 530 Landslide Commission Report**



Various guidance documents, not part of presentation

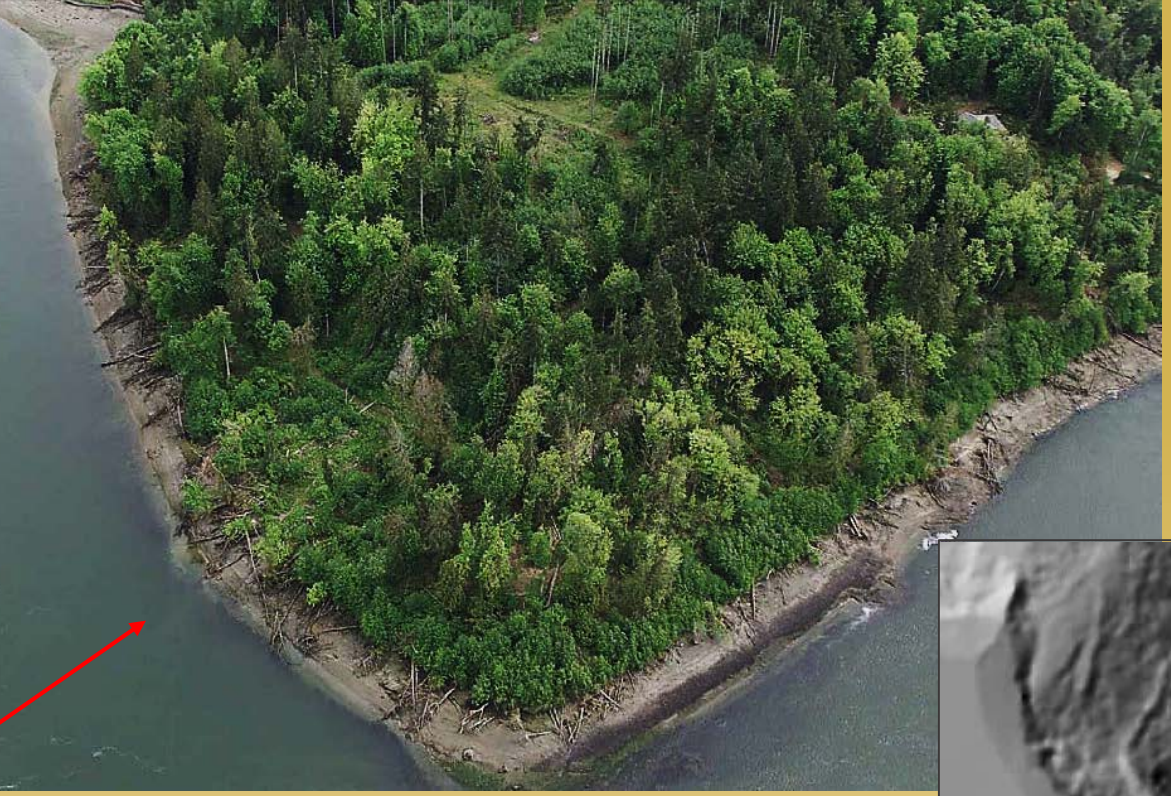
Photo by J. Brennan

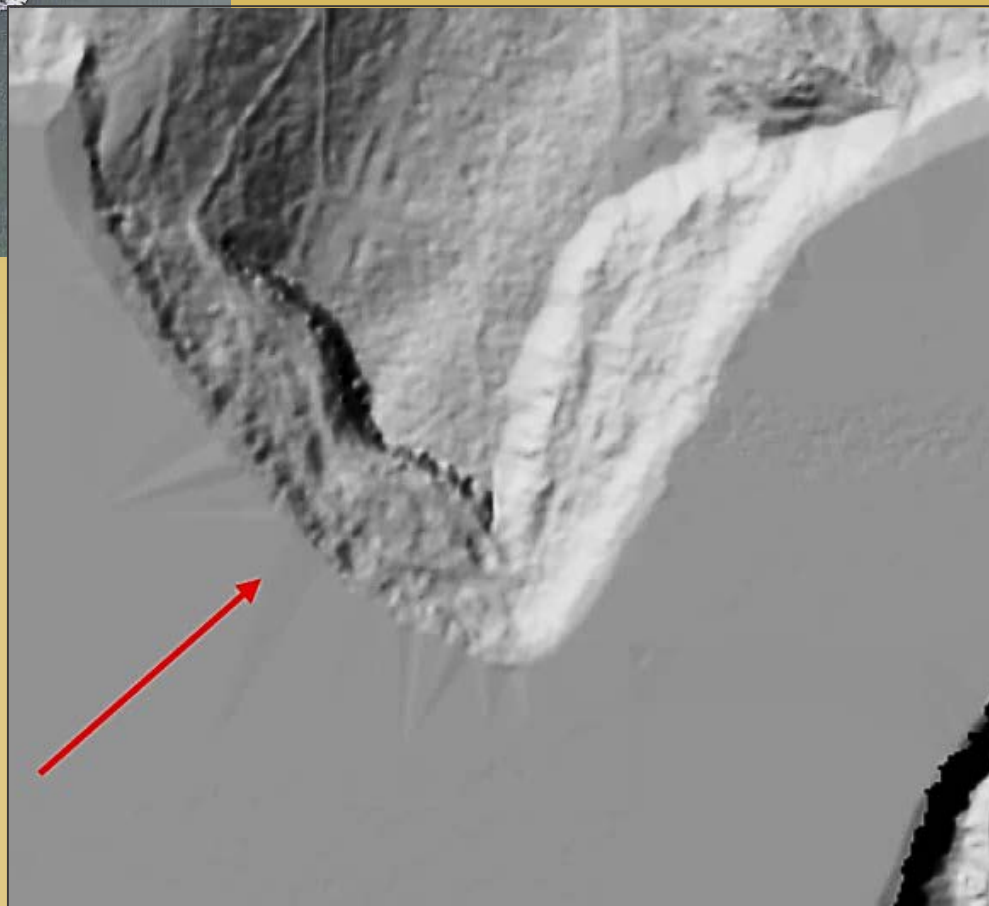
Engineered mitigation, not part of presentation

