February 28, 1980
Source: *The Province*, February 28, 1980.
Details: February 28, three avalanches closed the Salmo to Creston section of Highway 3. Highway maintenance crews hoped to reopen the highway on February 28. Traffic over the Rogers Pass section of the Trans-Canada Highway was also delayed by avalanche stabilisation work.

March 1980
Source: *Campbell River Courier-Islander*, February 16, 2007.
Details: In March, a section of bank let loose, slamming into what was then called the Island Inn Motel and causing extensive damage.

March 12, 1980
Source: *Campbell River Courier*, March 14, 1980; *The Campbell River and area Mirror*, March 19, 1980.
Details: Starting 10 p.m. on March 12, southeast winds caused power outages between Courtenay-Kelsy Bay, including Quadra Island. The Campbell River airport recorded winds as high as 80 km/h. A heavy blanket of wet snow compounded the problem. In the Black Creek and Campbell River area, about 11 cm of snow fell, while the Campbell River airport received 30 cm. At Campbell River's Tyee Spit, some floatplanes sank under the weight of the snow. A large helicopter was used to raise two of the aircraft.

Early June 1980
Source: *Victoria Times*, June 6, 1980.
Details: In early June, heavy rains caused several mud- and debris slides about 25 km north of Lytton. On June 6, this section of the Trans-Canada Highway reopened to one lane traffic.

November 1980
Source: *The Vancouver Sun*, November 28, 1980; January 3, 1981; *The Province*, December 1 and 10, 1980; January 7, 1981.
Details: In November, Vancouver experienced the wettest month in half a century. Its total rainfall of 310.9 mm was more than double the average of 145 mm and eclipsed the all-time record of 300.2 mm set in December 1972. *1)

About 15-20 years before the town was built, the last known mudslide in Elkford occurred. According to Alan Elford, editor of the *Elkford Ragg*, "it just slid into the river and pushed the (Elk) river out of its normal bank." Because Fording Coal, the town's major employer, knew of the slide danger before it built the town 10 years earlier, the provincial government ordered the company to pay the cost of relocating the residences and ten business from the affected area. It involved moving 75 mobile homes, a 250-unit apartment building and several stores and residences on the triangle bordered by the Elk River to the west and the highway through town to the east.

On December 1, Fording Coal Ltd. stated they were working on plans to move the buildings at Elkford, about 60 km east of Cranbrook. Early January 1981, Fording Coal officials called the report of mudslide hazards inaccurate but planned to relocate some workers anyway. They noted not to be bitter about the dispute but considered the publicity surrounding it as "overblown" (*The Province*, January 7, 1981).

---

*1) The previous highest rainfall for November was in 1959 with 281.9 mm.

December 8-15, 1980
(Rain-on-snow).
Discharge (m^3/s): Max. daily: December 16: BC/BB: 701; Sall.: 141; max. instant.: December 16: BC/BB: 725; Sall.: 241. (Both Salloompt River values are extreme records for the period 1965-1982).
Source: *Victoria Times*, December 15, 1980; *Terrace-Kitimat Daily Herald*, December 17, 1980; *Comox District Free Press*, January 2, 1981; Environment Canada 1988; Environment Canada 1992.

Details: Floodwaters wiped out two logging camps near Owikeno Lake, 145 km south of Bella Coola. The water level in the lake rose 6 m. On December 16, Owikeno Lake at Rivers Inlet recorded a maximum instantaneous water level of 5.074 m and an estimated maximum daily water level of 4.870 m (Environment Canada 1988). The Owikeno Indian Reserve was threatened. One family was evacuated. The previous peak flood had occurred in 1968.

Around the middle of December, the Oyster River threatened to burst its banks. The dyke sustained damage resulting in minor flooding. Following this flood, which caused an estimated $12,000 damage to the riprap, Comox-Strathcona Regional District (C-SRD) tried to convince the provincial government to fund the replacing of the riprap. On December 18, C-SRD was notified that it was not "within their (the government's) responsibility to do it." (See: December 23-27, 1980 event). C-SRD administrator Wayne D'Easum called this flood "a unique situation where it snowed like crazy and all turned to rain." (*Comox District Free Press*, January 2, 1981).

December 23-27, 1980

(Rain-on-snow and tidal flooding).

Discharge (m^3/s): Max. daily: December 26: Capil.: 293; Chem. 457 (extreme record); Kok.: 207; Zeb.: 384; December 27: L. Qual.: 162; Nan. C.: 714; Squam.: 2,020; Stamp G.: 319; December 28: Cowich.: 275; max. instant.: December 26: Capil.: 468; Zeb.: 790; December 27: Cowich.: 279; Nan. C.: 958 (extreme record); Squam.: 2,180E; Stamp G.: 327.

Source: *The Province*, December 28, 1980; January 4 and 7, 1981; *Victoria Daily Times*, December 29 and 31, 1980; *The Vancouver Sun*, December 27, 29 and 30, 1980; January 3, 6, 13 and 24, 1981; April 7, 1983; *Nanaimo Daily Free Press*, December 27, 29 and 30, 1980; *Times Colonist*, December 29, 1980; November 5, 1982; *The Nanaimo Times*, December 30, 1980; *Merritt Herald*, December 31, 1980; *Comox District Free Press*, January 2, 1981; *Citizen Shopper*, January 8 and 15, 1981; January 14 and 22, 1982; *Cowichan News*, February 4, 1981; January 3, 4, 9, 14 and 27, 1983; May 7, 1983; October 15, 1983; MacFayden n.d.; VanDine 1985 (p. 65); Environment Canada 1988; Environment Canada 1992; Church 1988 (pp. 216-217); Church and Miles 1987 (pp. 64-67); Watt et al. 1989; Lewis and Moran 1985 (p. A.24); Eisbacher 1983 (p. 31, 38, 42); Melady 1997 (pp. 87-97); Ministry of Environment files, Memo January 22, 1981 P.F. Doyle, File 069-B Inspection January 19, 1981-Flood damage Anderson River and Uztlius Creek and proposed new road on Anderson River; Memo January 12, 1981 P.F. Doyle, File 069-B-Field inspection January 5, 1981-Coldwater River flood, December 26, 1980; Memo January 8, 1981. H. Nesbitt-Porter. Re: Flood damage repairs estimate).

Details: Between December 25-27, southwestern British Columbia experienced heavy precipitation and unusually high temperatures. On December 26, a two-day rainstorm and a rise in temperature caused extensive debris floods in the southern Coast Mountains. The event produced a maximum streamflow well in excess of that expected for the storm, to judge from return period criteria for the rainfall (Church 1988). During a storm on December 23-24, a maximum wind of 64 knots/h (118.4 km/h) was recorded (MAST Shiplisting 1946-1983 In: Lewis and Moran 1985). It replaced a high-pressure ridge that had become established around December 17. Winds reaching 67 km/h caused several power outages throughout Greater Vancouver and the Fraser Valley.

The 1980 Christmas storm was the culmination of a series of cyclonic disturbances that moved into the area from the southwest after December 20. The southwesterly flow of warm air resulted in record-high temperatures from California to Alaska. On Boxing Day, the Vancouver International Airport recorded a temperature of 15^{o} C, one degree above the record set in 1937. Other daily maximum records were set in Port Hardy, Victoria Airport, Comox, Lytton, Cranbrook, Williams Lake and Prince George. The Victoria Patricia Bay airport recorded 15.5^{o} C breaking a 37-year old record by 5.5 degrees. Abbotsford was the hotspot in the province with 18^{o} C. Eight other communities broke or set temperature records for Boxing Day. During the event, there was a substantial snowpack. Freezing level records from two upper air stations in southern British Columbia indicate the possibility for snowmelt during the storm.

The month of December was unusually wet in the eastern Fraser Valley. At Hope Airport, the total precipitation for December was 441 mm, 152% of the long-term average. Of this, 185 mm fell on December

25-27. During the preceding three days, 35-60 mm of precipitation occurred in the region, mainly as snow. Between December 25-26, Hope recorded 124 mm of rain in two days. At high elevations, a deep snowpack existed (Church and Miles 1987). On December 25, Hope recorded 82.3 mm, bringing its three-day total to 134.8 mm. In Vancouver, the Christmas rain set a new precipitation record for December with a total up to December 27 of 139.7 mm. *1) Two-day rainfall at the Victoria airport totalled 53 mm and about half that amount at Gonzales. In the 24-hour period ending 4 p.m. on December 25, Sooke, Nanaimo, Port Alberni and Comox recorded 62 mm, 50 mm, 65 mm and 45 mm, respectively. On December 26, return periods of daily mean streamflows were in the range of 20-40 years. Instantaneous peakflows generally were somewhat less extreme with the exception of the Chilliwack River, where the 387 m^3/s had an indicated 25-year return period. On December 26, the Vedder River recorded a maximum daily water level of 4.709 m (Environment Canada 1988).

Storm runoff and snowmelt at higher levels brought about unusually high flows in most streams on Vancouver Island. Extensive erosion and overtopping of riverbanks ensued, causing inundation and subsequent loss or damage for many residents in southwestern British Columbia. In the Hope and Lower Fraser Valley areas, streamflows were uncommonly large and in many cases record flows. It appears that record peak instantaneous flows were recorded on the Coquihalla River, Chilliwack River, Cheakamus River, Lillooet River, Mamquam River, Squamish River, Stawamus River and Silverdale Creek. On December 26, the Chilliwack and Coquihalla rivers recorded peak instantaneous flows of 1,130 m^3/s and 708 m^3/s, respectively. Preliminary estimates of the frequency for these occurrences were in the 1:30 to 1:90-year return intervals. Maximum streamflows for Coldwater River at Merritt and Tulameen River at Princeton on December 25 were 4,860 m^3/s and 13,500 m^3/s, respectively and 6,500 m^3/s and 16,800 m^3/s instantaneous for same rivers. (comparing to peak streamflows for both rivers set on May 30, 1972 of 4,060 m^3/s and 13,200 m^3/s, respectively.

Data for the storm in the Upper Coquihalla Valley were as follows: total four-day precipitation: 218 mm, four-day snowfall: 21 mm; storm run-off: 142 mm; greatest day precipitation (December 26): 81 mm; greatest two-day precipitation (December 25-26): 155 mm; Instantaneous peakflow (December 26): 65.3 m^3/s; return period instantaneous peakflow: 27 years; daily peakflow: 46 m^3/s; return period of daily peakflow: 38 years (Church 1988).

Though the rainfall was not unusual for the time of the year, a combination of rain and the melting of snow packs caused flooding in such areas as Hope and Squamish. During this event, debris torrents occurred on tributaries in Coquihalla, Silverhope, and Nicolum valleys. They occurred on December 26, while some others took place on January 4, 1984 (VanDine 1985). Sediment and debris infilled the Silverhope (Silver) Creek channel at the Riviera Motel and near the Baker residence near the mouth causing channel migration. Severe erosion at the Riviera Motel resulted in the loss of a cabin into the stream.

On December 26, debris torrents blocked both major highways north and east from Hope and the Coquihalla Valley road. Torrents are also known to have occurred in the valley of Silverhope Creek. In Fraser Canyon near Yale, both the Trans-Canada Highway and the CPR line were cut. Flood damage was widespread, extending from Squamish to Princeton.

On December 26 in Hope, more than 60 families of two subdivisions including the homes in a new riverside subdivision near Coquihalla River were evacuated. Severe erosion occurred at several locations along the river. At Riverside Estates, extensive erosion occurred to some 200 m of riverbank. On Boxing Day, the river spilled its banks, sweeping through Glenhalla subdivision. The Coquihalla River was completely blocked by a logjam at Othello, 5 km (also reported as 8 km) above Hope. The threatening logjam in a narrow gorge near the subdivision held. After the water started making its way around the blockage, the threat of a wall of water come down towards Hope diminished. At one point, the river flooded the basement and lawns of about 30 homes. About 250 m of bank suffered erosion behind the Town of Hope Hospital.

