Use all resources at your disposal to prepare for this trip, and on and after this trip. Some good resources include (but are not limited to) those listed on the Week 3 Assignments handout and in the Keeping a Field Notebook handout. Use your resources and your learning from the Pre-Trip Questions as guides as you prepare your Field Trip Summary Paper. (Remember, all work must be fully sourced.)

**Background Information and Some Questions to Ponder**

Landslides cause millions of dollars of damage in the Seattle area during an average year. The slides are a result of a combination of geologic, climatic, and human factors. Landslides are numerous during particularly wet winters, and are most common after heavy rains. In addition, landslides may be triggered by earthquakes. Waves and streams speed up the erosion process and increase the risk of landslides.

Human factors that often contribute to landsliding include the diversion of drainage water onto a hillslope; excavations on a hillslope; and inadequate planning, construction, or maintenance of houses, retaining walls, and other structures. This field trip will acquaint you with some examples of landslides in the Seattle area.

Much of the Seattle area is built on thick layers of sediment deposited by a huge glacier during the most recent "ice age" (glacial maximum about 14,000 to 17,000 years ago). From the surface down, these layers may include glacial till (hardpan), sand, clay, and silt. Because these layers are loose sediment rather than hard rock, they are relatively easy to erode and thus prone to landslides.

The assigned readings (and others!) give more information on the factors and processes of landsliding.

**STOP #1 (Carkeek Park):**

Look north up the shoreline at the recent landslides. Estimate the height of the bluff, based on the height of the houses on the bluff. Then estimate how large each slide is, in terms of length, thickness, and height. Multiply these numbers together to get a rough idea of the volume of material that slid (volume = length * thickness * height). Notice that huge trees are tilted sideways or even toppled, due to the slides. Take notes and make sketches.

Next look southward, and if the weather permits, walk up close to another recent landslide on the bluff. What kind of material does the bluff seem to be made of (solid rock, loose sediment, ...)? How old do you think this landslide might be? What are some clues from the vegetation on the slide material? Take notes and make sketches.

**STOP #2 (Sunset Hill Viewpoint Park):**

Now we're on top of a bluff, a bit south of Carkeek Park. Why does the bluff edge appear "scalloped" from above? Some large slides occurred here in 1996-97. Do you see any clues in and around the sidewalk for these events? How about for sliding that's taken place since then, that is even going on today? How many landslides can you see on the slope itself? Can you estimate their age? How close are the houses to the park's sidewalk (near the fence)? Take notes and make sketches.

Look southward to Magnolia, the next "spit of land" beyond the Ship Canal. Notice the large grey vertical cliff. It's made of glacial sediments, which we'll see up close (tides permitting) at the next stop.
Why is this cliff so steep? How close are the surrounding houses (above and below) to the cliff? Take notes and make sketches.

**STOP #3 (Discovery Park):**

Here we'll get an up-close look at the glacial sediments that Seattle and much of Puget Sound is built on.

* The bottom layer is called the Olympia (or Kitsap) Formation. It was deposited by rivers before the most recent "ice age", when the climate was similar to today's.

* The next layer up is the Lawton Clay. It was deposited here when the huge continental glacier, flowing down from Canada blocked Puget Sound, making it a huge lake.

* The layer above is called the Esperance Sand. It was deposited by glacial rivers, when the ice sheet got closer to Discovery Park.

* The top layer is the Vashon Till. Till is deposited directly by glacial ice. It is a mix of all sizes of sediment, from clay to boulders. The fact that we have till at Discovery Park means that the glacier made it at least this far south during the last "ice age". (In fact, it made it to the southern end of Puget Sound.)

What do you see in terms of old landslides? Is there evidence of recent landslide activity here? How does the arrangement of glacial sediments increase sliding in Puget Sound? Take notes and make sketches. Make a stratigraphic section, to scale as best you can.

Look at the rocks (pebbles and sand) in the sediment on the modern beach itself. Identify the dominant rock types (from among the igneous, sedimentary, and metamorphic rock ID charts). Also identify some of the less-common ones. Hypothesize as to the possible sources of the rocks in the modern beach sediment. Take notes and make sketches.

**STOP #4 (Perkins Lane):**

Perkins Lane is famous for its view homes...and for its big, expensive landslides. Some people have lived here for many years, whereas others are just building their dream homes on this street. As we drive along, look for evidence of landslides, old and new. Also look for ways people have tried to prevent (or lessen the impact of) landslides here. At least one house slid enough that its owners moved it across the street (toward the water). Another is falling down and apparently being rebuilt. What locations on Perkins Lane do you think are the safest? The least safe? Why? If you were a scientist (or potential homeowner), how would you go about finding out? Take notes and make sketches.