Photo by Sound Native Plants

Wildfires and channelized debris flows, not part of presentation


Low bank, low-gradient, deep-seated
slope instability IS part of presentation





Dragovich, et al., 2002

Walsh, et al., 1987

Glaciers contributed sediment into Puget Sound

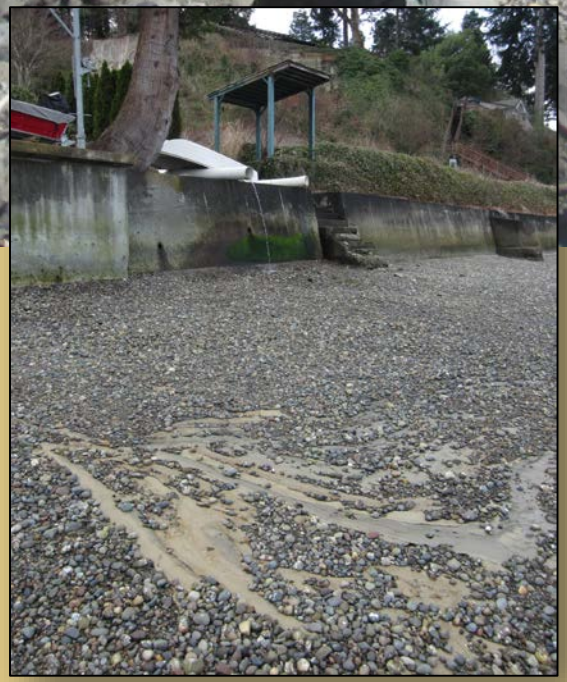
Matanuska Glacier, Alaska


Dave Tucker, 2015 (book cover)
Geology Underfoot In Western Washington
nwgeology.wordpress.com
Art © Eric Knight
ericknightart.com/guww.html
Volcanoes contributed sediment into Puget Sound