Erosion also occurred along substandard flood mitigation berms along the Campground area near Kawaka Lake Road bridge. Deroche (Crazy) Creek lived up to its local title “Crazy” by its violent behaviour in flood, causing erosion, abandoning its channel and rerouting on the alluvial fan. During the December storm, the creek caused considerable erosion, sedimentation and stream migration, threatening homes and

destroying a barn. Eng Creek broke out of its channel high on its alluvial fan, eroding a waterline and threatening a house. During the storm event, debris flows occurred in the Gordon Creek headwaters, contributing masses of forest and logging debris into the stream. Debris and sediment then plugged the large diameter culvert through the highway and CPR line, completely washing out the fills. Sedimentation and debris caused a minor diversion in Ryder Creek at its confluence with Chilliwack River. On the Chilliwack River, significant logjams and accumulations of debris occurred in at least nine different locations above the Vedder Road bridge. A private cabin opposite the motel was also lost into the stream. Flooding and erosion occurred at several locations on the South Alouette River. The most significant damage occurred to the houses owned by Mr. T. Charters and Mrs. A. Heads. The two houses were substantially wrecked by river erosion, which caused the loss of up to 15 m of land over a length of about 100 m of riverbank.

During the storm period, winds carried considerable floating logging and forest debris onto the Village of Harrison Hot Springs beach at the south end of Harrison Lake.

Near Whistler Village, the freezing level rose to approximately 2,000 m. Snowmelt combined with more than 100 mm of rain triggered debris flows in many torrents, such as Nineteen-Mile, Twenty-one mile and Fitzsimmons creeks. Some damage was done to roads and bridges in the valley (Eisbacher 1983, Jackson et al. 1985).

Hardest hit were Hope, Squamish and parts of Vancouver Island. During the Boxing Day floods an estimated 350 houses were damaged, 200 of which in the Squamish area. Basements flooded throughout most of Delta and New Westminster. High tides flooded basements in Surrey. In Port Coquitlam, Pitt River Road was closed to traffic. A combination of high run-off from the Pitt Lake area, high tides and heavy rainfall caused the flooding in Port Coquitlam. In addition, debris and floating logs jammed pumps reducing or even neutralising their effectiveness (*The Vancouver Sun*, January 6, 1981). Flooding closed the Lougheed Highway between Mission-Maple Ridge. Highway 93 closed east of Radium Hot Springs and the Rogers Pass section of the Trans-Canada Highway was closed east of Golden. All road links between British Columbia-Alberta were temporarily cut.

Water levels in the area lakes, Cheakamus, Daisy and Garibaldi were much higher than usual. Overflow from Daisy Lake caused to back up the Squamish River, closing Highway 99 between Squamish-Garibaldi. About 2 km of the old Highway 99, known as Government Road, was under water. The Cheakamus River threatened several cottages between it and Highway 99. Angry residents of the Upper Squamish Valley had accused Hydro of causing a good portion of the flooding problems, which destroyed or damaged 200 homes in the Upper Squamish and Squamish area by untimely releases of water from the dam. *2) Rescue co-ordinator for the provincial emergency program Al Bird was satisfied that BC Hydro did everything it could do to control the flow and that the public was “warned in reasonable time.” Dave McDonald, a production superintendent at BC Hydro, said: “Daisy Lake is a fairly small lake and we had absolutely massive amounts of water coming in. We made the decisions on holding it or releasing it in the interest of everybody’s safety.” BC Hydro defied provincial government regulations by holding back more water than permitted in the Daisy Lake Dam reservoir above Squamish. According to Bill McNeney, Hydro production manager in the area, the inflow into the reservoir on December 26 was ten times the normal amount for this time of the year. The top of the dam is 1,241.5 ft. (372.45 m) above sea level with the government calling for the level of the 36-ft. (10.8 m) deep lake to be held at 1,235 ft. (370.5 m). At one time on Boxing Day, the water level rose as high as 1,240 ft. (372 m), just 18 in. (45 cm) below the top of the dam.

Squamish was the hardest hit area in the province. The flooding of the night of December 26 was caused by logjams, which suddenly swept down the Squamish, Cheakamus and Mamquam rivers. A partial jam in the Mamquam River suddenly gave way, sending a wall of water down the river. The Squamish River jumped dykes flooding an area where the dyke was never completed because funding ran out. The riprap put in place was wiped out. According to an emergency measures spokesman, he had “never seen this much water come down the river in 30 years.”

In the Squamish Valley, many of the mobile homes in the Spiral Trailer Court were flooded, forcing the evacuation of a trailer park and other homes closest to the water’s edge. The heavy rain caused flooding in Squamish and Brackendale as four area rivers quickly rose to the flood stage. *3) Three helicopters and a

hovercraft were used to evacuate more than 500 people in low-lying areas of Squamish and Brackendale. Shortly after midnight December 26, most Brackendale residents were told to leave their homes. Several hundred Brackendale area residents were evacuated when floodwaters from the Squamish and Mamquam rivers threatened their homes.

On December 26, the Mamquam River flooded the Wagon Wheel Trailer Court and road. Debris washed down by the Mamquam River contained many old logs that had reportedly been in the river "for years and years," untouched by previous run-offs. At the Valleycliffe subdivision, the Stawamus River, diverted some years earlier by city engineers to form a park, reverted to its old course and threatened to sweep away the Johnny de Souza home. RCMP had special patrols out during the crisis to prevent looting. The BC Rail line was broken to permit the water out.

Floodwaters cut roads north of Squamish and three bridges on the road to Cheekye washed away. After the Cheekye bridge on the Cheakamus washed out, the residents of the Upper Squamish Valley about 35 km north of Squamish were flown out. A Comox-based Labrador Search and Rescue helicopter rescued two families trapped by rising floodwaters near Squamish. In a daring mission, the crew plucked two and four people, respectively to safety. Weather conditions during the operation were bad. According to pilot Keith Gathercole, "The rain was falling so bloody hard, the rotor blades were turning it into a fog. With the landing lights on, I couldn't see 10 ft. (3 m) in front, so I turned them off, but it was no better." (Melady 1997). Gerry Gray, one of the Search and Rescue Technicians, described the situation in Squamish. "We could see that half the town was under water." (Gary In: Melady 1997).

Dykes prevented flooding in Squamish itself and the new highway but the unprotected area on the north shore of the Mamquam River and from the confluence of the Mamquam and the Squamish rivers up to the Lions Easter seal camp suffered heavy flooding.

According to John Jellis, flooding on his property on Meadow Avenue near Brackendale was caused by an obstruction across Dryden Creek where a bridge had been built creating a culvert. Jellis said the log bridge filled with earth, which acted as a dam, backed up the water. When during high water a series of small culverts further down the creek broke the water went down (*Citizen Shopper*, January 22, 1981).

On December 26, a flood or debris flow event occurred on Culliton Creek, north of Cheekye. High rainfall caused debris and logs to block a culvert and wash out a highway (VanDine 1985). On December 26, during an intense rainstorm Culliton Creek, between Squamish-Whistler Village pushed several thousand cubic metres of debris and logs against the upstream embankment of Highway 99. The culverts across the road were completely plugged and overflow carved a wide gash into the roadbed. Judging from the stream gauge records of other torrents of similar size in this region, maximum flood discharge of Culliton Creek during this storm amounted to about 30 times the mean rate of discharge for the month of December (Eisbacher 1983). The dam at Culliton Creek held back only by a man-made dyke (*The Province*, December 28, 1980). The gorge at Culliton Creek had been bridged for the highway by construction of an about 25-m high earth-fill dam. Though the two large culverts allowed the water to flow through, the immense run-off built a head of water, the RCMP estimated at 20 m.

South of Pemberton, one abutment of the railroad bridge across Rutherford Creek washed out, necessitating replacement of the whole structure. In Pemberton, the Gordon Ferguson home was hardest hit by flooding. During the rainstorm there was a major shift of the braided Rutherford Creek channel between the bridge and Green River (Eisbacher 1983).

On the west end of Duffy Lake Road, washouts and mudslides stranded five people whose pickup truck went into a ditch. Pemberton RCMP using a helicopter rescued them the following day. The only way to travel north of Alpine Meadows on Highway 99 was by a stepladder across the rushing waters of 19 Mile Creek. Whistler volunteers dug out this section of the highway in order to save the surrounding residences from being washed away by the floods. On December 26, floods damaged Miller Creek bridge in Pemberton Meadows. The Squamish highway reopened on December 28.

On December 26, mudslides and washouts closed the Trans-Canada Highway near Hope. A washout on the Trans-Canada Highway near Yale would take at two days to repair. Mudslides and a washout at Gordon Creek, 16 km north of Hope, closed Highway 3 between Hope-Princeton for about one day. Extensive washouts also closed the highway between Hope-Vancouver, which was not expected to be

reopened till December 29. Highway 93 through the Kootenay region was closed east of Radium Hot Springs and the Trans-Canada Highway was closed east of Golden. On December 29, crews were still working to repair washed out portions of the Lougheed Highway.

On December 26, washouts damaged both the CPR and CNR main lines. A washout 16 km northeast of Hope closed the Trans-Canada Highway and the CPR mainline. It took repair crews till midnight on December 28 before the CPR mainline at Gordon Creek could be rebuilt. Here at Yale, a 100-metre stretch of track washed out. Repairs to the CN main line were expected to take till at least January 5 or 6. In the meantime, CN would use CPR tracks. VIA Rail, which used CN and CP tracks, continued to airlift passengers booked on CN trips at least till December 31. CP booked passengers would be moved on the CP line as soon as this would be reopened. The CNR mainline was severed at Hope when floodwaters of the Coquihalla River weakened a trestle. On January 8, VIA Rail service between Edmonton-Vancouver was back to normal.

The Chehalis River caused flooding and erosion and deposited logjams. At Pioneer Chehalis Village, water overtopped about 30 m of pre-existing dyke fill and caused lateral erosion of about 1.5 m along about 200 m of fill. Minor damage occurred to a swimming pool and outbuildings due to shallow overland flow.

In the Hatzic Valley, 10 km east of Mission, a mudslide swept away a house on Stave Lake Road just hours after the residents had left on a vacation. The slide initiated in a shallow natural drainage channel where a layer of colluvial material slid over a steep bedrock plane. The moderately large (estimated at 10,000 m^3) slide cascaded off the mountainside destroying one house, inundating Stave Lake Road, flowing completely around another house and against another one. On December 26, the debris torrent on Kenworthy Creek destroyed a house (P.J. Woods, pers. comm. In: VanDine 1985). About five families were evacuated after the “tons of mud” had roared down the hillside. “I thought it was a big plane but then it got louder and louder,” said the resident of a trailer next to the demolished home.

Over several days from Christmas to New Year’s, extensive flooding occurred around Hatzic Lake. On December 28, the water level in the sump of the Hatzic pumphouse was measured at about 12.1 ft. (3.63 m), giving an estimated peak lake level of about 12.2 ft. (3.66 m). This was approximately 0.3 ft. (9 cm) less than the attained lake level during the 1979 flooding. The pumps operated from December 26 to January 2, 1981.

Traffic on the 130-km stretch of track on the BC Rail line between Squamish-Lillooet was halted due to more than 20 washouts of roadbeds and bridges. BC Rail lost a railway bridge due to a washout at Rutherford Creek. As service was expected to be halted for about a month, 300 hundreds BC Rail employees were laid off until service would resume. Repair cost was estimated at between $850,000-1 million. By January 3, 1981, 13 of the 25 washouts were repaired and all slides cleared. Traffic along the BC Rail line was restored on January 15, nine days ahead of schedule.

A carry-over of an intense storm across the coastal mountains caused the December 1980 flood on the Tulameen and Coldwater rivers (Watt et al. 1989). In Princeton, volunteers spent most of December 27 sandbagging the banks of the Tulameen River while an ice-log jam upstream the Similkameen River to flood the town. In Princeton, the residents of 10 houses were evacuated. During the Boxing Day flood, the Coldwater River completely flooded Voght Park and Main Street. Six basements around the corner of Main and Canford Avenue flooded. On the morning of December 27, city work crews dug a ditch on Canford Avenue to drain floodwaters from Voght Park and channel it back into the Coldwater River. Near Merritt, the Coldwater River overflowed its bank, washing out a portion of railway track, 1 mi. (1.6 km) from Merritt in the direction of Brookmere. The Coldwater River washed out Coldwater Road in half a dozen places. The Spring Island Trailer Court was flooded. For the second time in nine days, its residents had to be evacuated, this time for 24 hours. When the floodwaters receded on December 28, two trailers were left uninhabitable and the possessions stored in some shed were lost. Apparently city crews cut the new dyke, downstream of the trailer court to allow the release of increasing floodwaters trapped behind the dyke. The total estimated cost of restorative work in the Merritt-Princeton area was $250,000, including an allowance for additional damages.