**STOP #5 (Magnolia Boulevard Viewpoint Park):**

Walk south (toward downtown) along the fence. When the path dips and the bluff cuts in a bit, go just a bit farther and then look back and down to the waterline. Look at all the wrecked houses, and the big mass of slide material. Take notes and make sketches.

What is the height of this mass movement, in feet? Its depth? Its length? Multiply these three numbers together, to get the total volume of this mass movement, in cubic feet. 100 cubic feet equals about 5 tons. How many tons was this mass movement? Have waves played any role in the development of this mass movement? How? Take notes and make sketches.

The citizens of the city of Seattle were sued by the owners of the wrecked homes, because this mass movement involved a public, city-owned cliff, and the city did not prevent this mass movement of the public property, which pushed their property into Puget Sound. The case was dismissed in the city's
favor. Are there any signs of damage to Magnolia Boulevard West behind you? Take notes and make sketches.

Look ahead as we drive east across the Magnolia Bridge...Notice the landslide restoration project on the slope (Garfield Street Emergency Slide Restoration). Also notice the houses around it. This has been an expensive project. Imagine you're in charge of this project. What things do you see that seem to be done well? And not so well? Take notes and make sketches (we may be doing this while moving, so be alert).

STOP #6 (Smith Cove Marina):

These sites are instructive because of several different examples of mitigation strategies, trying to slow down mass movement, or lessen their impacts, or stop them altogether. The most prominent strategy here is the use of "shotcrete": concrete sprayed from hoses onto the slopes (with or without forms). People who use shotcrete are trying to prevent rainsplash erosion of bare ground created by a mass movement such as an earthflow. Normally one waits until the ground is stripped bare by mass movements; in some really warped scenarios, the slope is devegetated by hand, and then sprayed with shotcrete. Some people incorrectly believe that shotcrete has the muscle to hold slopes in place. But what negative effects might the shotcrete produce? Take notes and make sketches.

On the site to the right/south, is there any evidence of very recent movement below the shotcrete? On the site to the left/north, we find a very impressive mass movement, that surges forward every rainy season. Old concrete power poles have been placed at the toe of the mass movement to protect the roadway. Is this strategy successful? The rockery to the right was built for exactly the same purpose. Take notes and make sketches.

Examine the topography of the hillside, both the bare and vegetated parts. Is the slope smooth and even, or is it lumpy and bumpy? Estimate how vertical the bluff itself is, and the tilt of the trees on the slope. Give a simple interpretation of the topography you see. Take notes and make sketches.

To the left and right of the large mass movement, there are small pipes sticking into the hillside. These are drainage pipes sticking into the hillside like perforated soda straws, trying to keep groundwater from building up. A drumlin is a long, steep-sided ridge made out of glacial materials (till, sand, clay) and molded into a torpedo shape by the passage of the glacier over the glacial materials. Think about the geology of the Magnolia drumlin. What's the best place to insert these drainage pipes? Usually there's water coming down the long black plastic pipe, and water coming out of a large buried pipe that's emptying into the storm drain. More are needed. Take notes and make sketches.

STOP #7 (Condominiums above Westlake Ave):

A number of condominiums and apartment houses sit at various levels along the extremely steep east side of the Queen Anne drumlin. With the incredible east-facing views of Lake Union and the morning sun, these condos and apartments do not come cheap. However, many are at serious risk for destruction or damage by mass movement, because of bad earth materials and steep slopes. Earthquakes will not be kind to these buildings, either!

How high is the cliff? What would be an appropriate setback, the distance back from the cliff that buildings should be situated? Is this slope smooth and even, or is it lumpy and bumpy? How wide is a typical mass movement along this hillslope? Is the typical mass movement here gouging deep into the hillside, or is it just sloughing off the upper foot or two of soil, etc.? Take notes and make sketches.

The large building has decaying "christo" (like shotcrete) from January 1997. The plastic tarp prevents revegetation of the bare slope; plants can't grow under the plastic. Is this good, bad, or indifferent? Why?
What "pioneer plants" are naturally revegetating the scars from 1997 and earlier? Parts of the slope are semi-stable; they have not moved for 40 or 50 years. How can you tell? Take notes and make sketches.