Cobbles

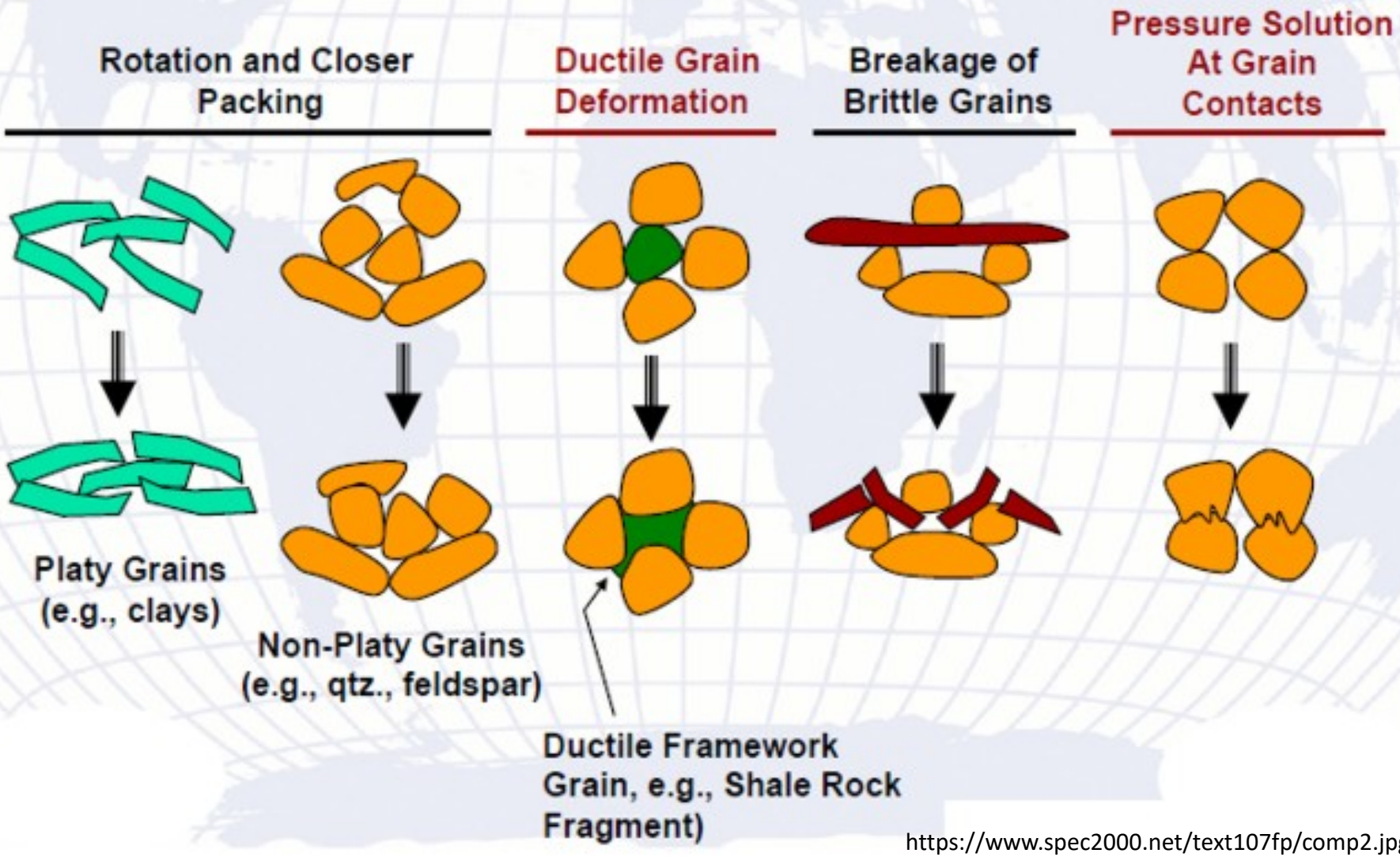

Sand and gravel

Silt and clay




Glacial till

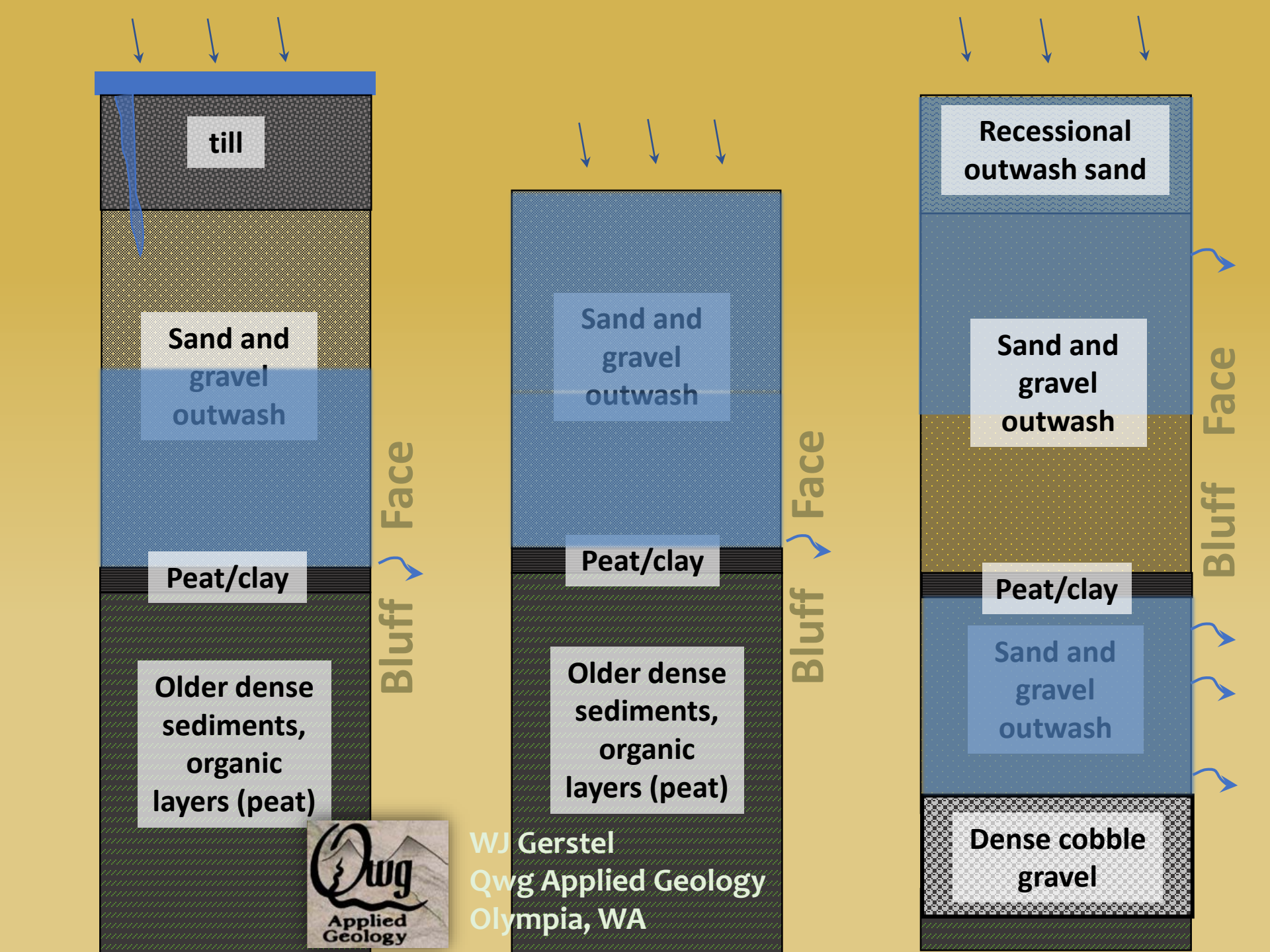
MECHANICS OF COMPACTION



https://www.spec2000.net/text107fp/comp2.jpg

Relative Permeability

"Borrowed" from Ben Alexander
Sound Native Plants


till
Sand and gravel outwash
Peat/clay
Older dense sediments, organic layers (peat)
Bluff Face
Sand and gravel outwash
Peat/clay
Older dense sediments, organic layers (peat)
Bluff Face
Recessional outwash sand
Sand and gravel outwash
Peat/clay
Sand and gravel outwash
Dense cobble gravel
Bluff Face
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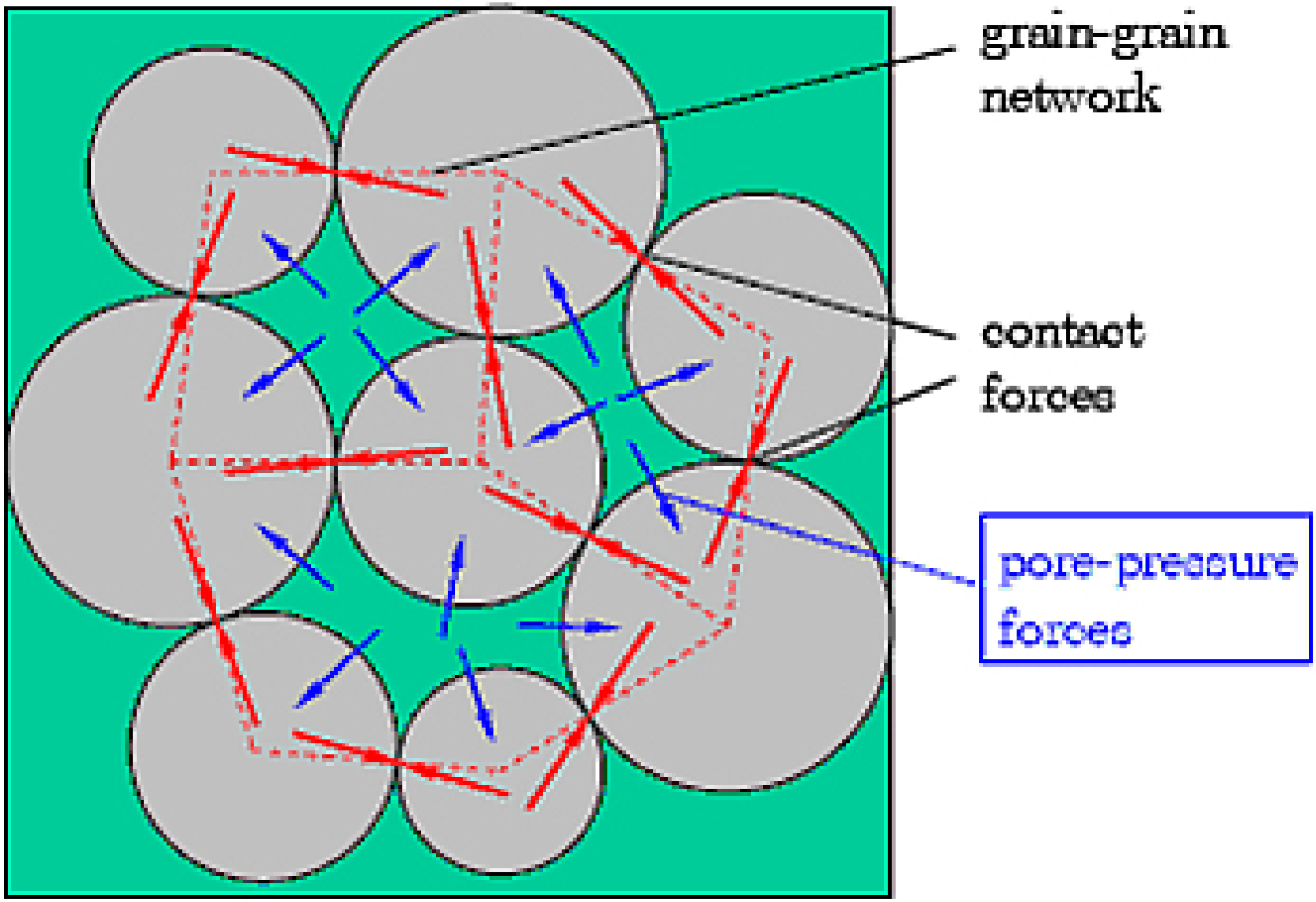