Numerous slides occurred both on natural and logged slopes on the main stem and the Middle Fork of the Anderson River for a few miles upstream and downstream of their confluence flow through steep-walled boulder-strewn canyons with narrow valley floors. Particularly downstream of the confluence, it is a very active slide area with the slides often happening by the river cutting away the toe of the slope. The largest of the slide, covering several acres, was in the middle of a proposed timber cut and crossed the proposed new access road on the Anderson River. The flood damage included breach of road embankment for 50 ft. (15 m) due to channel relocation at the mouth of Middle Fork on the north access to the bridge. On the Middle Fork, some bridges were damaged or destroyed and some road destroyed. On the main stem of Anderson River for about 3 mi. (4.8 km) upstream of Middle Fork were damaged. In some locations, the channel migrated laterally up to 40-50 ft. (12-15 m) or more.

The logging road paralleling Uztlius Creek in the valley bottom was obliterated for hundreds of yards in a few places or completely washed out at numerous locations. All bridges, about 10, in an 8-mi. (12.8 km) stretch of road were either lost or had one or both approaches damaged (Memo January 22, 1981 P.F. Doyle).

Worst damage occurred at the Patchett Creek bridge near the mouth of Midday Creek. On Patchett Creek Road about 20 mi. (32 km) from Merritt, Patchett Creek washed out a bridge approach. The gaping hole was blocked with a huge logjam. According to the manager of the Merritt Highways district Darcy Byers, the river had to be rechannelled before the approach could be reconstructed. There was 50-75 ft. (15-22.5 m) of right bank erosion upstream and downstream of the bridge for several hundred feet and approximately 20-30 ft. (6-9 m) of bank erosion on the left bank at the bend upstream of the bridge. About 70 ft. (21 m) of the right bank approach road from the abutment toward the bank was washed out completely. About 100 ft. (30 m) of the road leading down to the bridge washed out as well. Floating debris damaged the timber nose of the centre pier and part of the bridge railing. There was also negligible damage to the right abutment. The left bank approach road washed out at the eroded bend upstream. Other major highway damage included three road washouts in the vicinity of Shouz Creek where the highway runs adjacent to the outside of three sharp bends in the river. The maximum lateral erosion was about 40 ft. (12 m) in the worst of the three spots. The maximum stage in the main channel was about 1 ft. (30 cm) below the road surface at all three locations. Other minor damage was sustained by Highways, including some damage to the right abutment of the bridge at Kingsvale. From evidence at the bridge it appeared the peakflow was about 5,000 cfs (141.6 m^3/s) (Memo January 12, 1981 P.F. Doyle).

The logging road on the left bank of the Coldwater River just east of Fig Lake washed out at a step cut bank on the lower loop of the switchback climbing out of the valley. Damage to Coldwater Valley roads was estimated at $250,000. Floodwaters also closed Highway 8 to Spences Bridge for 28 hours.

Ryan Creek broke through the dykes in 12 places. The openings varied from 12 ft. (3.6 m) to 80 ft. (24 m) wide. This damage occurred over a 2-km length of the dyke. For a length of 4 km, including the above 2 km, the water reached the top of the dyke. A frozen layer of snow on top of the dyke prevented the water from overflowing the dyke over the whole length of these 4 km. Repair cost was estimated at $60,000.

Two slides came down in the mountain area of Miller Creek. Floodwater carried this slide material down to the valley floor. It was deposited in the creekbed raising the bed to an elevation that sent water over the banks in habitated areas, flooding farmland and four dwellings. Cost of excavating and hauling deposited gravel to restore banks and creekbed depth to original was estimated at $50,000.

The Lillooet River crested to within 3 in. (7.5 cm) of the top of the dyke in four areas in PVDD. Estimated cost of repairing washed out and damaged floodgates and three culverts on Lillooet System PVDD was $4,000. The Lillooet River overflowed its banks in area 9,527 to 10,042 (of riverbank protection works carried on in 1980), carrying a large amount of wood debris onto agricultural land. Estimated cost of cleanup was $2,500.

The Birkenhead River overflowed its banks near the John Williams residence, carrying vast quantities of gravel into agricultural land and containing large pools of water. Estimated cost of clean up was $2,500.

The cost of fabricating and installing a flap gate on the 60-in. (150 cm) culvert draining the main ditch from Mt. Currie under the highway was estimated at $2,500. Clean out of deposited gravel in

Pemberton Creek upstream of Highway 99 was $500. The roughly estimated amount for damage on Green River was $25,000 (Memo January 8, 1981 H. Nesbitt-Porter).

Between Christmas Eve-December 29, Victoria recorded 83.8 mm of rain. The heaviest downpour occurred on Boxing Day with 45.2 mm. *4) In Greater Victoria, largely in the Saanich and Langford-Colwood-Metchosin areas, backed-up drains flooded dozens of yards and basements. In Saanich, flooding was reported all over the municipality from Ten-Mile Point to Swan Lake and Oldfield Road. Panama Flats was completely flooded. In Central-Saanich, basements in the Oldfield area and Keating Cross Road flooded near Butler's gravel pit. On December 27, the Village of Sooke was cut off for several hours when Sooke Road had to be closed. Flooding also occurred in the Gorge-Tillicum area of Esquimalt and at Lakehurst and Goldstream at Langford. On December 26, runoff from a gravelpit in the Lakehurst subdivision near Goldstream Park caused at least $2,500 damage to a property at 2751 Faulkner. Water reached over 1 ft. (30 cm) in the basement and about 18 in. (45 cm) in the driveway, partially submerging a car. A second house nearby, also of cathedral entrance design and built some 2 ft. (60 cm) lower than the other houses in the subdivision, also suffered serious flood damage. Both houses have below ground basements and driveways. A plugged culvert in the Goldstream Meadows Ltd. gravelpit was responsible for the large amounts of water, which drainage ditches were unable to handle. Apparently the subdivision, which also flooded the previous year is only 8 ft. (2.4 m) higher than Langford Lake.

The Island Highway between Qualicum Beach-Royston was closed due to flooding. Crews worked overnight December 26-27 to repair a 40-ft. (12 m) washout at Dashwood about 1 mi. (1.6 km) north of Little Qualicum bridge. An 18-in. (45 cm) culvert washed out and a broken water main left about 200 homes without drinking water. The road reopened to single-lane traffic mid-day on December 28. The highway was expected to back to normal by January 2.

In the Qualicum Beach area, a new landslide approx. 200 ft. (60 m) south of "Snow White" cottages demolished two houses valued at about $30,000 each. A large tree in the mudslide coming down a steep bank pushed an unoccupied cottage in Bungalow Court off its foundations and sent it sliding to a halt against another dwelling almost 100 yd. (90 m) away. The slide left both perched askew on top of about 3,000 yd.^{3} (2,294 m^3) of slide material. After flooding occurred at Buckingham's, the owner temporarily evacuated the house.

On the Little Qualicum River about 200 lineal ft. (60 m) of water main washed out together with minor water scour near and around the pumphouse. The swollen Little Qualicum River overtopped the highway by approx. 1.5 ft. (45 cm) near the south bridge approach. Road shoulders were severely damaged. The Island Highway bridge over Little Qualicum River was flooded. A high tide and continuing rainfall aggravated the situation.

On Boxing Day, East Courtenay residents and businesses experienced the second flood to hit the area in five years. Though the rainfall was heavy, it was not record-breaking. But the CFB Comox weather station reported record-high warm temperatures on December 26 as well as during several days prior. This pushed the freezing level up to the 10,000-ft. (3,000 m) level, melting snow. (At this time of the year, it would normally be at the 2,000-ft. (600 m) level).

Courtenay city council registered their concern with the provincial highway ministry about the new 17th Street bridge and the effect it could have in blocking up river waters. During the Boxing Day floods, debris jammed up at the new bridge work resulting in reports that river water was 3 ft. (90 cm) higher on one side of the bridge compared to the other side. (The provincial highway ministry had studied the possible problems of debris block-ups at the proposed bridge's two in-river support piers and had assured the city there would be no problems.) Comox Road resident Charles Bolton said that in 27 years living on Comox Road, he had never seen flooding that bad in that area. "The water was a foot over the road, and we've never seen it up to the road before." Dyke Road resident Mrs. Gertie Hames agreed with Bolton in that floodwaters had never been higher in the Dyke Road area, at least during the 35 years she had lived there. Hames noted that she was used to flooding just about every winter, usually from a combination of heavy rains, a southeaster and a high tide. Though her basement was "built up" for those occurrences, during the Boxing Day flood she had 4 ft. (1.2 m) of water in her basement. "Far more than we've ever had," that did not recede with the tide as it usually did. Her pickup truck and camper were also flooded. Mayor Bob McPhee

said the flooding happened quickly, so quickly that in a space of just a few hours, the floodwaters "completely engulfed" his own sports car parked on property near the river. The water was over the top of the car. "Something more than rain caused it," he said. According to McPhee, BC Hydro had apparently opened its up-river power dam, releasing waters downstream "when the tide was high."

Lewis Park flooded extending over the highway length between the Courtenay Hotel to the bridge crossing, closing the road for a period of time. Although not flooded, water surrounded the Courtenay House Hotel. Some flooding also occurred in the Willemar and First areas of Courtenay, on the Dyke Road and on Anderton towards Condensory Road crossing where the Puntledge River eroded the right bank. Some 20 ft. (6 m) in width had been lost.

Most of the damage, however, was confined to Rye Road, one of the hardest hit areas. *5) Extensive flooding occurred behind the Comox Road dyke from Comox Hill to Ryan Road over a distance of about 3 mi. (4.8 km). The average depth of the water was estimated at 4 ft. (1.2 m). Rye Road resident Gunter Preiss had to evacuate his home by canoe after his living room filled with 2 ft. (60 cm) of water. Preiss blamed a good deal of the flooding on poor planning when Rye Road was built. He believed the culvert was too small and unable to take the water away and the road more acting like a dam. As 4-5 ft. (1.2-1.5 m) of water sluiced into the area just behind Bud's Drive-In about four or five homes were evacuated. The flood left a high water mark at the 3-ft. level of Puddleduck Pre-school on Rye Road, which sustained a fair amount of damage, mostly to supplies stored in the basement. Pearson Tire, just down the road from Comox Valley Ford, sustained damage when 14-16 in. (35-40 cm) of water flooded the building. Many other residents and business establishments suffered losses.

Fields of Farquharson Farm were flooded. According to the owner John Farquharson, "the river was higher than it's ever been… (BC) Hydro let Comox Dam go at their convenience… the water went up awfully fast and went down awfully fast." He noted that the sluice gates on the Dyke Road were too small and he blamed some of the problem on them. Field Sawmills suffered between $10,000-20,000 in damage in the flooding, which undermined their retaining wall. A spokesman for Field Sawmills, situated across the river from the bridge false work, agreed that it had backed the water up and had changed the flow of the river. He said that logs and debris were caught up on the false work and that it acted somewhat like a dyke.

On Boxing Day, several basements flooded in Nanaimo. Millstone River was running very high in the downtown Nanaimo area. Flooding was also reported from the river mouths of Englishman River at Parksville and at French Creek. Floodwaters also threatened the North Shore Road at Lake Cowichan, where Mead Creek bridge lost a timber support and was closed.