**STOP #8 (Newly Bulldozed Townhouses on Lakeview Blvd):**

The city of Seattle acquired the steep bluff leading up to St. Mark's Cathedral, to establish the St. Mark's Greenbelt. Greenbelts are often established on steep slopes that are unfit for development. However, the acquisition of steep, landslide-prone terrain then puts the city at risk for lawsuits, if the city's cliff moves and damages private property (either above or below). Three townhomes, built within the last 10 years or so, were located at 1515, 1517 and 1519 Lakeview Boulevard East. Damage increases to the north, but all 3 townhomes were condemned in January 1997 and sat abandoned until bulldozed in early 2004. The townhomes were built solidly, both to keep out freeway noise and to prevent earthquake damage. What's the lesson here? Take notes and make sketches.

A bit north on Lakeview Boulevard (just before the freeway overpass) is a steep slope with a staircase running up it. This slope moved on New Years, 1997, partially blocking Lakeview Blvd E for a couple of days. The slope varies from 35° in angle at the bottom to 60° at the top. A green rental home with a black plastic drain pipe is perched precariously. The wooden staircase is new, there was none before the mass movement. The staircase has been built right on the fresh scar. You can argue that this is the best place for the staircase along this slope. Why put the staircase on the scar? Take notes and make sketches.

There are some red alders (*Alnus rubra*) on the south end of the scar, colonizing the scar (plant pioneers). They are 7 years old. How tall are they, on average? How tall will they be in 13 more years, when they are 20 years old? Older broad leafed maple (*Acer macrophyllum*) trees are found to the north and south of the scar. The north ones are leaning out from the slope, and have curving tree trunks. Slow downslope movement of the soil can cause this kind of tilt and curvature. But there is another cause of plants leaning out from a slope, that is not related to slope movement. What is the other cause? Take notes and make sketches.

Across the street is a very large boulder, about 3 feet in diameter, made of some kind of granite. The boulder weighs 3-4 tons. When Lakeview Blvd was built 85 years ago, they pushed this boulder out of the middle of the roadway. How did it get here? (Think about what you saw at Discovery Park.) Take notes and make sketches.

**STOP #9 (St. Mark's Cathedral):**

Now we're looking down on the Lakeview Boulevard townhouse site... What do you see? How far back is the cathedral set from the cliff? How far back is the edge of its parking lot? How old might the last major slide be? What evidence do you see for recent movement on this bluff? What do you think about using plastic sheeting on the slope? Take notes and make sketches.

*(If time permits, we'll head to West Seattle to see Lincoln Park, Alki Beach/ Harbor Avenue, and California Way. And/or, we may go to Saltwater State Park near HCC campus.)*

And back to HCC campus!
LANDSLIDES OF SEATTLE FIELD TRIP

POST-TRIP SUMMARY WRITE-UP INSTRUCTIONS

TOPIC: Write a professional (not chatty) report summarizing the major findings of this field trip. Based on your observations and interpretations, explain the landslide hazards of the Seattle area, including the processes and factors involved. Don't simply recite what we saw at each stop; put it together into a coherent story. This must include a chronological history and geological interpretations of the glacial sediments we saw. Be sure to cite the geological evidence (observations) that your interpretations are based on. You will also want to note any assumptions you made in making your conclusions. Don't just answer the questions, write a 2-plus-pages (typed, single-spaced) geological story. Include a bibliography of sources outside of the material on the handout.

DUE: 9:00 am Saturday, May 1st (That is, the start of the next class period. No exceptions.)

SUBMIT:

* **Summary Paper** = Minimum 2 pages of text, word-processed, single-spaced, printed out, stapled. Your name on each page. The 2-page minimum refers to text - Your references, pictures, etc. will lengthen the paper (but their judicious use is encouraged). Write and rewrite before you submit it - and of course, proofread it for grammatical, spelling, and logical errors, too. Please use the college's Writing Lab or other reliable sources to get these problems solved before you turn in the report.

* **Field Notebook** = Also turn in your fieldbook (which I'll return to you, of course!).

* **Answers to Pre-Trip Questions** = Attach them to the back of your Summary Paper, unless I asked you to give them to me at the end of the field trip. (These answers were due at the start of the field trip.)