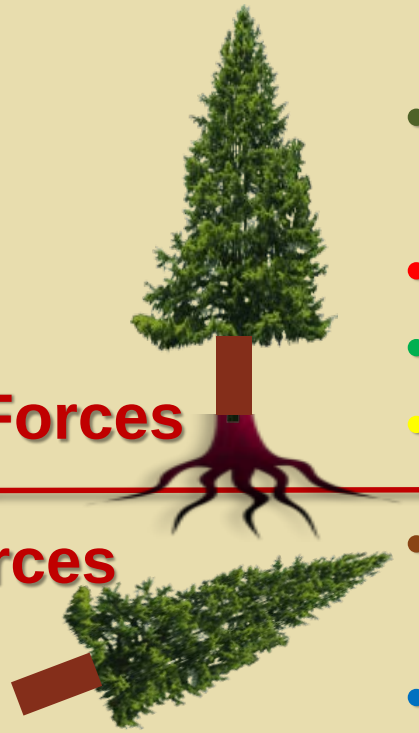
WJ Gerstel
Qwg Applied Geology
Olympia, WA


grain-grain
network
contact
forces
pore-pressure
forces

Factor of Safety



$$= \frac{\text{Resisting Forces}}{\text{Driving Forces}}$$

- **Sediment strength properties** (cohesion, internal friction)
- **Slope gradient** (gentle=gravity contributes to friction)
- **Weight at toe** (buttress)
- **Trees** (weight; ET/interception)
- **Root strength**

- **Sediment strength properties** (weak zones within/between layers)
- **Pore water** (saturation=buoyancy)
- **Slope gradient** (steep=gravity overcomes friction)
- **Excavation toe of slope** (+steep)
- **Weight added top of slope**
- **Trees** (weight)