Nanaimo River rose about 10 ft. (3 m) above its normal level but stayed about 18 in. (45 cm) below the 1974 flood level. The Nanaimo River burst its banks, flooding Cedar Road and Riverside Auto Court in Cedar. Early on December 27, many roads in the Cedar area were closed, including Cedar Road, Macmillan Road, Aikenhead Road, Raines Road and Wilkinson Road. In Cedar's Wilkinson Road area, two families were evacuated overnight December 26-27. Floodwaters gushed through the Riverside Trailer park on Wilkinson Road and most of the 15 families in that area and others on the Indian Reserve left their homes before the river rose to its dangerous level. For Winston Andrews, who had been living in the area for 12 years, this was the sixth flood. One of the hardest hit on Riverside Road was Gene Scarpino. Floodwaters swept right through his house. Water sweeping across Raines Road flooded the basement of a new two-storey house with more than 2 ft. of water.

Heavy flooding was also reported in the Cowichan valley. In the Duncan area, the Cowichan River flooding in conjunction with Somenos Creek extended from Provost Road along Lakes Road to the Junior Secondary School at Beverley Street. Floodwaters reached to within inches of the school floor. The flood level in Somenos Lake came within 1 ft. (30 cm) of the road in one area and an average of 3 ft. (90 cm) below the highway pavement. In Duncan, residences flooded in the Wharnecliffe, Marchmont, Campbell and Trunk road areas. *6)

In the Cowichan estuary, Koksilah, the Dinsdale property and Indian Lands the total farmland including the tennis court area was covered with up to 4 ft. (1.2 m) of water. Minor erosion occurred along the left bank downstream of the butcher shop bridge, with repair cost estimated at $2,500. Below the Clarke property, the Dinsdale dyke lost 200 ft. (60 m) and additional erosion along the bank, estimated repair cost

$4,000. Road shoulders in the Doman Industries area required repairs. A logjam was reported against the Pimbery bridge.

The Cowichan River washed out the gravel berm in two locations at the Mobile Home Park. Emergency sandbagging prevented a major breakthrough that could have inundated about 200 trailers. The concrete abutment of the Youbou bridge over Meade Creek collapsed. The Robertson River caused the loss of about 300 ft. (90 m) of gravel dyke and extensive bank erosion.

High water flows on Nile Creek caused the loss of two log crib retaining walls at the intake works of Horne Lake Water Works. A small logjam formed on French Creek, diverting the river to flow towards the Rawlings' property resulting in minor flooding.

Near Port Alberni, floodwaters closed Highway 4, isolating Tofino and Ucluelet. Traffic to the Parksville to Port Alberni highway was reduced to single lane due to flooding at Cathedral Grove. The Gold River highway was also reported impassable and was closed. Traffic on the Sooke Road was disrupted for two hours due to flooding between Humpback-Gillespie.

Youbou was also hit with heavy flooding. Traffic to Youbou and points north was re-routed through Cowichan village. According to an employee at the B.C. Forest Products Youbou mill, the water in the lake was at the 3.5 m level and within 30 cm of flooding part of the operation. At mid-afternoon on December 25, flooding was reported from "all over Lake Cowichan" and the other lakeside communities. On December 26, the Pioneer water system, which serviced about 60 families from Coon Creek, and the B.C. Forest Products system serving the mill and main townsite from Youbou Creek were plugged with tons of gravel, silt and deadfall brought down the watershed. Pioneer's holding tanks on Coon Lake were filled with 5 ft. (1.5 m) of gravel and silt, and the wingdam that regulates the water supply was full of boulders and gravel. According to Jeff Abbott, chairman of the Pioneer water system's user association, they had floods in the past but "never anything like this." *7) Howard Smith, another user of the Pioneer system, described the creek as "a hell of a mess." He noted the logging had to affect the water system "It's nearly a mile up from the lake to our dam, a 2,500-ft. (750 m) straight drop. When it rains, the stuff just drops straight down."

While the Campbell River caused only minor flooding, along the Quinsam River extensive flooding occurred. The storm hit the Oyster River watershed most severely with the loss of houses, extensive loss of protective works, loss of dyke, formation of logjams, erosion of riverbanks and the inundation of several homes in the lower reaches of the river. The Boxing Day flooding saw 22 homes evacuated. Five houses were water-damaged, one destroyed and another one left dangling over the riverbank and a further home in a collapsed state.

On the left bank, extensive damage occurred downstream of the present highway bridge. In addition to the previous stream damage, Don Knowles lost his house completely to the river and about half of his land, valued at about $80,000 plus household effects. His second house on the same property was in danger of being lost also. The main river flow had undermined one corner. Immediately downstream of the Knowles property, the owner of a large home was in danger of losing his situated about 20 ft. (6 m) from an eroding bank.

On the right bank downstream from the old Highway bridge, extensive erosion now exposed the riverbank to within a few feet of an autocourt leaving about 10 units in immediate danger. The estimated cost for repairs was $15,000. At Pacific Playgrounds, location 9074 Clarkson Road, a small house with an estimated value of $15,000 was undermined and probably a total loss. Upstream of the present highway bridge, the right bank bridge approach required rock replacement with an estimated cost of about $15,000. The cost of minor riprap repairs was estimated at about $5,000. At the upstream end of the subdivision, the first lot (owner Mr. Read) sustained severe water damage to both land and house. The approximate cost of replacement for the land and house was $10,000 and $8,000, respectively. In the center of the river along the upstream subdivision area and near house number 2411, extensive debris hang-ups occurred. *8)

Peak streamflows (previous maximum and estimated frequency in brackets) December 26: Coquihalla River near Hope: 708+ (490 - 1:30); Coquitlam River at Port Coquitlam: 132 (199); Chilliwack River at Vedder Crossing: 1,130+ (787 - 1:30); Stawamus River below Ray Creek: 158+ (112 - 1:20); Silverdale Creek near Mission: 38.2+ (21.2 - 1:50); December 27: Cheakamus River near Brackendale: 920+

(861 - 1:25); Lillooet River near Pemberton: 993+ (858 - 1:90); Squamish River near Brackendale: 2,480 (2,230 - 1:50).

The Christmas week flooding caused “devastating” salmon losses as many spawning beds in creeks and rivers in British Columbia and Washington were damaged. Preliminary reports indicated salmon stocks virtually wiped out in some areas and severely damaged in others. Less extensive flooding in the previous year also ruined some stock. The damage effect two years back to back could be devastating. The losses will only be known two to five years down the road depending on species when the salmon return to spawn. On the Clearwater River near Hope, extensive salmon rebuilding efforts were virtually wiped out with a total loss of the 1980 stock. The losses included virtually 100% of salmon stocks of the lower Squamish River system, Clearwater River, Birkenhead River, and in the Hope area. At least a 50% loss on the Vedder River, in the Upper Squamish River region, the Kitimat River, Rivers Inlet and in the Bella Coola region. Many Washington hatcheries reported losses with the worst on the Skagit River where the water ran above the ponds (*The Province*, January 7, 1981).

Damage suffered as a result of floods in late December for the Lower Mainland alone was estimated at $6.5 million (*The Vancouver Sun*, January 24, 1981). On December 27 with reports still coming in, highways minister Alex Fraser estimated the damage done to highways at least $3-4 million. Provincial Environment minister Stephen Rogers put the damage to highways at $4 million and said that damage to private homes would easily surpass $2.5 million. Damage estimates were: $5.8 million for highways; $3 million for forests; $2 million for homes and small businesses; $1.7 million for environmental damage and $500,000 for municipalities. *9)

It would cost about $1.8 million to rebuild Forest Service bridges, culverts and roads in the Vancouver Forest Region. Destroyed in the flooding were 53 Forest Service bridges, 265 culverts and 160 km of roads on Vancouver Island and the Lower Mainland. The Chilliwack Forest District was the hardest hit. More than 24 km of roads, 32 bridges and 58 culverts were washed away. Because this forest district contains more forest service road systems than any other within the region does, the percentage was expected to be high. The forest industry also suffered loses to damaged road links. MacMillan-Bloedel reported a cost of $160,000 to repair damage in its Squamish division. Replacement cost for a lost bridge and to repair a damaged one in their Menzies Bay division was unknown (*The Vancouver Sun*, January 13, 1981).

Summary of expenditures December 27, 1980 flood: D’Arcy area: Gates River and Blackwater Creek ($15,538). Pemberton area: Miller Creek; Ryan River; Wolverine Creek; Speech (Spetch?) Creek; Eight Mile Creek; No Name Creek; Pemberton Creek; Lilted River; Grandmothers Slough; Green River ($242,670). Upper Cheakamus area: Culliton Creek; Cheakamus River; Swift Creek ($109,056). Squamish area: Squamish River; Mashiter Creek; Mamquam River; Stawamus River ($313,670). The summary of expenditures for the December 1980 flooding in the Merritt-Princeton area totalled $230,000 (File P80-21, June 9,1981).

Estimated cost of restoring streams on Vancouver Island, excluding $113,000 for work on Indian Lands, would be $374,000. Additional possible works on a cost-sharing basis have been estimated at $247,000 with a further capital requirement of $68,000 for work on Indian Lands. Location of works: (Vancouver Island) Cowichan River; Koksilah River; Meade Creek; Robertson River; Sutton Creek; Nanaimo River; French Creek; Little Qualicum; Nile Creek; Oyster River; Trent River; Tsolum River; Quinsam River; Zeballos River. (PEP or DIA $486,650 and other $314,000). (Southwest British Columbia. December 1980 Flooding-Vancouver Island area). (Lower Fraser Valley): Chehalis River; Chilliwack River; Deroche (Crazy) Creek; Eng Creek; Harrison Lake; Lagace Creek; Ryder Creek; South Alouette River. (Hope area): Coquihalla River; Gordon Creek; Silverhope (Silver) Creek; (total cost restorative work for the Hope and Lower Fraser River areas was $426,408). (1980 Storm Damage Assessment. Southwest British Columbia-Hope and Lower Fraser valley areas).

Final flood repair costs for flood of December 28, 1980 were: D’Arcy area: $15,538.61; Pemberton area: $242,670.72; Upper Cheakamus area: $109,056.45; Squamish area: $313,670.71 (MacFayden n.d.).

---

*1) Following the record November rainfall, December with 220 mm was well above the average of 165 mm. By December 27 with a total of 1,397 mm of rainfall, the year 1980 was already the wettest year on record, surpassing the record of 1,367 mm in 1961 (*The Province*, December 28, 1980). On December 29, *The Vancouver Sun* reported a total of 1,412 mm of rain for Vancouver.

*2) A previous three-year study concluding that the 400-metre cliff known as the Barrier, could come down as it did in 1855 covering an area presently occupied by the community of Garibaldi. The report stated that such a slide could also cause the Daisy Lake reservoir to overflow and flood the Garibaldi area. As a result, BC Hydro agreed to lower the lake level by 2 m as an interim safety measure (*The Vancouver Sun*, December 30, 1980).

*3) Following the flooding, some 400 residents petitioned the three levels of government to construct a well-designed dyke system for the whole district of Squamish. According to Attorney-General Allan Williams, MLA West Vancouver-Howe Sound a major hydrology study was required as the current dyking arrangement was clearly not sufficient. The provincial government compensated flood victims of the floods that damaged hundreds of homes in the Squamish and Hope areas. The federal government confirmed to pay about $6.5 million. This federal contribution was based on the provincial government's estimate of $13 million damage to homes and roads (*The Vancouver Sun*, January 3, 1981). P.M. Brady, Director of the provincial environment ministry's inventory and engineering branch, expected worse flooding of the Squamish River in the future. He said the Squamish River had been ignored for the last four years requests by the ministry for better flood protection. Instead of requiring that homes be set back from waterways and raised above a safe level, the district appeared to have caved in to developers and sought money for dykes. Squamish mayor Jim Elliott, in office less than a month, noted that his council could not stop people from building on flood plains until it had a bylaw in place, which could take up to a year (*The Province*, January 4, 1981). The provincial government paid $6.2 million for flood compensation during 1980. An additional $500,000 for flood damage that occurred in southwestern British Columbia in December 1979 and $2 million for damage in Bella Coola in December 1980 (*The Province*, July 22, 1981). Due to road and bridge washouts delays were experienced in assessing homes and contents in the Upper Squamish and Upper Cheakamus areas (*Citizen Shopper*, January 22, 1981). On January 8, 1982, Stephen Rogers announced the approval of a $750,000 grant for dyking in the Squamish municipality. The District of Squamish had already committed $250,000 towards dyking. According to Mayor Jim Elliott, the first priority would be dyking on the right bank of the Mamquam River between the old and new highways. One million yards (764,600 m^3) gravel was to come out of the Mamquam River. Internal drainage in the Squamish River was required and dredging of both rivers scheduled to be done in July and August and the material stockpiled for later in the fall (*Citizen Shopper*, January 14, 1982).

