GeoTour Lynn Canyon:
The River and Its Landscapes
(draft version)

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Overview
Lynn Creek offers opportunities for the study of a coastal mountain watershed. Much of the watershed lies within park areas and can be accessed easily. There has been significant human impact on its lowest reaches, particularly its industrialized estuary area on Burrard Inlet (**Figure 1**). Lynn Canyon Park contains some of the middle parts of the watershed where the stream flows in both open valleys and narrow bedrock canyons. This guide focuses on field observations that allow interpretation the role of the river in creating the landforms of the park

This guide is designed for periods when there are low flow levels on Lynn Creek. These typically occur through most of the winter, spring and summer. However, during periods of heavy rain in the autumn, and during peak snow melt in the spring, high water will obscure Stop 1 and 2, and possibly restrict access to Stop 3. However, such flood events are what shape the river, and if they can be observed safely provide important insights into how the river carves its landscape.

Stop #1: Sleuthing out Evidence for Floods
Open valley of Lynn Creek

Directions: from the Lynn Canyon Ecology Centre walk toward the suspension bridge. Just before the bridge, take the trail that heads upstream (to the north, left) on the west side of Lynn Creek. Descend to a wooden walkway along Lynn Creek just above the canyon (**Figure 2**). Walk to the flats at the upstream end of the walkway.

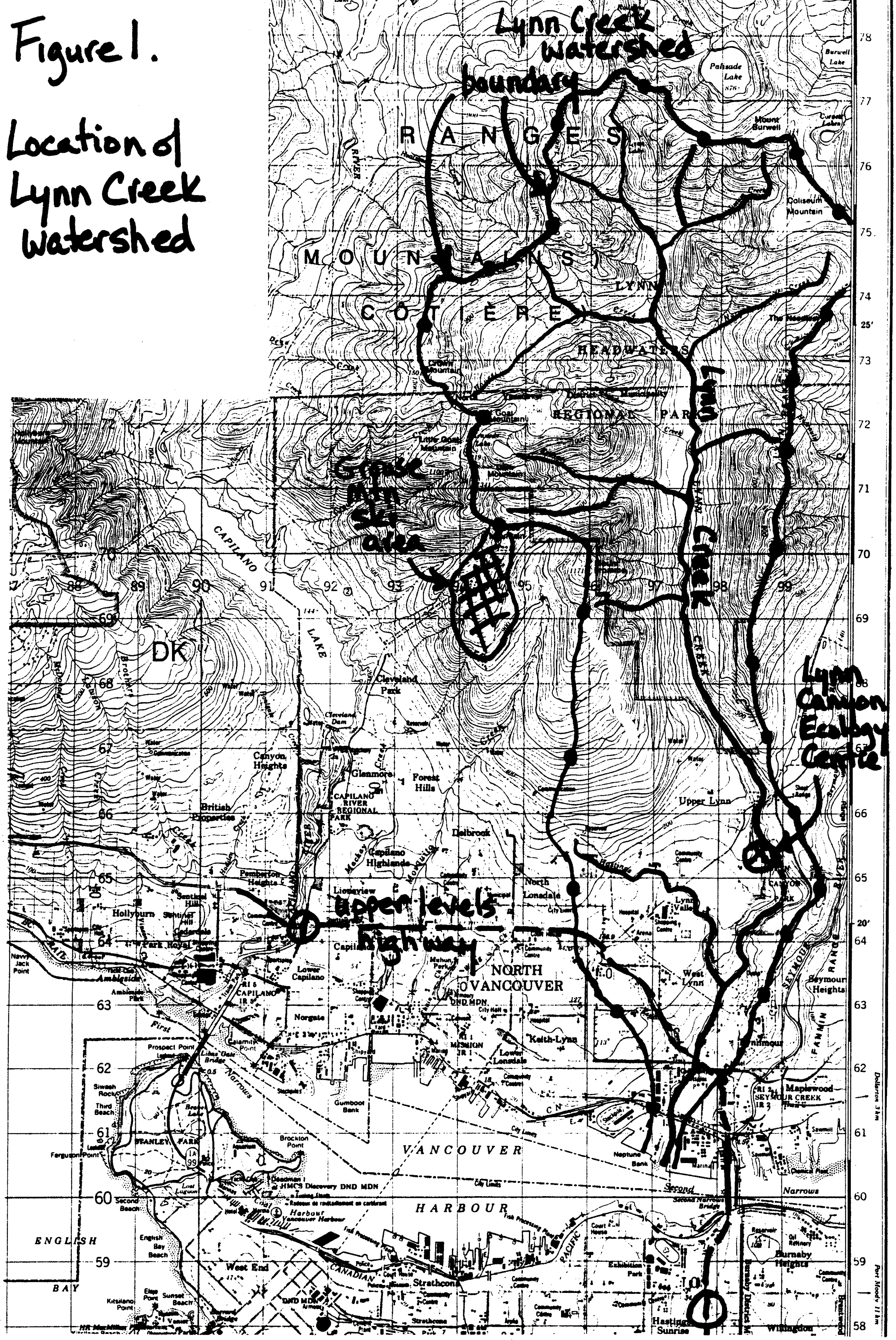
Purpose of stop
• Look for evidence of past floods (**Figure 3**).

What You See and Questions to Ponder
You are standing near the transition in the valley of Lynn Creek from open valley to narrow canyon (just downstream). In the open valley Lynn Creek flows across a boulder stream bed, flanked by flat forested floodplains.

What evidence is there of the height of past floods?
See **Figure 3**. Look for stranded flotsam litter of small logs and branches, and scars on tree trunks caused by collision with floating logs. Also, just downstream are rock surfaces scoured of soil and vegetation overlain by eroded scarps in sediment.

Figure 1.