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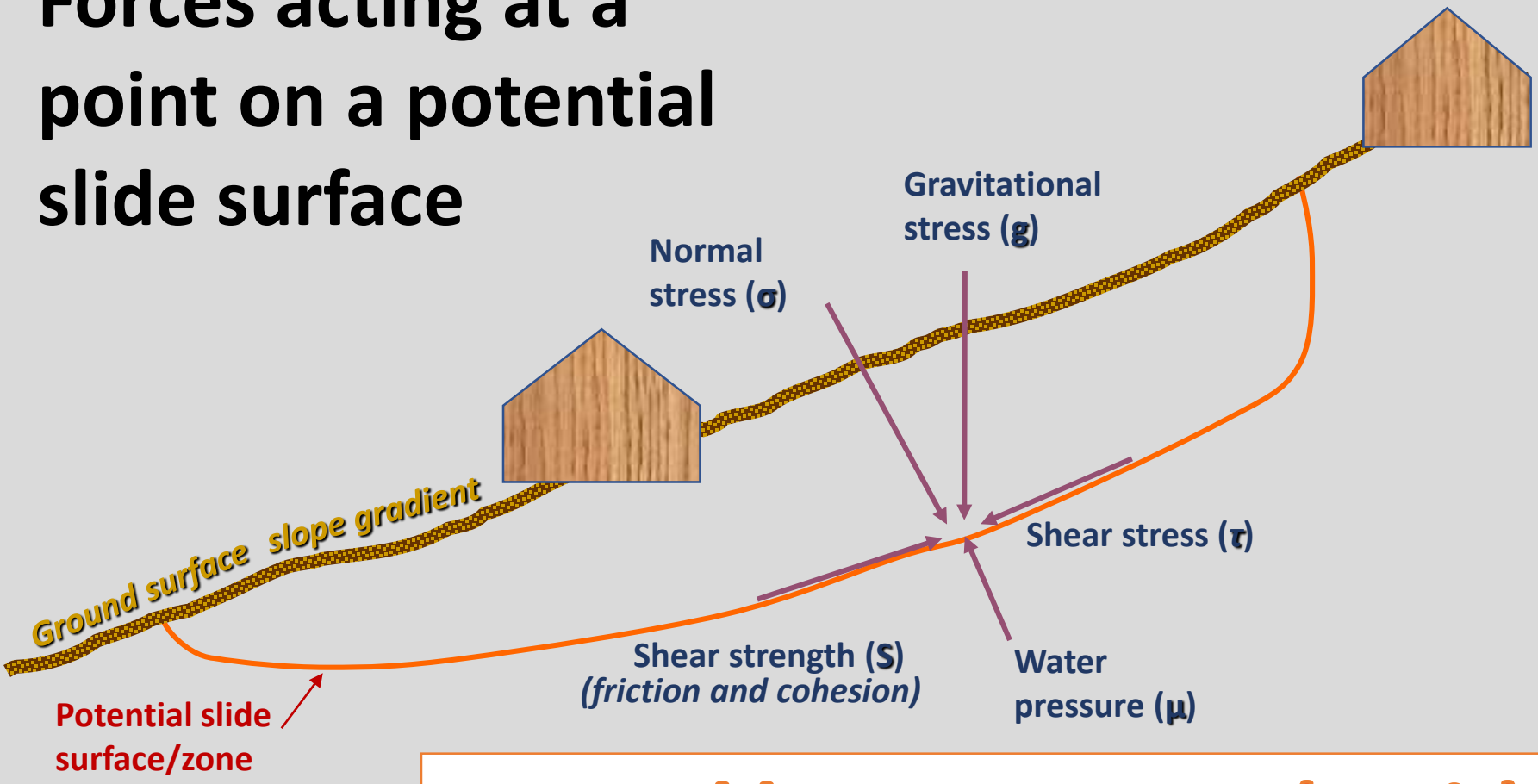
Forces acting at a point on a potential slide surface



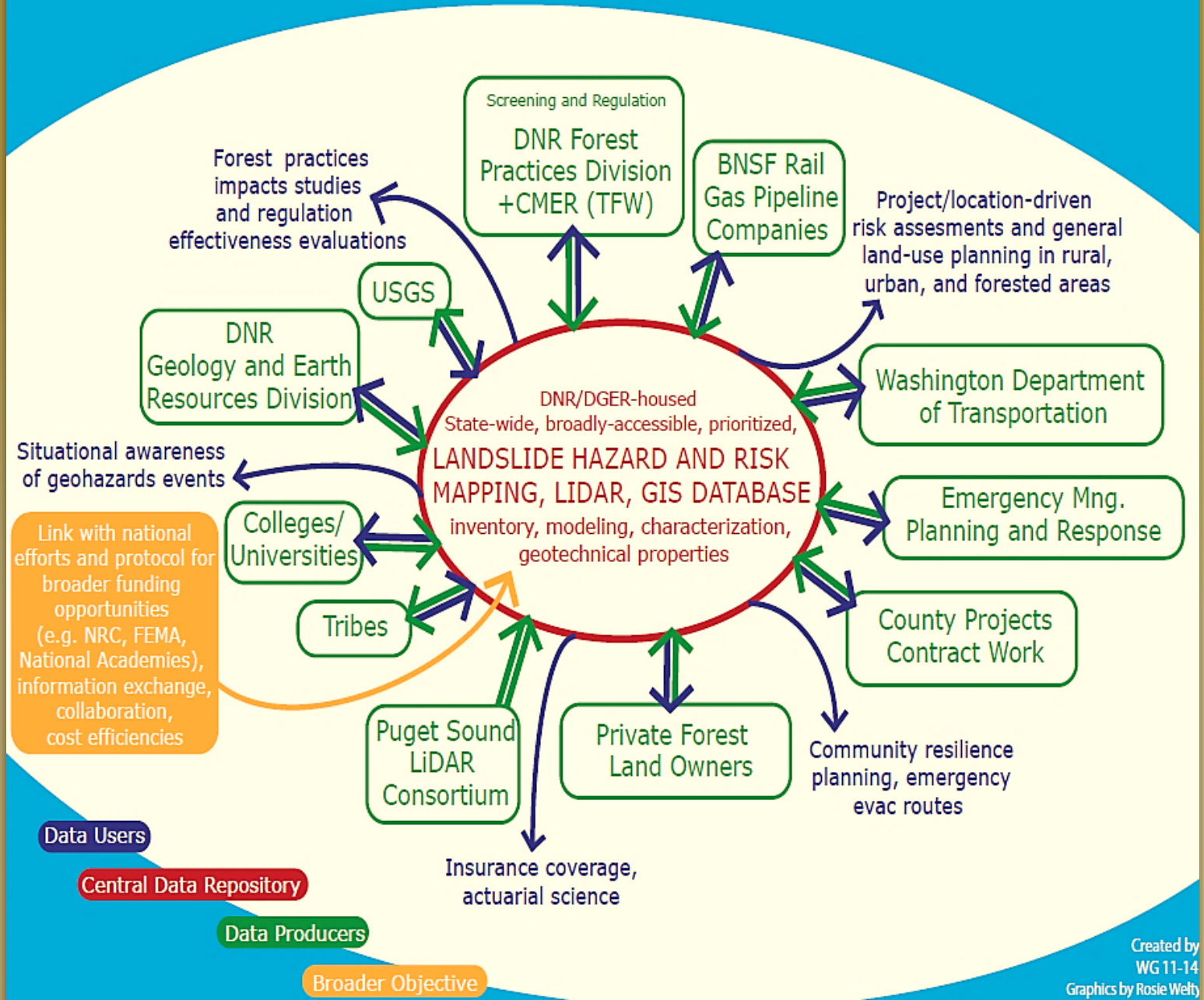
Acceptable FS ~ 1.25-1.5 (static)