*4) By December 29, Victoria had recorded 181.1 mm of rain. This was above average but still below the all-time record of 1,101 mm set in December 1948 (*Times Colonist*, December 29, 1980).

*5) A report commissioned by the Water Investigations Branch of the Environment Ministry recommended as the solution to the flooding problem the dyking of the Island Highway from the bridge to Rye Road. However, in reality a portion of the highway would be below the flood level, acting as a sluice gate and making a small lake on the arable land. There were only a couple of small streams to empty the flooding from the fields, which would take a long time (*Comox District Free Press*, January 2, 1981).

*6) Some residents believed the flooding to be a direct result of North Cowichan municipality raising Lakes Road and the height of its municipal dykes. They accused Duncan council of being "insensitive" to the plight of its citizens and "neglectful" of its duties in allowing residential development in a floodplain. They also blamed the lack of co-operation between North Cowichan-Duncan council in proceeding with a joint flood control program several years earlier. At that time, estimated costs were about $1.2 million. Costs for a similar program were estimated to have escalated to about $8 million. The residents requested immediate

action of a flood control program. Mayor Mike Coleman suggested that council reconsider its three-phase 1980 control plan. It called for extensive dredging of the Cowichan River in 1981 with attention to the condition and extent of dyking. Coleman also recommended a joint meeting with North Cowichan to co-ordinate pressure for federal and provincial assistance in a broad flood protection program for the entire Cowichan Valley.
In January 1981, Duncan city council approved an expenditure of $361,000, first part of a flood control system to alleviate the annual flooding at Duncan's East End. It was one part of a three-phase project with a total cost of $1.3 million to ensure the residents' homes not being flooded (*Times Colonist*, January 27, 1981). Duncan had dyked the city (north) side in the early 1950s. In the early 1980s, North Cowichan, which had jurisdiction over the south bank, used provincial funds to complete the dykes on its side. The Department of Fisheries and Oceans objected to Duncan's application to raise its dykes as it could harm "the highly productive fish habitat in Fish Gut Alley and the Rotary Park Channel." (*Times Colonist*, October 15, 1983). See also *The Vancouver Sun*, April 7, 1983 and *Times Colonist*, May 7, 1983. Federal fisheries stalled attempts to get the gravel of the north fork of the Cowichan River cleaned out for a year. With a $18,000 grant from the Provincial Emergency Program, work started in 1982 (*Times Colonist*, November 5, 1982). See also October 24, 1982 event.

*7) Abbott blamed Pacific Logging Company for the flooding that hit the town directly below the watershed. He held the logging company responsible for damaging and disrupting the two community water systems and contributed to flooding in the area.

*8) Flood-stricken riverside residents blamed the Comox-Strathcona Regional District (C-SRD) for failing to repair damaged to the dyke, which resulted from minor flooding three weeks earlier when the Oyster River first threatened to burst its banks. Quick action could have prevented the flooding that caused thousands of dollars worth of home and property damage. Others blamed Federal Fisheries in its failure to remove a long-standing collection of logs and debris upstream from Glenmore Road. Some people maintained that if a smaller logjam, which had formed between the old and new bridges prior to the flood, the damage would have been minimal. Apparently Fisheries did not allow the removal of the logs.
C-SRD patched up what was destroyed in the previous flood and for two days was the only agency involved in repair work, which according to C-SRD administrator Wayne D'Easum "was way beyond our capabilities." C-SRD spent $25,000, over twice the original amount needed, to fix the dyke and replace the riprap (*Comox District Free Press*, January 2, 1981).

*9) Early January 1983, the federal government made its first payment of $1.5 million towards the damage cost of an estimated 2,000 homes and several bridges the floods throughout southwestern British Columbia (Greater Vancouver, Squamish, Whistler, Hope and Chilliwack) in December 1980 (*Times Colonist*, January 9, 1983). As of January 17, 1981, 278 flood claims had been submitted for compensation of the flooding in the Fraser Valley, Vancouver Island and Kamloops areas during the last week of December 1980. According to Senator Ray Perrault, "Ottawa will provide about half of the estimated $13 million required to repair the recent flood damage in southwestern British Columbia." Under the federal-provincial cost sharing agreement, Victoria must pay the first $1 per capita in aid, amounting to $2.5 million. The federal and provincial governments spilt the next $2 per capita, or $5 million. The federal pays the next 75 per cent of the next $5 per capita or $12 million and the same percentage over any excess. (*The Vancouver Sun*, December 28, 29, 30 and 31, 1980).
In the political aftermath, both provincial and federal politicians called for long-term flood planning. Perrault said that it would be wise to improve flood-control programs now to avoid worse disasters in the future. Rogers noted that the provincial government would have to devise a long-term policy to deal with future floods and claimants who were asking for assistance for the second and third times. He warned people who continued to build in areas prone to flooding could find compensation cut off in the future (*The Vancouver Sun*, December 30, 1980).

January 21, 1981
Source: *Citizen Shopper*, January 22, 1981; *The Vancouver Sun*, January 22, 1981.
Details: Early on January 21, a temporary log bridge on the main Whistler to Squamish highway washed out. The structure at Culliton Creek, 19 km north of Squamish, had been installed only weeks prior as a replacement for the permanent bridge that had been washed out during the Boxing Day floods. According to Department of Highways spokesman Bob Vietch, the washout was caused by heavy rain developing a dam, which broke and released the floodwaters. As the water was running too fast, crews were prevented from constructing a walkway.

Since the floods also washed out an old logging road bridge into the area, children going to school in Squamish and residents going to work, walked across a 47-m long railway bridge across Culliton Creek. Because of its length and a curve in the rail line making it extremely dangerous, BC Rail security posted a "no trespassing" sign on the bridge temporarily the only lifeline for 25 Upper Cheakamus Valley families. Poor visibility for the rail crew and because it was the steepest grade on the entire line, trains could not be stopped on time.

Whistler Mayor Pat Carleton said the highway bridge was expected to be reopened by early January 23.

August 21, 1981
Source: *The Province*, August 21 and 23, 1981; *The Golden Star*, August 26, 1981.
Details: On August 21, heavy rain caused a large mud and rockslide onto the Trans-Canada Highway about 6 km east of Golden. The flash rainstorm loosened "thousands of tons" rock and mud. It was 3 ft. (0.9 m) deep by the road and up to 6 ft. (1.8 m) deep at the far end of the road. An eyewitness said, "It came down like icing on a cake." It had started with a slow ooze but exploded in seconds. The rockfall killed one person, trapping the victim while in a traffic jam. Emergency crews from Golden spent over an hour working to extricate a 31-year old woman from her pinned position between the vacation trailer and the roadside guard beside a 500-ft. (150 m) ravine. She died shortly after being rescued. Her husband and three pre-teen children managed to escape. The lower half of the car and the trailer were buried in the rubble. The family had been waiting in their trailer in a 15-mi. (24 km) traffic jam created by an earlier head-on fatal accident 1 mi. (1.6 km) further east. *1) A 2-ton boulder just missed striking two cars. Soon after, a second slide a quarter mile (400 m) away, closed the trap on 20 other vehicles. The highway was cleared of the slide debris by 10 p.m.
---
*1) This stretch of highway is considered as one of the most treacherous ones in Canada. When the road was constructed in the early 1950s, a Highways Department vehicle operator escaped probable death after jumping from his out of control vehicle as it plummeted over the edge down into the Kicking Horse River (*The Province*, *The Golden Star*). In 1954, three passengers were killed when a light truck was swept over the cliff. A string of 5-ton concrete barriers now lines the road. The highways department also plans to widen the two-lane to four lanes (*The Province*).

October 4, 1981
Source: *Citizen Shopper*, October 4, 1981; *The Vancouver Sun*, October 5, 1981.
Details: On October 4 at 7:30 a.m. following heavy rain, an estimated 300 m^3 of rock came down onto the Squamish highway, 2 km north of Sunset Beach. *1) The rockslide knocked out a power line and blocked traffic for nearly four hours. Shortly after 11 a.m., enough rock was cleared away to allow a single lane of traffic. The disruption led to long line-ups in both directions most of the day. A concrete guardrail on the highway prevented the rocks from tumbling further downhill and possibly knocking out the BC Rail tracks below. On October 8, the work on clearing the highway continued.

Some residents in the area north of Sunset Beach and south of Lions Bay were without electricity and 300 Lions Bay residents had no telephone service for most of the day. One kilometre of telephone cable had to be replaced. Both utilities were back in service late on October 4.
---

*1) According to Dan Williams, a ministry of highways technician, earlier in the year extensive slide damage occurred in the Tunnel Point area of the Squamish highway, 2 km. north of Lions Bay.

October 27-31, 1981

Discharge (m^3/s): October 31: Capil.: 336; Chem.: 457 (extreme record); Sall.: 40.6; Zeb.: 277; November 1: L. Qual.: 85.5; Sproat: 162; Squam.: 2,110; Stamp G.: 246; November 3: Wan.: 1,210E; max. instant.: October 30: Zeb.: 560; October 31: Capil.: 471 (extreme record); L. Qual.: 105; November 1: Nan. C.: 585; Squam.: 2,270 (extreme record); Stamp G.: 249; November 3: Wan.: 1,280.

Source: *The Vancouver Sun*, October 28, 29 and 30, November 17 and 25, 1981; December 12, 1981; January 28, 1982; *The Globe and Mail*, October 29, 1981; *Times Colonist*, October 28 and 29, 1981; *The Province*, December 16, 1981; *Citizen Shopper*, December 21, 1981; *The Sun*, September 25, 1985; *The Squamish Times* (*Times Today*), April 6, 1982; MacFayden n.d.; Eisbacher 1983 (pp. 17-22); Van Dine 1985 (p. 68); Skermer 1988 (pp. 21-23); Thurber Consultants 1982; Thurber Consultants 1983 (Appendix B); Hungr et al. (1984); Jackson et al. 1985 (p. 4-21); Church and Miles 1987 (pp. 69-70); Environment Canada 1992; B.C. Ministry of Energy, Mines and Petroleum Resources 1993; Evans, unpublished data; Ministry of Environment files.

Details: After October 24, a sequence of Pacific storms moved onshore. A weak, double-centred low that dissipated over the coast was followed by a major cyclonic storm that formed in the southern Gulf of Alaska on October 27. Warm-front rain on October 27 from that storm produced the M-Creek debris torrent and minor debris movements on two other creeks. Late on October 28, its occluded front moved inland and a new storm approached the coast. On October 30-31, this storm delivered far heavier rain to the region. Local flooding occurred in Howe Sound, including at Furry Creek and debris torrents were triggered in the mountains east of Howe Sound (Church and Miles 1987). One death was attributed to the flooding of Mosquito Creek.

Around midnight on October 27, a small avalanche came down M-Creek, a high-gradient (48%) creek 2 km north of Lions Bay. It marked the first occurrence of debris flow in the region in nine years. The event, caused by temporary damming of water or by debris surcharge, triggered a major debris flow that cleared out the rockbound gully to its base near sea level (Church and Miles 1987). Apparently debris clogged the creek and formed a dam higher up that apparently broke during the heavy storm of the night of October 26-27. *1) Above the bridge the creek falls about 130 m through a steep canyon from the top of the ridge along the coastline between Horseshoe Bay-Britannia Beach.