Location of Lynn Creek watershed



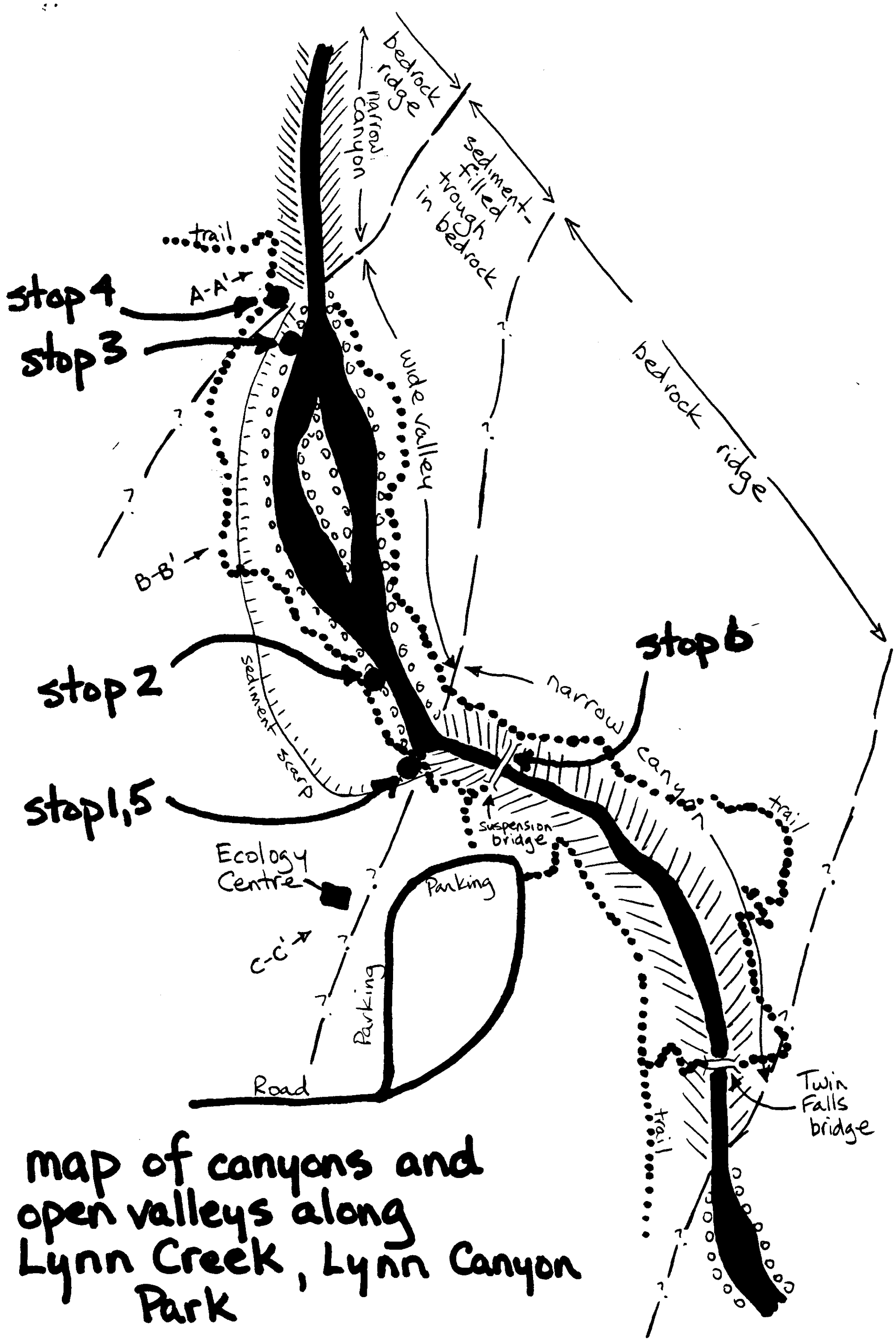


Figure 2

map of canyons and open valleys along Lynn Creek, Lynn Canyon Park

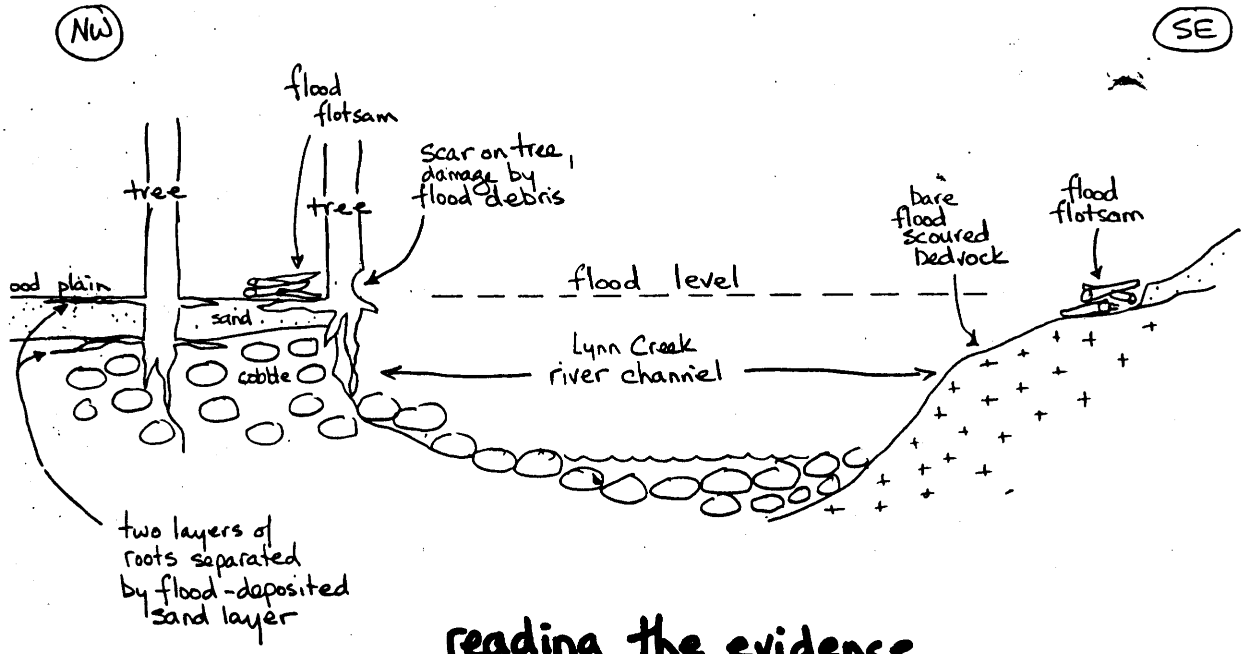


Figure 3. reading the evidence of past floods

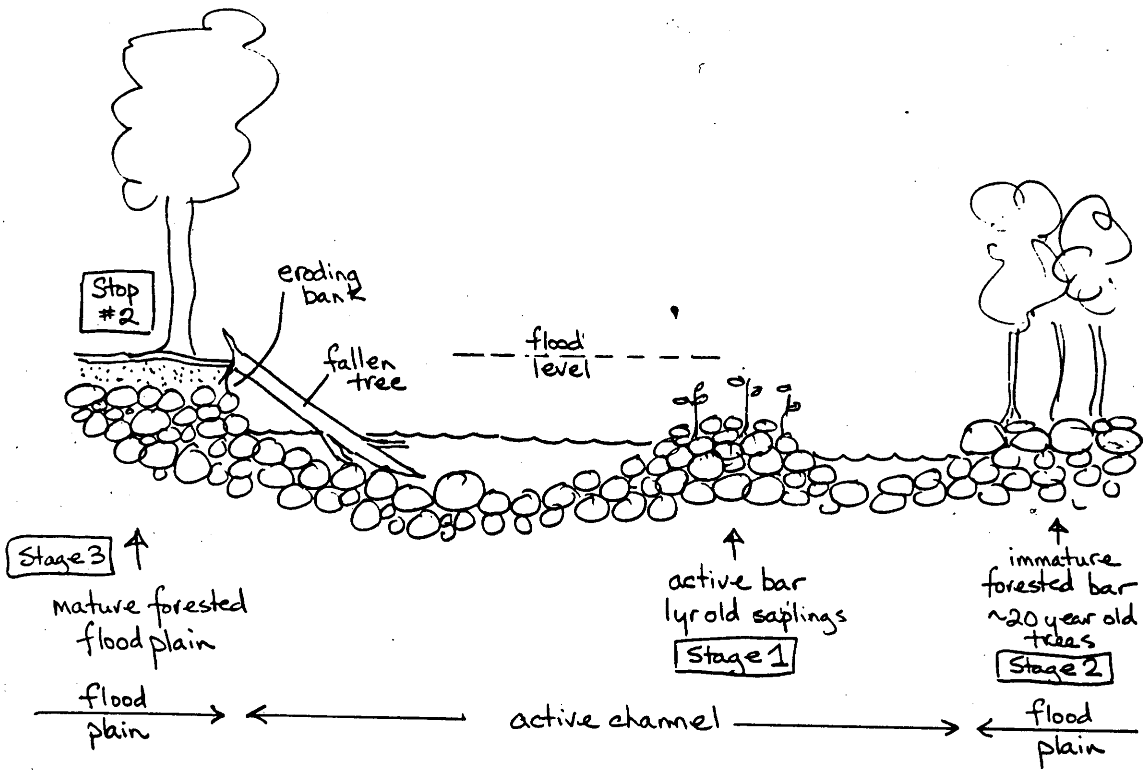


Figure 4. evolution of landforms on the floodplain

When the river floods to the observed level, what area is flooded?
The entire forested plain west of Lynn Creek - this then is referred to as the floodplain.

The roots of large cottonwood trees nearby are partially exposed. One tree has roots developed at two distinct levels separated by 0.3 m of sand. How would you explain this?
The lower root set developed just below original land surface. Flood deposited sand layer 0.3m thick raised the land surface. The tree responded by growing a new, higher root set just below the new surface.

What underlies the flat floodplain surface that extends upstream along the west side of Lynn Creek?
A lower layer of boulders are overlain by 0.3m of coarse sand. A poorly developed dark, organic-rich layer overlies the sand.

Stop #2: How to Build a Floodplain
Open valley of Lynn Creek

Directions: Continue up trail along west side of Lynn Creek. About 50 m upstream a short 10 m trail leads to the bank of Lynn Creek (**Figure 2**).

Purpose of stop: To understand the role that shifting stream channel position has in the origin of the floodplain (**Figure 4**).

What You See and Questions to Ponder
You are standing on the top of a forested bank of Lynn Creek. The stream channel is composed of large boulders. In places the stream flows around elongate boulder ridges within the channel (bars) formed during higher flow stages. Across the stream and upstream a low flat bouldery surface that supports a forest of 10 m trees forms the east bank of the stream. Upstream the river flows around an island with larger trees (**Figure 4**). The bank you are standing on exposes a lower layer of boulder overlain by a layer of sand.

How can you tell the "age" of the boulder bar?