$$\frac{\text{Resisting Forces}}{\text{Driving Forces}} > 1 = \text{no movement} \quad < 1 = \text{movement}$$

- Undercutting slope toe = over-steepening, de-buttressing
- "Loading" slope/slide head
- Adding water
- Loosing cohesion
  - ❖ Site history

Qwg
Applied Geology

A VISION FOR LANDSLIDE HAZARD MANAGEMENT IN WASHINGTON STATE



Created by
WG 11-14
Graphics by Rosie Welty

Lessons Learned	Recommendations
There were many successes associated with the response	
Sufficient, sustainable funding and cross-jurisdictional coordination for emergency management efforts is vital	❖ Integrate and Fund Washington's Emergency
	❖ Establish Adequate Funding in the Disaster Response Account ❖ Pro-Active Preparations
Command and control must operate and transition smoothly from one phase of the response to the next – so that leadership and management are seamless among and across responding organizations	❖ Activate Washington's Command and Control Structure for Catastrophic Events ❖ Develop a Standardized Process for Requesting, Tracking, Mobilizing, and Demobilizing Resources
Continue to study and monitor the SR 530 landslide and adjacent landslides	❖ Conduct Landslide Investigations
Large incidents with multiple fatalities can overwhelm the capacity of local coroners and medical examiners	❖ Prioritize Mass Fatality Management Planning Statewide
Local residents, loggers, contractors, business owners, officials, and many more were invaluable to the rescue effort	❖ Improve Volunteer Process
It is important to coordinate with tribes prior to and during an emergency	❖ Deploy Liaisons to Coordinate with Each Impacted Tribe
In emergency events, effective communication is challenging. Issues fall into the categories of	❖ Activate the First Responder Network Authority
Disaster assistance after an event needs a "one stop	

Washington State has few adequate landslide hazard, risk, or vulnerability maps

- ❖ Support a Statewide Landslide Hazard and Risk Mapping Program
- ❖ Establish a Geologic Hazards Resilience Institute

Washington Administrative Code guidelines for designating geological hazard areas and assessing risk are permissive, due in part to the lack of statewide geologic and geohazard mapping

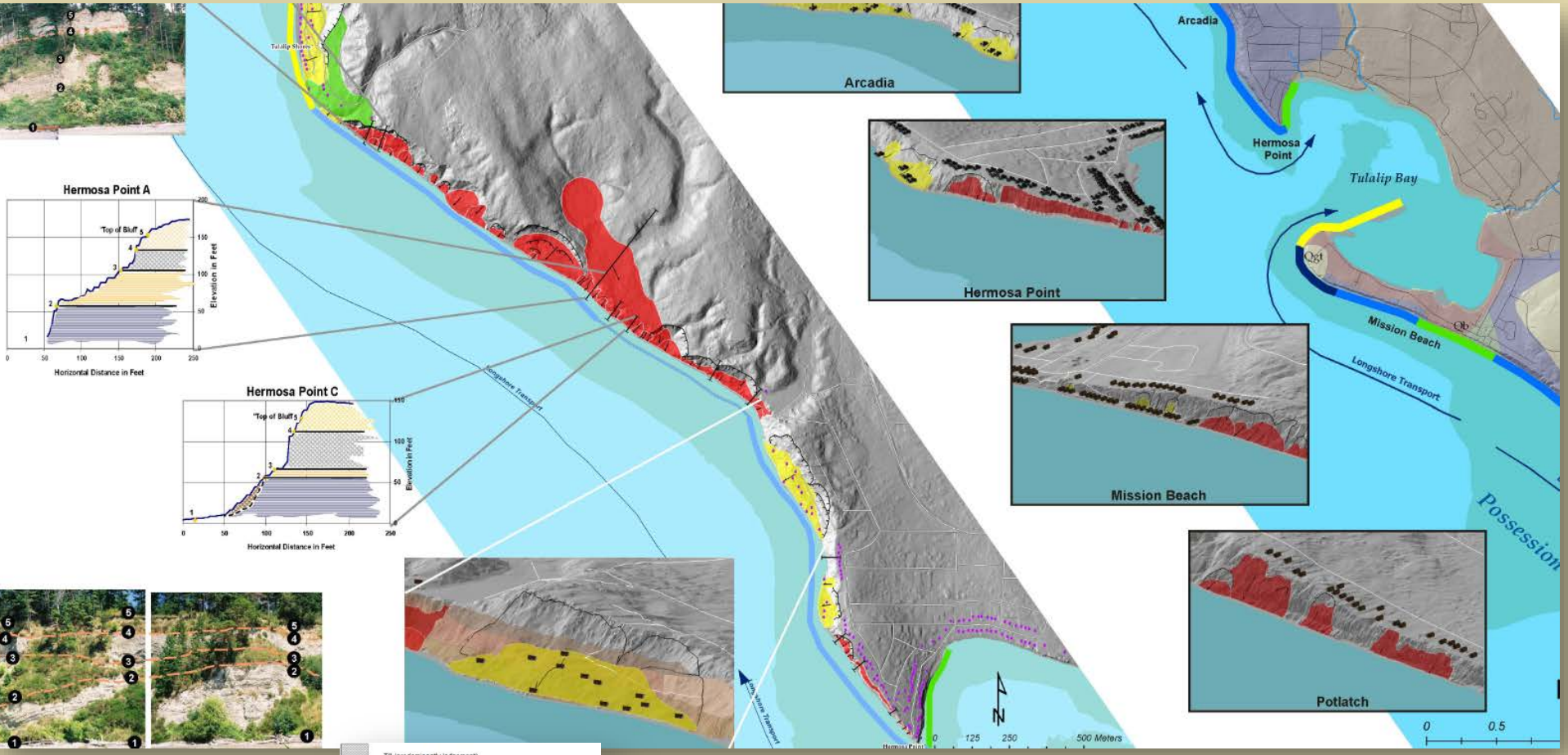
- ❖ Update the WACs Related to Critical Area Regulations