The avalanche, which consisted of surficial debris and fractured bedrock, failed along a steep tributary draw along the margin of an old clear-cut at an elevation of 1,500 m. The destruction of an old logging bridge 650 m upstream of the M-Creek bridge on Brunswick Mountain caused debris to pile up. The debris grew to a volume of approximately 15,000 m^3. Thurber Consultants (1983) put the volume at approximately 20,000 m^3. The rock debris brought down onto the fan was estimated to have covered 0.7 ac. (0.3 ha.) or approximately 25% of the total fan area and the after-flow of liquefied organic mulch covered 1.5 ac (0.6 ha) (Thurber Consultants 1982).

It is believed that within about five minutes, the pulses of debris subsided. Most of the debris came from the accumulated load in the creek channel (Skermer 1988). Normally, M-Creek is only about 1.2 m wide and a few cm deep. Fresh mud on the side of the canyon indicates that the torrent of water and debris must have been at least 6 m high when it hit the bridge (*The Vancouver Sun*). The mud line on the walls of the rock canyon near the bridge reached up to 25 ft. (7.5 m) and 15 ft. (4.5 m) on the north and south sides, respectively (Thurber Consultants 1983).

Hungr et al. (1984) estimated the velocity of the 1981 M-Creek debris flow at 4.2-4.7 m/s (Evans, unpublished data). *The Vancouver Sun* put the speed at 80 km/h (22.2 m/s). At sometime between 12:20-12:30 a.m., the slide, which piled 6 m high in the narrow creek gully, flattened out to a 1.5-m wall before reaching the bridge. It ricocheted in the gully and smashed against concrete foundations, knocking it over before speeding down the final slope to the sea. Sometime between 12:30 a.m.-1:13 a.m., the torrent knocked out the central wooden support columns and the 18-m long and 8-m wide center span of the old highway bridge and cut an 18-m gap across the roadbed. The supporting column resting on the foundation

fell, taking with it the centre span. Another column fell, and two more spans of the bridge collapsed. The wall of the slide roared by, sweeping away 70 m of BC Rail track and a small house built on the beach near the creek's mouth. The bridge had been demolished in less than 30 seconds (*The Vancouver Sun*, November 25, 1981).

The fatal spot is about 70 m north of a curve, and for northbound drivers the gap would have been difficult to spot immediately on a bad night. It was raining hard at the time. The accidents claimed nine lives. One car was on the bridge when it was destroyed. Later three other cars plunged into the 30-m deep chasm. Two of the cars, with four people inside, washed into Howe Sound. Four people in a van and one died in another car (*The Squamish Times*, April 6, 1982). According to VanDine (1985) and the Ministry of Energy, Mines and Petroleum Resources (1993), the M-Creek debris torrent caused 10 deaths. *2) Five of the victims were recovered immediately. Around November 16, Squamish RCMP recovered another body in about 80 m of water in Howe Sound and located in the same area a vehicle containing two other people. The ninth and last body was recovered on December 11, one-an-a-half months after the disaster. Police divers discovered the victim's car in 75 m of water in Howe Sound. On November 18, the search had been called off because of equipment failures and mounting costs but the victim's family asked that it be resumed.

The BC Rail line was inundated and a portion of the rail was also taken out. Seventy metres of line were destroyed and the bridge covered in debris (*Times Colonist*, October 28 and 29, 1981). The rail bridge over the creek, to the railway known as Yahoo Creek, was covered in rubble and mud. The rail line was back into service late on October 28. On October 31, the road was opened to light traffic over a temporarily installed four-section Bailey bridge.

On October 28, Magnesia Creek experienced a very small debris torrent or flood (Jackson et al. 1985). Rock and boulders rolling down the creek blocked the BC Rail bridge over Magnesia Creek. Water flowed over the bridge and washed out a portion of the left bank of the creek. This temporarily diverted the creek through the property at the mouth on the north side of the creek and buried a truck and garage with rock (Thurber Consultants 1983).

At Kallahne Creek, the highway culvert blocked. After the culvert and road washed out, a large amount of material was deposited downstream of the highway (Thurber Consultants 1983).

A regional rainstorm deluged the North Shore mountains near Vancouver during the night of October 30-31. In West Vancouver, a torrent in Lawson Creek locally undercut its bouldery embankments and plugged a narrow culvert with debris eroded along the embankments. Debris and floodwater overflowed the culvert onto the inconspicuous cone of the torrent. Damage from this debris flood was estimated between $500,000-1 million (Eisbacher 1983). *3) On October 31, at Furry Creek the bridge abutment fill washed out. The washout was attributed to high creek flows and debris jamming (Thurber Consultants 1983).

On October 31 during a heavy rainstorm, flooding occurred at Mosquito and Lynn creeks and Seymour River. Debris plugged a "trash rack" over a culvert, forcing the Seymour River out of its bed and through a residential area. About 50 homes in the Seymour Creek area were evacuated. Fifteen homeowners later took the municipality to court for damages (*The Vancouver Sun*, September 25, 1985). *4)

Along Lynn Creek, the Dyke Road was lost, exposing the landfill and up to 25 m of material washed into the creek. The leachate system was exposed as well. Farther upstream, the creek also changed course by up to 75 m into an area under preparation for future landfill.

Mosquito Creek was reported to have suffered extensive erosion and transport of debris. The Mount Royal Fire Hall was flooded by up to 1 m of water, damaging accommodation. The creek jumping its banks upstream apparently caused this. Fire fighting equipment was moved to safety and undamaged. The Mosquito Creek sedimentation basin was filled with some 20,000 $yd.^3$ (15,292 m^3) of gravel and sediment. Water went around the inlet but fortunately re-entered the concrete box culvert/flume. The intake structure was undermined and required backfilling and grouting to restore the foundation.

In the District of North Vancouver, flood damage included problems in the vicinity of the Main Street bridge on Seymour Creek. Erosion occurred around the Main Street bridge abutments. Just downstream of the bridge, severe erosion occurred to cause the failure of about 40-m of concrete retaining wall. Part of the parking lot was lost behind this and an addition to a warehouse (Microlin Ltd.?) collapsed and swept away. Upstream of the bridge, it was reported that a garbage disposal business (Smithrite

Disposal?) lost some 30 m of bank laterally over a reach of 150 m. It was understood that considerable equipment in the form vehicles, trucks and disposal units were swept into the creek and lost. Reports conflicted with loss here ranging up to $1 million. Just upstream of the Main Street bridge, the high water mark was observed to be within about 3 m below bank full. North of the Grantham Bridge, the river overtopped its banks flooding down Seymour Blvd. In this area, about 20 houses suffered damage due to shallow flooding.

Substantial bank erosion occurred on the west bank of the Seymour River between 400-500 m upstream of Main Street bridge to properties occupied by Smithrite Disposal Ltd. and Arrow Transfer Ltd. Smithrite, the upstream property, sustained a loss of 2-8 m along a 100-m frontage, with additional sloughing to the still existing bank. The company claimed the loss of several truck tailgates and a damaged disposal truck that was parked near the bank. Their property has been used as a landfill disposal area previously with about 2 m of waste material visible at the eroded riverbank. Erosion to the Arrow Transfer Ltd. property was estimated for a length of 100 m with a loss of 20-25 m of their parking lot at the centre of the washout. A shed at the north end was being undermined for 3 m with a total loss of another shed reported. The property is about 1.8-2 m lower than the Smithrite and experienced flooding across their parking areas.

Erosion to the east bank of the Seymour River occurred at and above the east abutment of the bridge. The washout at the Battison Enterprises Ltd. property, just south of the east abutment of the bridge, for a length of 35 m continued for another 10 m into the next property downstream.

In the District of West Vancouver, flood damage occurred in two general areas: the downtown core and the British Properties. The damage occurred in the Ambleside district over an area of about 10 square blocks in the downtown core. A plugged culvert on Lawson Creek where it crosses Marine Drive just east of 18th Street caused this. The blockages, of rocks and logs, caused the stream to overflow on Marine Drive flowing eastward to about 13th Street. Shallow flooding of shops and businesses and basement flooding occurred along Marine Drive. Downhill of here, small businesses and shops were flooded to a depth of over 1 m by floodwater ponding behind the railway. An area of over 10 square city blocks received damage. According to Mayor D. Humphreys, this could contain upwards of 150 businesses. City crews drained the area by breaching the railway.

A blocked culvert on Brothers Creek on Eyremount Road caused erosion damage to the British Properties area in the Westhill subdivision. Damage occurred as erosion along the road curbs, which exposed storm drains in places. Also about five or six homes suffered damage from shallow floodwaters that caused local erosion to landscaping and flooding of basements, etc.

The City of North Vancouver suffered extensive damage to its water intake on Lynn Creek and minor local damage to a dyke failure on MacKay Creek. The city's main water supply intake, bridge crossing, intake building and associated trash racks and ancillary works were extensively damaged due to a diversion of the creek around the structure. The system was rendered inoperable forcing the city to purchase water from the Greater Vancouver Water District. Damage could total $100,000. Below the intake, extensive amounts of garbage exposed by erosion were strewn along the creek down to Burrard Inlet. On MacKay Creek, a small dyke south of Marine Drive broke possibly causing shallow flooding to a "Hometown store."

Several instances of culvert and storm drain blockages and local flooding were reported. At Newdale and Stardale roads, a culvert was plugged, washing out the road with several homes suffering minor flood damage. At Kilmore Road, a large 6-ft. x 8-ft. (1.8 m x 2.4 m) box culvert plugged with debris. It caused the road to wash out and water and sewer mains to be exposed. Other minor culvert and storm drain blockages occurred. The City Engineer John Bremmer estimated a total up to 20 homes might have suffered minor local flooding in different areas.

During the 48-hour period ending November 1 at 8 a.m., Squamish and Pemberton recorded 177 mm and 96 mm (7 in. and 3.8 in.) of rain, respectively. Prior to this date, this area had experienced mild temperatures with above normal rainfall, and below normal snowpack at higher elevations. The most common damage resulted from scouring, bank and dyke erosion, channel changes, wood debris, bedload deposition, landslides and inundation. The degree of damage to transportation, private dwellings and utilities, prompted the provincial government to extend aid under the Provincial Emergency Program. In

addition to providing compensation for damage to personal property. This program provided for restoration of river channels, repairs to dykes and bank protection.

High water in the Birkenhead River washed out the Sam Jim Bridge over the Birkenhead River, isolating three families. The December 1980 flood had previously damaged this structure. Though the Indian Band had placed a value of $40,000 on it, actual replacement costs would exceed $250,000. The need for this structure would be eliminated by constructing a road along the left bank of the river for about 3,380 m to the new bridge constructed during 1980 to facilitate access to the new town site. Estimated road construction cost was $35,000.

The Lillooet River overtopped its banks, washed out the airport access road, landing strip, newly constructed fence and deposited about 150 mm depth of silt over the entire area. The cost of bringing the airport to its pre-flood condition, excluding the fencing, was estimated at $10,000. *5)

The Squamish River overflowed its left bank from the downstream end of the dyke completed in 1975 to the BC Rail crossing at Government Road and then along the BC Rail right-of-way, through the Spiral Mobile Park and then into the area of the confluence of the Mamquam and Squamish rivers. The total cost of all equipment and materials was $32,620. Horse Ranch Creek inundated the Easter Seal Camp area. Cost of building a temporary dyke was $3,050.

Summary of expenditures October 30, 1981 flood: D'Arcy area: Gates River and Blackwater Creek ($822). Pemberton area: Miller Creek; Pemberton Creek; Birkenhead River; Green and Soo rivers and Rutherford Creek areas; Ryan River; Wolverine Creek; Spetch Creek; Pemberton Creek; Salmon Slough; Grandmothers Slough; Green River ($323,319); Lillooet River. Whistler area: 19-Mile Creek; Fitzsimmons Creek; Cheakamus River; Alpha Creek ($7,827). Upper Cheakamus area: Culliton Creek; Cheakamus River; Swift Creek ($81,261; Cheekye. Squamish area: Squamish River; Mashiter Creek; Mamquam River; Stawamus River; Horse Ranch Creek; Shannon Creek; Kallahne Creek ($289,460). Howe Sound area: Cypress Creek; Magnesia Creek; Strachan Creek ($14,443). For detailed damage information see: MacFayden n.d.