Small cottonwood trees 1 m high have grown since the last flood swept across the bar. Therefore, the bar was last active - meaning the boulders it is composed of were last redistributed - a year ago. Since then it has been stable enough for trees to start to grow.

Do all the forests along the stream look to be the same age? Are there areas where the trees seem to be the same age?
The forest along the stream is a mosaic of patches of different age forest. The age of each forest patch reflects the date that area was an active bar in the channel of Lynn Creek.

What does the variable age of the forests on the floodplain tell you?
That the river channel continually shifts its position, and new forests form when the river abandons a channel or migrates away from an area.

What evidence is there that the bank you are standing on is being eroded by Lynn Creek?
It is steep and unvegetated, the stream flows near its base, and there are trees that have toppled from the bank into the river due to undercutting of the bank.

Stop #3: Tale of Two Rivers: Narrow Canyon and Open Valley

Thirty Foot Pool

Directions:: Continue up trail along west side of Lynn Creek. The trail cuts away from Lynn Creek and crosses forested floodplain. Leave the trail just beyond a wooden boardwalk across a side channel of Lynn Creek and before the trail climbs a long set of stairs. Walk north (upstream, right) up a dry boulder channel of Lynn Creek about 100 m to the large pool at the mouth of the rock canyon ("Thirty Foot Pool") (**Figure 2**).

Purpose of stop: To consider the origin of bedrock canyons along Lynn Creek versus open valley floodplains (**Figure 5**).

What You See and Questions to Ponder

You have just walked up an inactive channel of Lynn Creek. The lack of vegetation suggests that Lynn Creek has flowed down it recently, perhaps during the last flood event. During higher waters, stream flow fills several channels across the floodplain.
You are now standing at a major landscape transition in Lynn Creek: upstream it has cut a narrow canyon into bedrock while downstream it broadens and splits as it flows across a wide floodplain. To the west of the canyon mouth is a 15 m high cliff that exposes layered sands and gravels (**Figure 5**). This cliff forms the western side of the floodplain.