Public awareness of the potential negative impacts to property caused by the existence of geologic hazards is important in ensuring the protection of the general public

- ❖ Advance Public Awareness of Geologic Hazards

From SR 530 Landslide Commission Report to Gov. Inslee; 2014

Tulalip Reservation
landslide characterization and inventory



and

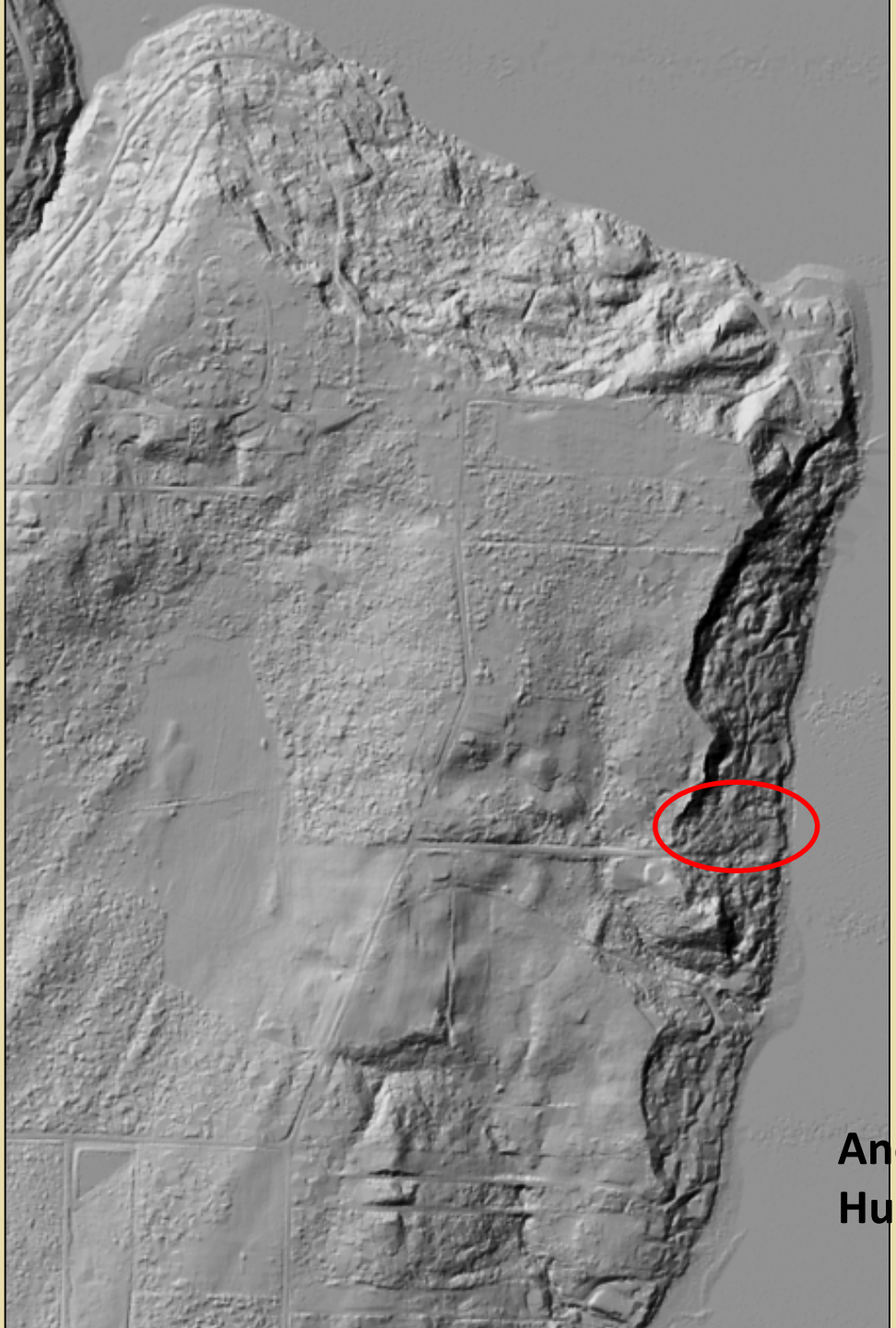
Kitsap County shoreline mapping

Sediment Sources of Kitsap County

Priority Reach Sites

Morning field trip
Focus Area #1 - ~2013

Morning field trip Focus Area #2



Another example for discussion:
Hunter Pt. area Thurston Co

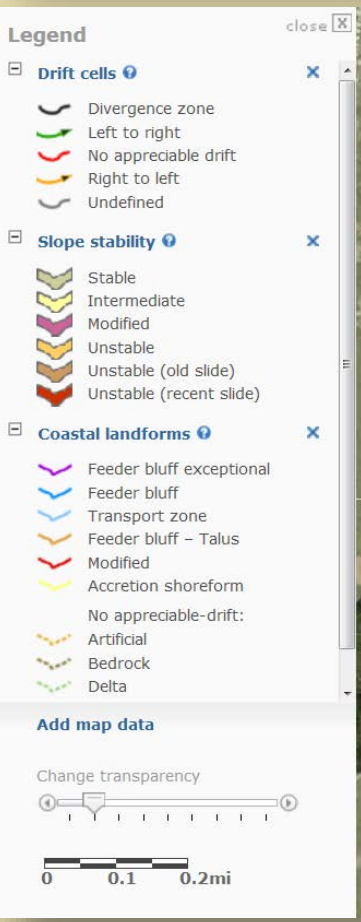
Example for discussion: Hunter Pt. area Thurston Co. deep-seated landslide with recurring activity.
House center of photo permitted conditionally with thick foundation walls. Note linear string of lo