Total damage costs October 31, 1981 flood for D'Arcy area was $822,68; Pemberton area: $323,410.95; Whistler area: $7,827.00; Upper Cheakamus: $90,268.04; Squamish area: $403,834.13; Howe Sound-North Shore area: $41,862.56, for a grand total of $1,548,961.52 (MacFayden n.d.). Restoration costs by watershed: Gates River ($2,000); Wolverine Creek ($7,000); Lillooet River: ($69,000); Ryan River ($20,000); Miller Creek ($104,200); Pemberton Creek ($54,400); Birkenhead River (cost alternate access road $37,000); Stawamus River ($100,000); Horse Ranch Creek ($25,000); Judd Slough (I.R.) ($25,000); Outdoor School ($10,000); Upper Cheakamus ($40,000); Culliton Creek ($20,000); Swift Creek ($6,000); Cheekye River ($12,000). (Memo November 6, 1981-File P81-10).

---

*1) A highway employee blamed the failure of logging operators in past years to clean out debris from the creek. Though *The Vancouver Sun* called the M-Creek event a mudflow, the accepted word in North American technical usage is debris flow, or debris torrent in the Pacific Northwest. Eight of the 18 bridges on the Squamish highway were of similar construction as the collapsed 25-year old M-Creek bridge (*The Province*, September 28, 1982). Since the 1981 debris torrent, blasting rock from the mouth of the steep, narrow, rock gorge to the east has relocated the highway at M-Creek. A new free-span steel-concrete bridge was completed across the torrent in 1982-83 (Eisbacher 1983, Jackson et al. 1985). The new structure rests on a skewed abutment on spread footings partially on rock and partially on gage steel H-pile. The 41.48-m long single-span steel girder structure has a 10.8-m roadway and two concrete parapets (*The Squamish Times*, April 6, 1982).

*2) In April 1982, during the M-Creek inquest in the coroner's court it was found that the accident occurred "because of an Act of God" and that the old wooden bridge was not at fault. As a result of the accident, safety measures were introduced including a tape-recorded highway status system, a series of roadside emergency telephones and 24-hour road patrols at a cost of almost $5 million (*The Vancouver Sun*, February 11, 1983). At the end of December 1981, Highways Minister Alex Fraser announced that up-to-date road conditions on Highway 99 would be broadcast on Radio 1490. Two small transmitters were installed – 1.5

km south of Squamish and 1.5 km east of the Eagle Ridge overpass near Horseshoe Bay – that would broadcast endless loop tapes containing reports on highway conditions. (*Citizen Shopper*, December 24, 1981). In August 1983, the provincial government announced it would spend $138 million to improve and widen the Squamish Highway to four lanes from two. The program was to be carried out over a 12-year period (*The Vancouver Sun*, November 16, 1983).

*3) The federal government agreed to pay $1.15 million towards the cost of the recent flood damage. The total cost of cleanup was estimated at over $5 million (*The Vancouver Sun*, November 25, 1981). By December 16, the total of the damage claims of the late October in the Squamish area and North Shore of Burrard Inlet reached over $500,000. Slightly more than 240 flood damage claims were received (*The Province*, December 16, 1981). At the end of January, a total of $127,740 had been paid out to settle damage claims from the October 31 floods in Squamish, North and West Vancouver, Coquitlam and New Westminster. Of a total of 258 claims, 49 had been allowed, 74 denied and 135 pending (*The Vancouver Sun*, January 28, 1982).

*4) Almost four years later, North Vancouver District was found liable for the flooding of private property in the Seymour Creek area. In September 1985, B.C. Supreme Court Justice George Cumming found there was an infringement of the rights of property owners. According to the judge, the municipality should have designed the culvert or creekbed so it would not cause flooding during heavy rain. Cummings did not award any damages yet (*The Vancouver Sun*, September 25, 1985).

*5) A 1984 study estimated that it would cost $1.6 million to protect the airport buildings and runway with dykes (Ministry of Environment files).

November 11-14, 1981
Source: *Richmond Review*, November 18, 1981; *The Vancouver Sun*, November 12 and 17, 1981; *The Daily News*, November 16, 1981.
Details: On November 11, the Cheakamus River overflowed its banks, breaking dykes and washing out a 300-m stretch of road at Paradise Valley, 12 km north of Squamish. Eighteen pupils and three teachers from Brackendale elementary school were left stranded in the Cheakamus subdivision and an area known locally as Upper Cheakamus. The remainder of the school's 350 pupils was not affected. Squamish RCMP reported no other flooding in the area. Squamish mayor Jim Elliott said that work crews hoped to have the road repaired later on November 12.

November 19, 1981
Source: *The Squamish Times*, November 24, 1981; Ministry of Transportation and Highways, Rockfall notification summary.
Details: On the night of November 19, 500 m^3 of rock came down onto Highway 99 (at 2.5 km) at Thursday Nite Slide, just north of Horseshoe Bay.

December 4, 1981
(Rain-on-snow).
Discharge (m^3/s): Max. daily: December 5: Kok.: 127; Nan. C.: 414.
Source: *Citizen Shopper*, December 10, 1981; *The Vancouver Province*, December 6, 7 and 17, 1981; November 17, 1983; Eisbacher 1982 (p. 132); Eisbacher 1983 (p. 19); Thurber Consultants 1983 (Appendix B); Lister et al. 1984; Hungr et al. 1987 (pp. 212-213); Church and Miles 1987 (p. 73); Environment Canada 1992.
Details: On December 4 in the Howe Sound area, debris torrents occurred at Charles and Newman creeks and flooding at Alberta Creek (Church and Miles 1987). On December 4, at Strachan-2 (Charles) Creek, a

high-gradient torrent (52%) 4 km north of Horseshoe Bay, some 30,000-40,000 m^3 of debris mobilised from the rubble-filled upland ravine.

The event was composed of many small surges, with an estimated maximum discharge of less than 100 m^3/s. The surges failed to displace the low subdivision road bridge and began depositing behind it, quickly filling the available channel freeboard. It is assumed that the resulting loss of channel confinement caused further progressive deposition upstream of the small bridge, until the 6-m clearance of the large highway bridge was infilled. The remainder of the debris flow event, amounting to at least 20,000 m^3, then deposited above the highway bridge and on top of it, covering the highway to a depth of 6 m. The post-event flood flow was diverted along the highway ditch and caused severe damage to residential properties 500 m distant from the creek (Hungr et al. 1987). *1)

The event was caused by a squall of rain (approximately 20-30 mm/5 hours) coupled with rapid snowmelt at higher elevations. The mass movement of debris appears to have occurred in two or more surges. At 9:15 p.m., a surge of debris came down the creek and stopped at and on the highway bridge. The debris blocked the channel causing the creek to divert and subsequent flooding downstream. Eyewitnesses to the event indicate that the debris piled up as a series of pulses rather than discrete surges (Lister et al. 1984).

At about 10 p.m., residents living on the fan of Charles Creek heard an approaching noise “not unlike a train but much louder.” There was a slow moving churning mass of rock pieces, water and silt. Eyewitnesses described the flow as similar to slow moving lava. The movement was so slow that one ton boulders came to rest against bridges without cracking or chipping the concrete. The rock flow came to rest blocking and overtopping the creek channel with some 20,000 m^3 of material. Stream flows were diverted from the infilled channel and flowed across the fan surface between houses on the south. On the north side of the creek, water and gravel sized rock inundated two houses, though no structural damage occurred (Thurber Consultants 1983). The total amount of debris deposited was estimated between 10,000-20,000 $yd.^3$ (7,646-15,292 m^3) (Thurber Consultants 1983). The flow contained blocks with diameters of more than 2 m. According to Lister et al. (1984), between 10,000-15,000 m^3 of debris were deposited in a 1,800 m^2 triangular area upstream of the highway. Boulders up to 3 m in diameter were present although most were in the 0.5-1.0 m range. An afterflow of clean uniform sand was also present. The torrents originated in the talus material that fills the main channel at the 950-1,000 m elevation (Lister et al. 1984).

On December 4, more than 40 people were evacuated from the 14 houses located below Strachan Creek Bridge No. 2. Highway 99 was closed for about 48 hours. The bridge was buried in more than 10 ft. (3 m) of mud and gravel. Logs jammed underneath forced the creek to flow over top of the debris and alongside it. Until the Highway Department was able to clear the mud and debris from the road, the highway was initially only open 10 minutes every hour. When the highway reopened on December 6, southbound traffic was backed up to the highway near the Valleycliffe entrance.

Unlike M-Creek, the Strachan Creek bridge was not washed out. In a 100-m swath, the bridge was buried under an estimated 32,000 m^3 (40,000 $yd.^3$) of rock. (*The Vancouver Province*, December 6, 1981). The highway bridge withstood the pressure of the slow-moving boulder lobe and blocked its further advance onto the debris cone where several homes were built in the 1970s. During the hasty evacuation of about 40 people, a woman was caught in the floodwater and swept away. On December 16, Squamish RCMP permanently called off the search for the woman missing since December 4. They had searched an area in Howe Sound 180 m in each direction from Strachan Creek up to a depth of 150 m (*The Province*, December 16, 1981).

The highway bridge was completely buried by debris. The private bridge upstream was also buried. Under the rail bridge, the bed of the creek filled in leaving only 5 ft. (1.5 m) of clearance under the structure. North of the highway bridge, debris blocked the bridge. As a result, water flowed over the north abutment following a rock cut along the highway for about 150 ft. (45 m) before descending onto the railway tracks below. Material picked up from a small slump in a cutbank was deposited against two homes. Water flowed between the rails depositing a layer of silt. A second flow of debris was deposited on the BC Rail line just north of the end of the rail bridge. Water from this flow also ran northward down the road and southward across the lower private bridge. The creekbed below the lower private bridge scoured down 6-8 ft. (1.8-2.4

m). Gabions along both banks at the lower end of the creek were undercut, but remained in relatively good condition (Thurber Consultants 1983).

During the night of December 4, Harvey Creek came close to avulsing below the subdivision bridge below the highway bridge. The creek water got to within 1 ft. (30 cm) of the top of the creek bank before a downstream constriction broke and the water level was lowered. Also on December 4, a small debris flow passed under the Newman Creek bridge. Though not substantiated, it was reported that 4,000 yd.^{3} (3,058 m^3) of material was involved in this debris torrent. A large amount of debris blocked the marina bridges and the BC Rail bridge. Water and debris came over the lower marina bridge and flowed to the left. It deposited large material just below the marina road, while mud and small boulders were directed towards the warehouse. Some mud was also deposited inside the warehouse (Thurber Consultants 1983). *2)

In this series of storms, other debris spilled into Capilano Lake, a water reservoir north of Vancouver. For more than two weeks the city's drinking water turned murky (Eisbacher 1982).

---

*1) The bridge consisted of two steel I-beam stringers approximately 0.75m high, covered by timber planking. It had a maximum clearance of only 1.5 m and was located 20 m downstream from a concrete highway bridge with a 6-m clearance. Both were located a short distance downstream of a fan apex where the channel slope was approximately 14 degrees (Hungr et al. 1987). In view of the M-Creek disaster and the recent problems at Strachan Creek, in the inaugural meeting of the council for the District of Squamish on December 7, the feeling was expressed that a positive position must be taken with the provincial government on the construction of dykes and drainage systems in Squamish in the near future. The government's commitment of building four "catchment basements" to contain slide debris at Alberta and Harvey creeks in Lions Bay and at the Charles and Magnesia creeks, Vancouver geologist Lou Bayrock was doubtful whether they would even help. Nigel Skermer called Alberta Creek a "loaded gun." (*The Province*, November 17, 1983).

*2) At the time, four bridges crossed the apex of the cone, providing some protection to the houses located below (Eisbacher 1983).

December 20, 1981

Source: *The Vancouver Sun*, December 21, 1981.

Details: On December 20 at about 8 a.m., a rock- and mudslide came down and partially covered the Squamish highway. On December 21, crews were still working the slide and hoped to restore the road to two-lane traffic later that day.

On December 20 at 5:13 a.m., a rockslide destroyed about 100 m of CNR track in the Fraser Canyon. Trains were re-routed at Basque onto CPR tracks. The CNR line was expected to be restored to service late on December 21.