Why does the stream change here from canyon to broad floodplain?
Upstream, the surface of the bedrock is above the creek level. Lynn Creek has only been able to cut a narrow canyon through this hard rock. Downstream, the bedrock surface is buried. The river has cut a much broader valley in the much softer, thick sediment that overlies the bedrock. These sand and gravel sediments are exposed in cliff of the canyon mouth.

Why is there a large pool here?
Within the canyon, the flow of Lynn Creek is focused between narrow walls. This focused flow has scoured a deep pool in the gravels at the mouth of the canyon. Scour takes place during floods when the energy is highest. As the stream waters spread out, they lose energy, and the pool shallows downstream.

Is the sand and gravel cliff being actively eroded?
The absence of vegetation along the cliff indicates it is too unstable for vegetation to develop and therefore must be actively being eroded, probably during floods when waters lap up against the base of the cliff.

Where do the boulders we are standing on come from?
Some boulders are brought through the canyon from upstream areas. Others are eroded from the sediment cliffs above you. Remember, the floodplain has been carved from the thick sequence of sediment deposits. Most of the sand and fine gravel has been transported downstream, probably all the way to Burrard Inlet. However, the largest boulders have remained as a residue on the floodplain.

What is the origin of the layer of boulders at the top of the cliff?
The boulder layer is very similar to the boulders presently within Lynn Creek channels, and the boulder layer that underlies the floodplain. Above the cliff is a flat surface or terrace similar to the present surface of the floodplain. Therefore it is likely that the terrace is an ancient floodplain surface that formed when the river flowed at a higher level (**Figure 5**). Stop #4 is at the top of this cliff.