Driving Directions

From HCC campus to **STOP #1** (Carkeek Park - 950 NW Carkeek Park Rd, Seattle) - Directions from the Seattle City Parks website: Take I-5 North. "Taking Exit 173 to Northgate Way and turning west. After crossing Meridian, Northgate Way becomes NW 105th Street and crosses Aurora Ave N (Highway 99). Turn right on Greenwood Ave N and left on NW 110th Street (look for the crosswalk lights above the street). After 6 blocks, NW 110th Street becomes NW Carkeek Park Road and winds down into the valley for 1/2 mile to the park entrance. Watch for the "rainbow-colored" Department of Parks sign on your left." Take left into park. Continue straight (road soon becomes one-way loop). We will park in playground parking lot.

To **STOP #2** (Sunset Hill Viewpoint Park) - Loop back through park, make right onto 3rd Ave NW. Take right turn onto Holman. At NW 85th St make right (west). Go left onto 32nd Ave NW. Take right onto NW 77th St, then left (south) onto 34th Ave NW. Park on road.
To **STOP #3** (Discovery Park) - Continue south on 34th Ave NW, to NW 75th St. Go left on NW 75th St, then right onto 32nd Ave NW. Continue on 32nd Ave NW to end. Turn left onto NW 54th St (road becomes NW Market St). At 15th Ave NW, turn right. Drive over Ballard Bridge, and follow sign for Fisherman's Terminal / Elliott Ave. You'll take first right after Ballard Bridge, onto W Emerson St. Go past Fisherman's Terminal, then turn right onto Gilman Ave W (sign "To Fort Lawton") (road becomes Government Way). Continue into Discovery Park. Park in visitor center parking lot (on left). (Good stop for lunch and rest rooms.) We'll get special permission to park our van near the lighthouse.

To **STOP #4** (Perkins Lane) - Drive back out of Discovery Park, and back onto Government Way. Take right onto 34th Ave W. At first light, make right onto W Emerson St. Go almost to the end of the road, taking left onto Perkins Lane. This is a very narrow road, with few places to park. Please respect the privacy of the residents by not parking in their private spaces. If possible, park and walk to end (past "Dead End" sign), or drive to end and turn around without parking.

To **STOP #5** (Magnolia Blvd Viewpoint Park) - Returning from the end of Perkins Lane, take your first right, uphill onto Raye. At the top of Raye, make a right (south) onto Magnolia Blvd. (You can park along the road and walk down staircase to Perkins Lane to see STOP #4 locations.) Continue on Magnolia Blvd to the parking lot for the viewpoint park.

To **STOP #6** (Smith Cove Marina) - Continue south on Magnolia Blvd. Take right onto Howe, then right onto Magnolia Blvd again (road becomes Galer). To get to the marina, you have to drive east across Magnolia Bridge, then loop back and drive west across Magnolia Bridge. (To do that, take right on 15th and immediately merge left and turn left immediately onto Galer. Stop and wait, watch the very fast traffic. Turn left onto the bridge.) Stay right on the bridge, and near far (west) end of bridge, take right exit. Go left under bridge toward Smith Cove Marina. Park in parking lot.

To **STOP #7** (Condominiums above Westlake Ave) - Retrace path under and onto Magnolia Bridge (east). At far (east) end of bridge, take left onto 15th Ave W. Turn right at the "Emerson / Nickerson" exit, following the left (Nickerson) branch. Drive past Seattle Pacific University, and under the Aurora Bridge (road becomes Westlake Ave). Continue on Westlake Ave. At about the 2400 block, make left turn into Gove's Cove parking lot (beware potholes).

To **STOP #8** (Newly Bulldozed Townhouses on Lakeview Blvd) - Continue on Westlake Ave to Roy St. Make left on Roy St. Bear left (onto Fairview Ave N; road will become Eastlake Ave). Turn right on East Lynn. Take right onto Boylston, bear left (= Newton) under I-5, then follow road (becomes Lakeview Blvd) to the 1500 block, just before Egan House. Park on side street to right.

To **STOP #9** (St. Mark's Cathedral) - Double back on Lakeview Blvd. Instead of bearing left under I-5, take Harvard Ave E up steep hill. Make right onto E Miller St, then right onto 10th Ave E. Turn right into St. Mark's parking lot or park on side street.

*(If time permits, we'll head to West Seattle to see Lincoln Park, Alki Beach/Harbor Avenue, and California Way. And/or, we'll go to Saltwater State Park near HCC campus.)*

**Back to HCC** - Go left out of parking lot, onto 10th Ave E. Make left on Roanoke. Go straight over I-5, and take left immediately thereafter (you'll be paralleling I-5 South). Follow signs onto I-5 South.