piles possibly delineating limits of earlier landslide toe position. Bulkhead on left now disrupted b
post-construction movement of landslide in that area. Section between bulkheads recently armore
(after this photo.)

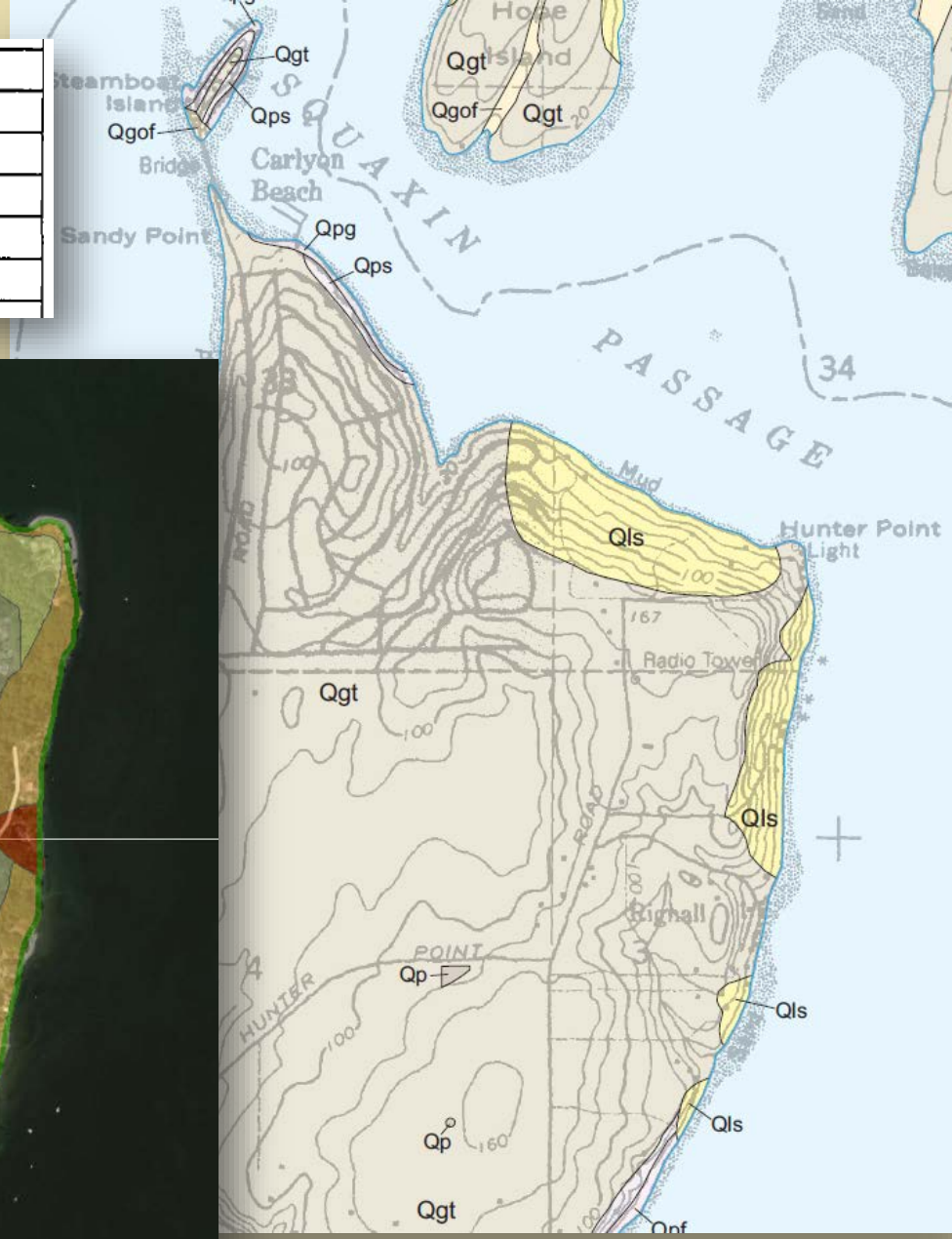
Although not perceived as the classic high-bank 'feeder bluff', this large landform (see lidar) provid
chronic delivery of fine sediment.


Another example for discussion:
Hunger Pt. area Thurston Co

Low bank sediments exposed in Hunter Pt. area discussion example, Thurston Co

MATERIAL	FROM	TO
BROWN SILT	0	4
GRAY CLAY	4	80
GRAY SILT	80	158
GRAY SILT, FINE SAND	158	180
SAND, GRAVEL AND WATER	180	182





Hunter Pt. area, Thurston Co.; Geologic and shoreline information available on line at Wash. Depts. Of Ecology and Natural Resourrces


Yorkshire Dales example of creative surface water management