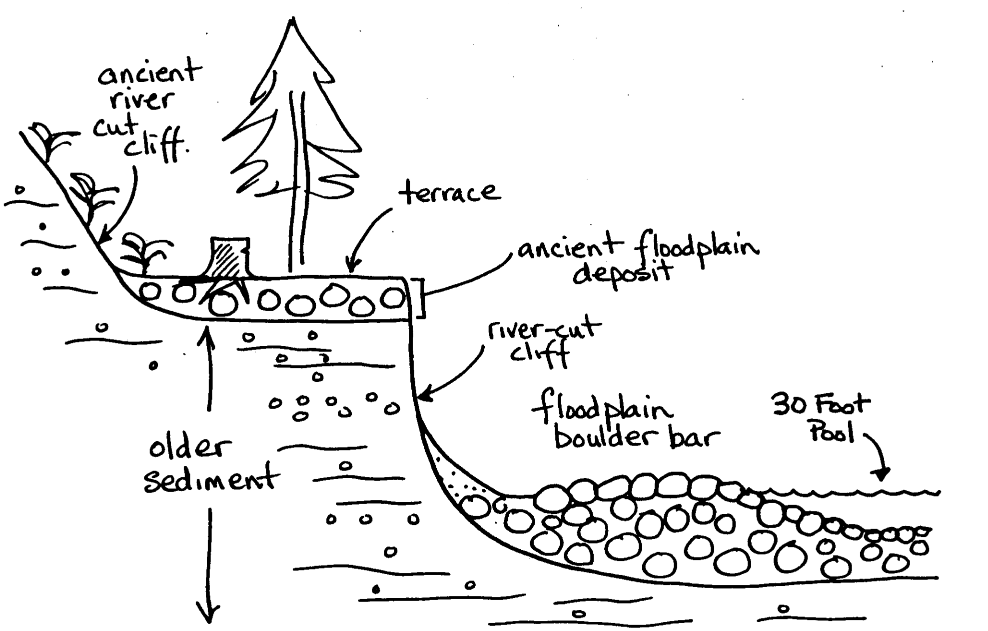


Figure 5.
pools, bars, cliffs and terraces, stop #3

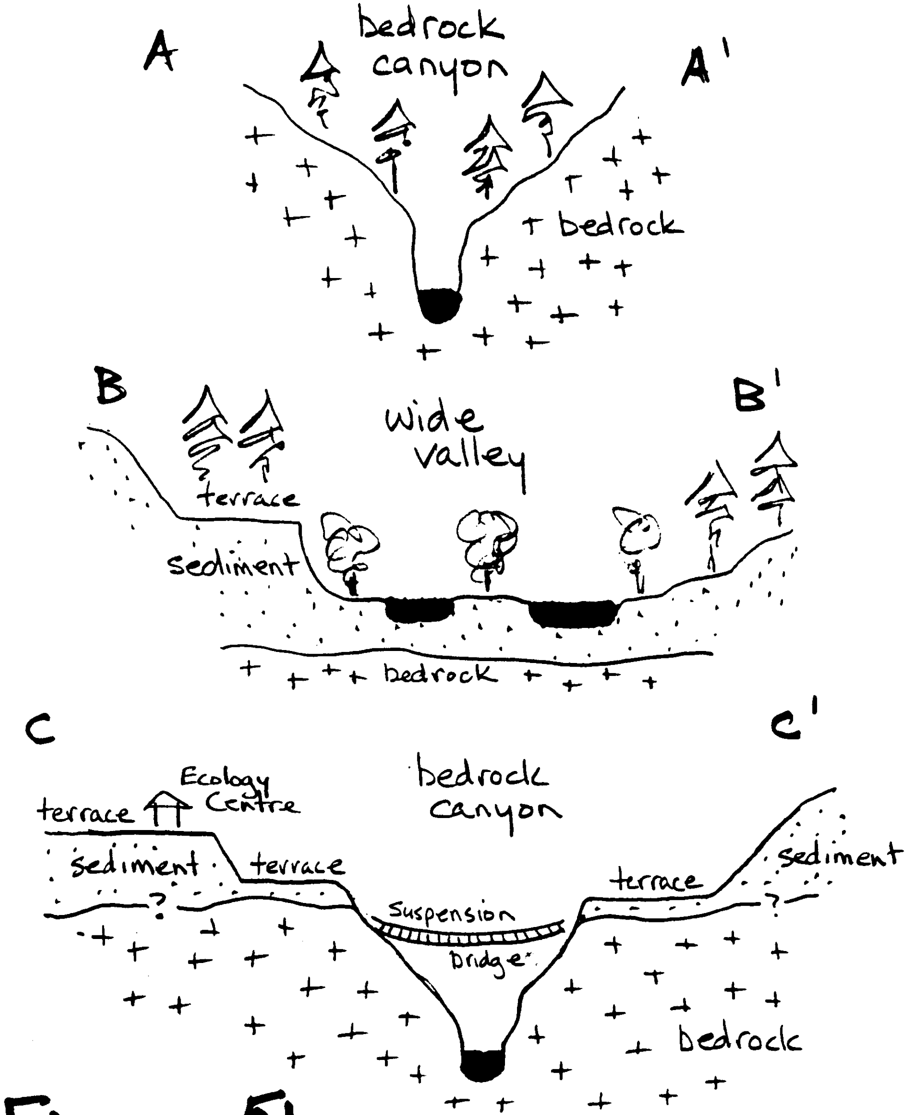


Figure 5b
sections across Lynn Creek (see map for location of sections)

Stop #4: The Ancient Floodplain

Bluff viewpoint across floodplain and open valley

Directions: Return down abandoned channel to trail. Note 3m diameter boulder exposed in channel that is too big for river to move - it must have been eroded from sediment layers that were once above this spot. Climb the wooden stairs to the west up the vegetated cliffs cut in sediment. These cliffs form the western boundary of the floodplain. The forest growing on these cliffs is young and the age of these trees date to the last time these cliffs were last actively eroded by Lynn Creek. The main trail continues along the top of the cliffs, then splits. Take the main trail to the left away from the cliff. The trail route follows the base of a slope that skirts a flat surface that extends to the cliffs. Turn downhill (right) where at the trail junction several hundred metres up the trail. Follow the trail back to the top of the cliffs where there is a view back down the valley of Lynn Creek (**Figure 2**).

Purpose of stop: To consider the origin of ancient floodplain surfaces elevated above the present stream level (**Figures 5, 6, and 7**).

What You See and Questions to Ponder

You are now directly above Stop #3 and Thirty Foot Pool. You are standing on a flat surface tens of metres wide that extends from the cliff edge to the base of a slope to the north and west. The layer of boulders immediately below this surface was visible from Stop #3. Some moss-covered boulders protrude above the forest floor. To the south, the broad valley of Lynn Creek is visible, extending from the mouth of the bedrock canyon at Thirty Foot Pool to the head of the next canyon downstream (just below Stop #1).

What is the flat surface you are standing on?
The flatness of the surface suggest it formed as a floodplain (floodplains are the most common origin of any flat surface in our area). The presence of a boulder layer under this surface that is very similar to the boulder layer under the modern Lynn Creek floodplain supports this interpretation (**Figure 5**). An elevated floodplain surface such as this is referred to as a <u>terrace</u>.

How do terraces form?
When a river cuts downwards, it leaves remnants of its old floodplain surface as elevated terraces (**Figure 6**). As the river migrates laterally, it erodes into the old terraces, forming a new floodplain. Terrace formation suggests that the river has alternated between periods of downcutting and periods of little downcutting. During periods of little downcutting, the river continues to migrate laterally, gradually forming a broad floodplain.

What is the origin of the sloping surface along the trail route we have just walked?
This slope extends down to the ancient floodplain and must be an old bank eroded when the stream was actively forming this floodplain surface. It is an ancient equivalent to the cliff in front of us; its gentler slope reflects erosion of the upper slope after the river stopped undercutting its base.

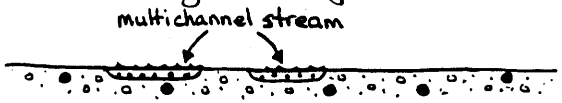
How old is this ancient floodplain?
This surface must be at least as old as the oldest tree growing on it. There are old growth stumps on this surface, with springboard notches, that indicate trees cut in the late 1800's. These trees were likely several hundred years old (300-1000 years?), so this ancient floodplain is at least several hundred years old. It could be much older than that, with older generations of trees now completely decayed.

Figure 6.

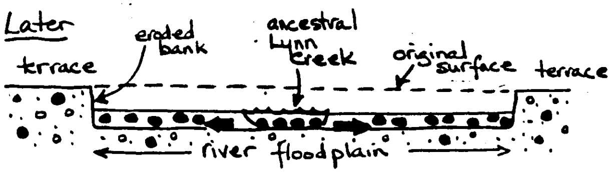
The origin of terraces on Lynn Creek: a hypothesis

① Waning Ice Age 12,000 – 10,000 years ago

- glacier meltwater stream with high sediment load builds broad sand-gravel surface.

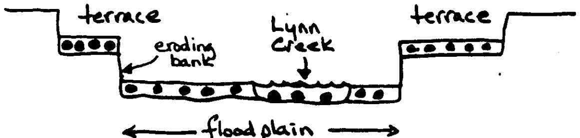


Later



- rising land / falling sea level increases gradient of Lynn Creek, causing downcutting. Lateral migration of creek creates broad flood plain below level of old flanking surface (terrace). River removes sand + fine gravel, leaving residue of boulder

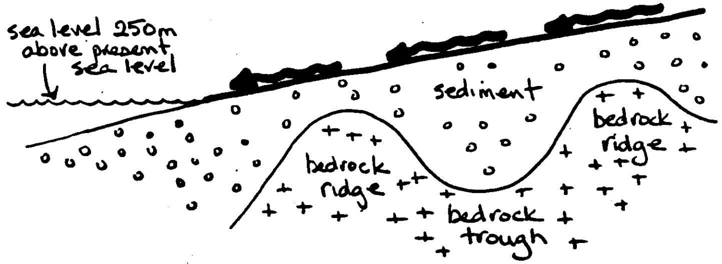
③ Present



- continued fall of sea level increases creek gradient, causing further downcutting and stranding older stream boulder deposits under elevated terraces.

A) Ancestral Lynn Creek (10,000 – 12,000 years ago)

- flows down sediment covered slope to sea



B) Modern Lynn Creek

- canyons form where river cuts through bedrock ridges. Open valleys remain where river cuts through sediment cover, above troughs in bedrock.

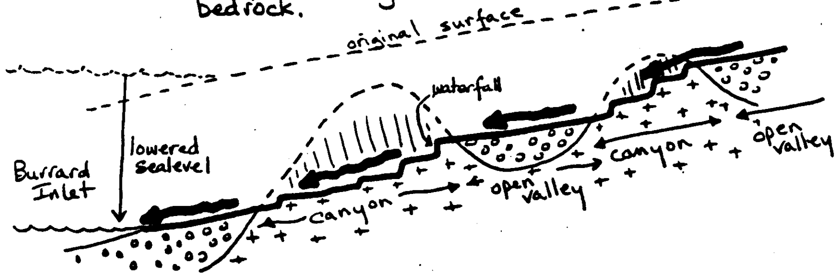


Figure 7

The origin of canyons on Lynn Creek; a hypothesis

Why did the river cut down below this ancient level?
The gradient of Lynn Creek is steep, and the present stream is continuing to cut downwards in its upper reaches. The gradient of ancestral Lynn Creek was much less at the end of the last Ice Age when sea levels were 200-250 m above present sea level (**Figure 7**). Relative sea level fell dramatically as the land rose in rebound to the removal of 2 km of glacier ice. As sea level fell, it increased the gradient of ancestral Lynn Creek (Figure 6), increasing the rate of downcutting. It is possible that this terrace dates to the period of higher sea levels.

Young (0-50 years old) forests of cottonwood (lighter green in summer, bare branched in winter) dominate the valley floor floodplain of Lynn Creek. Older dark green conifer forests (50-150 years old) forest cover adjacent valley sides and uplands. Why is this?

Cottonwoods, (also alder and maple) are capable of colonizing bare sand and gravel channel deposits. If the channel remains inactive, they form forests. Under the canopy of the early deciduous forest, and as leaf litter builds an organic mulch surface, young cedar and hemlock conifers sprout, eventually growing to replace the early deciduous forest. The absence of significant conifer groves on the Lynn Creek floodplain indicates this surface is active and much of it has been disturbed by channel migration and switching in the last 50 years. Valley slope forests are mature and therefore dominantly conifer, except where locally disturbed by recent blow down or logging.

Why does the river alternate from canyon to open valley.
Lynn Creek cuts through a series of bedrock ridges that trend oblique to the course of the stream. Where the stream cuts through these hard bedrock ridges, narrow canyons are formed. Bedrock ridges are separated by bedrock troughs that are filled with unconsolidated sediments. Where the river cuts through these sediment-filled troughs, it easily erodes the soft unconsolidated sediments, forming a broad valley floor (**Figure 7**).

Stop #5: Evidence of an Ancient Landscape
Ancient peat layer exposed in river bank

Directions: Return to the wooden walkway at Stop #1.

Purpose of stop
• To look at ancient sediments (glacial, marsh and lake deposits) that represent ancient and different landscape than the present (**Figure 8**).

What You See and Questions to Ponder

You are standing at the transition between the floodplain-open valley reach of Lynn Creek and the next bedrock canyon downstream. Upstream of here Lynn Creek crosses a sediment-filled trough in the bedrock surface; ahead the bedrock surface rises to form a high ridge. The wooden walkway crosses a small stream tributary of Lynn Creek, and connects the trail along the floodplain upstream with the trail that climbs the bedrock ridge to the suspension bridge.

The wooden walkway crosses the creek, then turns east an parallels a low cliff cut in sediment. The top of the cliff is a narrow flat surface with mature conifers growing on it. The cliff exposes an upper layer of boulders overlying tilted layers of stoney clay east of the walkway (glacial till), and dark peat and grey clayey silt (west of the walkway).

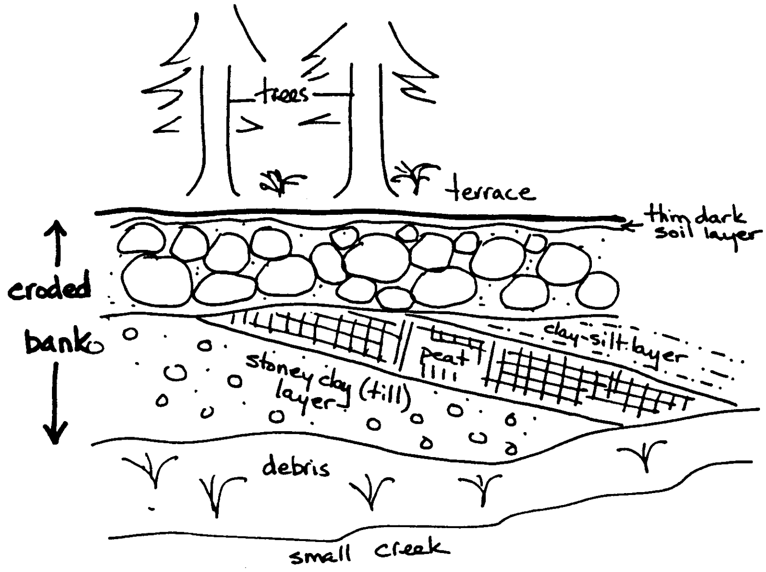


Figure 8: view of river-cut bank at stop #5

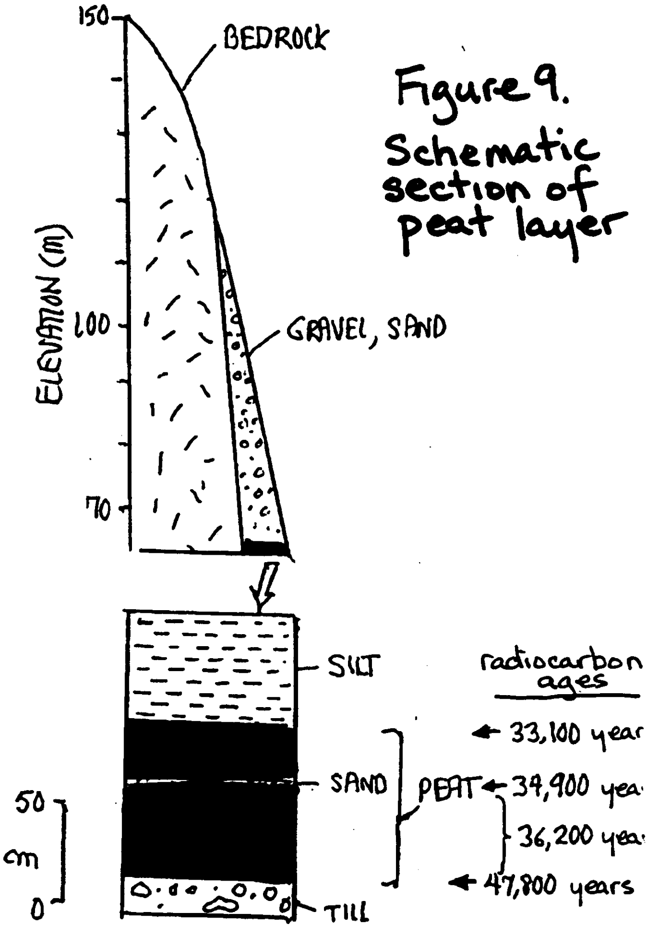


Figure 9. Schematic section of peat layer

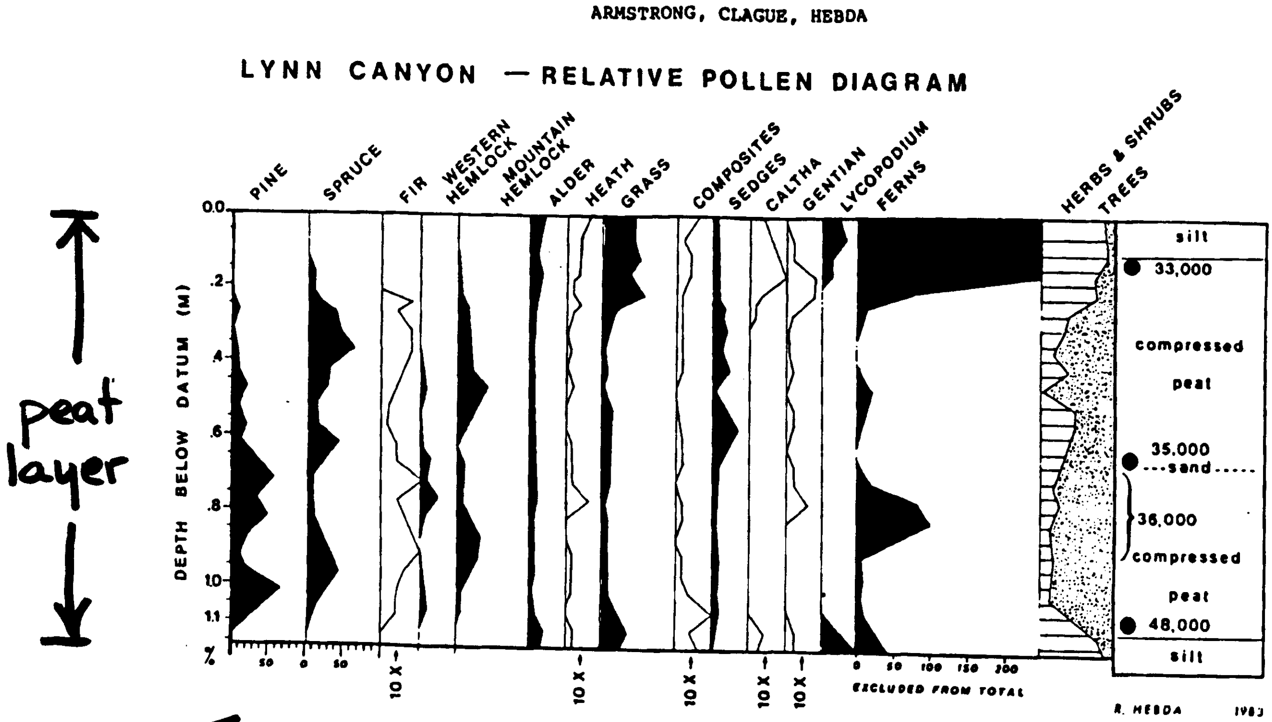


Fig. 10 vertical profiles of pollen contained in peat layer.

Organic material in the peat layer has been age dated by means of radiocarbon analysis (**Figure 9**) which indicate the peat spanned a period about 47,800 to 33,100 years ago. This coincides with the interglacial period prior to the last glacial advance. Examination of the pollen contained in the peat indicates a much cooler climate than today (**Figure 10**). The youngest and oldest layers of peat contain pollen from mosses and herbs that grow only in the alpine zone today. The central peat contains evidence of forests of western hemlock, spruce, lodgepole pine, and mountain hemlock. The presence of mountain hemlock pollen, trees which now occur only above 1000 m elevation, and the absence of Douglas Fir, suggest a cooler climate than today.

What is the origin of the boulder layer?
The boulder layer lies above the present floodplain and underlies a flat terrace surface that extends up to the bedrock slope. It is similar to the higher elevation terrace of stop #4 and likely represents an older floodplain surface. The boulder layer cuts across the underlying tilted sediments and therefore formed after the sediments were tilted.

Is this terrace surface older or younger than the terrace surface of Stop #4.
It is likely that this terrace is younger than the Stop#4 terrace because this terrace surface is less elevated above the present floodplain. As the river continues to cut down, older terraces are more elevated than younger ones.

The stoney clay, peat, and silt layers are very dense and difficult to break. In contrast, the sand matrix in the overlying cobble layer is loose and erodes with gentle finger pressure. Why are these layers so different?
The stoney clay, peat and silt layers formed prior to the last glaciation and were overridden by a glacier as much as 2000 m thick. The weight of the glacier ice compacted these sediments. The peat, which originally was porous and water-filled, was condensed to about 10% of its original thickness. The overlying boulder unit formed after the glaciation and was never deeply buried by ice, so remains loosely compacted.

Stop #6: Cutting a Canyon! Birthing a Terrace
View from the suspension bridge

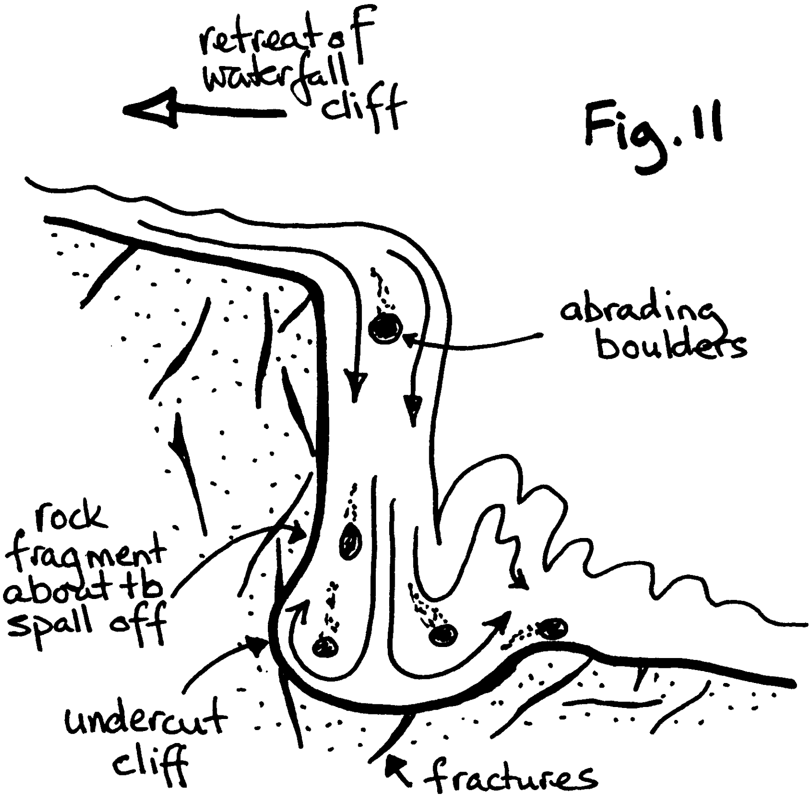
Directions: Continue south along the trail as it rises up the bedrock ridge. Several viewpoints of the canyon can be accessed via short side trails. Angular blocks of rock on the slope along the trail represent the ongoing rockfall from the bedrock cliffs, a process that widens the upper slopes of the canyon. Turn east at the trail junction and walk to the center of the suspension bridge. Stand to one side to allow others to pass by.

Purpose of stop
To consider the processes that cut the canyon (**Figure 11**).
To consider how canyon cutting can create terraces upstream.

What You See and Questions to Ponder

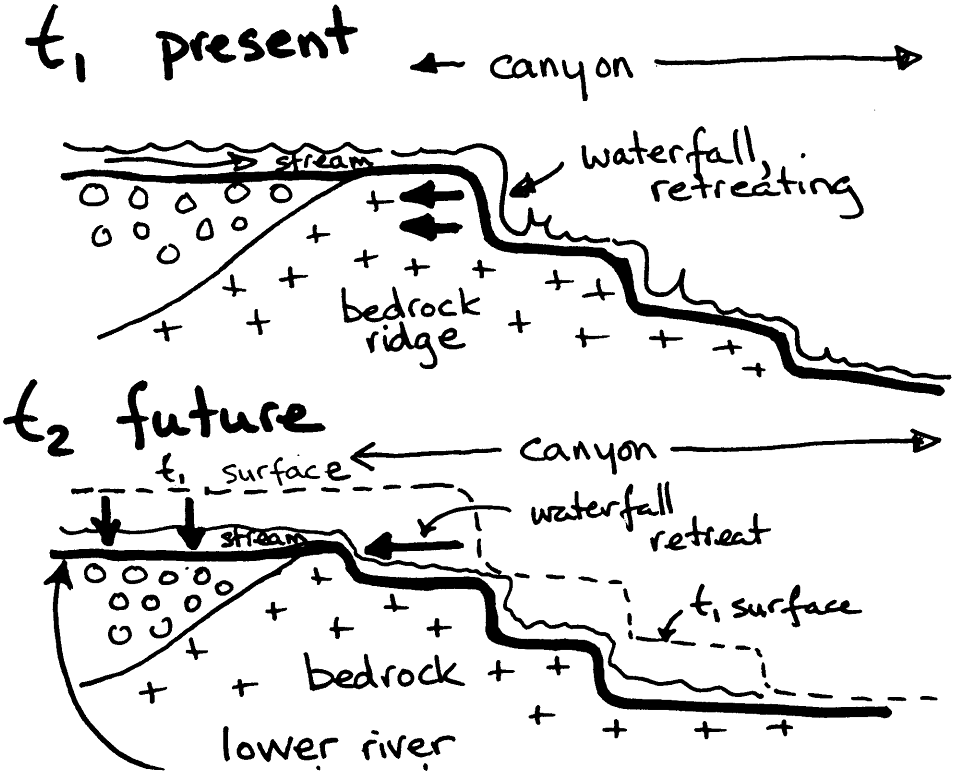
The river canyon upstream to the open valley reach is visible from the suspension bridge. The canyon is a series of waterfalls, pools, and bedrock slides. The uppermost waterfall is just downstream from the transition to the open valley reach.

Fig. 11



profile of a waterfall in retreat

Fig. 12



waterfall retreat lowers bedrock lip of canyon, causing incision of stream channel upstream

How do waterfalls cause down cutting?
Waterfalls continually retreat upstream due to ongoing collapse of the rock cliff underlying the waterfall. Collapse is due to undercutting by erosion at the upstream end of the pool at the base of the waterfall. Erosion is due in part to abrasion by moving rock particles from sand to boulder (Figure 9). Pressure fluctuations due to falling and flowing water can transmit pressure waves through adjacent rock, causing fractures in the rock to fail.

A rock rib above the highest waterfall controls the upstream gradient of the stream. What will happen when the highest waterfall retreats back through this rock rib?
When the rock rib is removed, the river level at the top of the canyon will drop. This will cause the gradient of the river upstream through the open valley to increase, and the river will downcut its channel through underlying sediments. The adjacent floodplain of the open valley will be stranded as an elevated terrace (a terrace will be born!)