January 16, 1982

Source: *Citizen Shopper*, January 21, 1982; *The Daily News*, January 18, 1982; *The Citizen*, September 19, 1991; Eisbacher 1983 (p. 22).

Details: On January 16, heavy snowfalls brought traffic on Highway 99 to a standstill. This controversial stretch of highway between Horseshoe Bay-Whistler claimed another victim. At Brunswick Point, 5 km north of Lions Bay, a woman was killed when a single block fell from one of the cliffs on the stopped car (Eisbacher 1983).

On January16 at approximately 8:45 a.m., a single boulder falling from a rockface on Highway 99 approximately 7 km north of M-Creek. It landed on top of a VW Sirocco, killing a 28-year old woman from Toronto, Ont. The father of the victim was seriously injured. The impact of the rock, which landed in the middle of the car, crushed the vehicle (*Citizen Shopper*, January 21, 1982). The survivor later sued the provincial government for $1 million (*The Citizen*, September 19, 1991).

Toppled by the weight of heavy snow, a 10-m long Douglas fir tree set off the rockslide onto Highway 99. The tree became dislodged after a series of heavy winter storms hit the area in January 1982.

Experts believe that the heavy snow coupled with weakened rock caused by the swelling of the tree's frozen roots caused the tree to fall.

According to news reports, highway personnel were stationed at M-Creek during the heavy snowfall but they did not stop traffic as long as the vehicles had winter tires. Apparently traffic was at a standstill at the time because a number of cars were stuck having only summer tires.

January 20-26, 1982
(Rain-on-snow).
Source: *The Saanich Tribune*, January 20 and 27, 1982; *Times Colonist*, January 25 and 26, 1982; March 18, 1982; April 20, 1982; February 2 and 5, 1983; *The Province*, January 25, 1982; *The Peace Arch News*, January 27, 1982; Eisbacher 1983 (p. 11, 14); VanDine 1985 (p. 65); Lewis and Moran 1985 (p. 5.252); Hartman (Ed.) 1983.
Details: On January 23 following heavy snowfalls, both the Trans-Canada Highway and Hope to Princeton highway closed due to snowslides. The snowfall caused minor power outages in several Lower Mainland communities, including Abbotsford, Chilliwack, Mission, Langley and Surrey. Some 5,000 Fraser Valley residents from Langley to Chilliwack were left without power because of the sudden snowstorm compounded by rain. The weight of the snow and ice brought power lines down or by heavily laden trees toppling onto the lines. By January 25, both the Fraser canyon highway and Highway 3 from Hope to Princeton were expected to reopen. Highway 6 from Nelson to Nakusp and the Salmo-Creston highway remained closed.

The White Rock-South Surrey area was hit by heavy rain followed by periods of snowfall. On January 23, up to 55 mm of rain was recorded within a period of 12 hours in Surrey. According to Mayor Tom Kirstein, there were 20 slides during the previous week between White Rock-Crescent Beach. Slides trapped a Burlington Northern Railway train, interrupting rail traffic for at least two days. Towards the end of the storm a debris avalanche came down on Bayview Street near Crescent Beach, demolishing part of a home (Eisbacher 1983). The next day, the rest of the house was "buckling." Melting snow had waterlogged the hillside above. It took the mudslide 10 seconds to split the house in two. A few days prior to the slide, residents had diverted a stream away from the house. *1)

The storm, which dumped 44 mm of rain at the Patricia Bay airport, caused flooding throughout Greater Victoria. Basements, roads, yards and ditches flooded. On January 20, Colquitz River overflowed its banks. A large area of land in the Blenkinsop Valley was flooded. On January 23-24, flash floods occurred all over the capital region. Saanich Mayor Mel Couvelier asked the provincial government for special financial assistance for the incurred flood damage. Municipal administrator Bill Tremayne put the damage to municipal property alone at $40,000. Worst hit was Saanich, as in the storm two weeks earlier. The flooding of the flats east of Hillside Mall forced the evacuation of 35 families on Doncaster and Edgeware. The neighbourhood of small, older homes was hit hard. A city-sponsored request to the provincial government for financial aid was refused. *2) Police borrowed a Zodiac from the Canadian Coast Guard and a high-bellied troop carrier from the military to reach the stranded residents as floodwaters rose to nearly 2 m in low spots. In some homes, the water was up to the windowsills. The heavy, but not record downpour had shown the system could not handle such rain. *3) The flooding was caused by the rack on Bowker Creek culvert on North dairy Road becoming clogged with debris. The blocked grille caused Bowker Creek to overflow its banks and flood the Doncaster area. An old storm drain flooded several properties on Union Road. The rack had been installed to keep children and animals out of the culvert. According to a Saanich works official, portions of the Saanich storm sewer system would have to be redesigned. A lot of the problems were attributed to sub-standard undersized storm sewers. *4)

Improvements made to the Bowker Creek watercourse in Oak Bay reportedly paid off. The only place where the swollen creek spilled over was at the outlet. A basement of an apartment at 2575 Beach Drive flooded with about 1.5 m of water. Many roads in Oak Bay flooded. Water running off the grounds of George Jay Elementary School surrounded a home at 1161 Empress. The intersection of Saanich and Cloverdale was flooded, and so were Colquitz, Glen Lake, Wilkinson and portions of Shelbourne. Water at the intersection of Douglas and Finlayson was almost 1 m deep. Flooding made Sooke Road impassable and

the West Coast Road was blocked by a slide at Gordon's Beach. Cordova Bay and Ash roads near Mount Douglas Park were under water as were portions of Ellery, Colville, Devonshire, and Tillicum in Esquimalt.

On January 23, a debris flow occurred on one of the many creeks on Mt. Agassiz (Martin et al. In: VanDine 1985). On January 21-22, 33.4 cm of snow fell and on January 22-23, accompanied by warm temperatures, 68.4 mm of rain. The estimated 11,000 m^3 of debris consisted of mud, rocks, trees and assorted debris. The amount was similar to that of an event in 1962. The debris covered a parking area and destroyed a fence (VanDine 1985).

Near Carnation Creek on Vancouver Island, two debris avalanches occurred adjacent to the Carnation H-watershed (Hartman 1983).

On the afternoon of January 25, a blizzard in the Mount Washington area left an estimated 300 people stranded on the ski hill. Just after 4 p.m. on January 25, the Jordan River to Port Renfrew highway closed after a mudslide buried several metres of road surface. Clearing of the slide near the Jordan River Hill west of the townsite started on January 26. It is not known how long it took to clear it.

On January 25-26, storm-force winds were reported in a storm, which lasted 24 hours. Frontal waves had been forming and moving northeastward along a weak front, which stretched from Vancouver Island to Hawaii between two cells of Pacific high. On January 24, one of these waves formed a circulation and continued to deepen into a small but intense storm. Waves of 9 m and a maximum wind of 68 knots/h (125.8 km/h) were reported. Late on January 26 the centre moved ashore and deteriorated over the mountains (Lewis and Moran 1985).

---

*1) According to the occupant of the demolished house, most of the damage was caused by a large felled tree that had been lying at the top of the property since it was taken down as a hazard in September. Also, several times complaints had been made to Surrey municipal officials about a culvert on adjoining property that had been overflowing onto the hillside lot (*The Province*, January 25, 1982). In light of the disaster, Alderman Clayton Campbell, supported by Surrey council, asked the administration to prepare a draft bylaw to permit the municipality to control development and in particular drainage and storm run-off where there is a hazard.

*2) In April, homeowners in the Hillside-Doncaster area hit by flooding filed writs in British Columbia Supreme Court claiming damage against Victoria and Saanich. A total of 74 plaintiffs were named in the writ seeking unspecified damage from the Bowker Creek flood. The writ alleged that the culvert under North Dairy Road on the Saanich-Victoria border diverted the creek from its natural course. Almost a year later, 47 residents in an out-of-court settlement accepted collectively $300,000. All but six of the claimants lived on the Victoria side of the border, though the culvert was in Saanich (*Times Colonist*, April 20, 1982 and February 2, 1983).

*3) The downpour did not even come close to the record rainfall for a single day, set on January 15, 1961 with 92.5 mm (*Times Colonist*, January 25, 1982).

*4) Twenty-six years earlier, Bowker Creek, an open ditch at the time, spilled its banks and rampaged all the way through to Oak Bay. Tommy Hunt, who had been living at 1900 Haultain Street a short distance from where Bowker Creek flows under the street to the Fort Street-Foul Bay-Cadboro Bay roads intersection, suggested two ways to correct the situation. Ever since the placement of underground conduit allowing the transfer of creek waters from Saanich to Victoria to Oak Bay, Hunt had his home flooded, three consecutive winters. According to Hunt, Bowker Creek is too shallow to drain large areas of Saanich and Oak Bay when runoff is heavy. Not only should the banks be widened but also the capacity of the culverts should be increased. But he considered the most obvious impediment to flood level runoff the unnatural triple-right angle bend in the underground portion near the Fort Street intersection. This part of the system was installed by the City of Victoria, just inside its Saanich-Oak Bay boundary where the creek cuts a triangular corner off Victoria before entering Oak Bay under Foul Bay Road. Restoring the natural curvature to this section would allow floodwaters to runoff more rapidly, helping to prevent the backup that results into flooded

property a block north of Haultain. Hunt's second suggestion was to have alternate drainage from the creek somewhere north of Fort Street, possibly branching off by means of a pipeline running east to the sea from around Kings Road (*Times Colonist*, February 5, 1982).
In March, Saanich approved some $1.25 million to correct drainage problems. The area's drainage problems could only be solved by the installation of a storm sewer system to replace open ditches. The work involved "virtually building a new drainage system in the neighbourhoods affected by flooding." Almost half the money would be spent in the Garnet Road-Kisber Avenue-Ansell Road area replacing an undersized system. Ancient wooden culverts and poor foundations were the major reasons for the problem in this area. Upgrading the water collection system in the Alderwood-Oakwood-Birchmont area would cost $160,000. In the Shelbourne-Pear-Mortimer streets area $62,000 was allocated on culvert improvements and installation of a removable trash rack, which could be periodically cleaned. A short stretch of open ditch would also be enclosed at a cost of $35,000. In the Vanalman-Roseridge-Springridge district, $73,000 would be spent rebuilding the local sewer lateral system and improvements to Colquitz Creek. A culvert washed out in the flooding which caused Bowker Creek to overflow was to be rebuilt at a cost of $20,000. Improvements would also include installing a new trash rack. An enclosed drainage system on Union Road would be re-routed at a cost of $35,000 and $56,000 spent replacing culverts at Corners Place near the municipal works yard on McKenzie Avenue. Only $10,000 would be spent rectifying problems in the Gorge neighbourhood. Open ditching on the Queen Alexandra Solarium property would cost $10,000. An additional $83,000 was included in the estimates to correct on more than 100 properties scattered throughout the municipality and $22,000 was allocated on solving the drainage problem on James Heights (*Times Colonist*, March 18, 1982).

February 12-14, 1982
Discharge (m^3/s): Max. daily: February 16: Zeb.: 160.
Source: *The Province*, February 15 and 16, 1982; *The Vancouver Sun*, February 15, 1982; *Echo Valley News* (Sicamous), February 17, 1982; *The Peace Arch News*, February 17, 1982; *The Daily News*, February 14, 1982; *The Vancouver Sun*, February 15, 1982; Eisbacher 1983 (p. 11, pp. 14-15); Environment Canada 1992.
Details: Between January 12-14, the Lower Mainland experienced two days of snow, followed by heavy rain. A series of weather systems moved in from the southwest. Heavy rain caused flooded basements, landslides and following heavy snowfalls in the interior avalanches closed highways. On January 13, Abbotsford recorded 83 mm of rain while the Vancouver International airport recorded 63 mm. Between January 12-14, a total of 96.8 mm of rain was recorded in 48 hours in the Lower Mainland. This brought the total precipitation for the month till 10 p.m. on January 14 to 107.3 mm. *1)

The mountain areas of the Squamish Highway, North Shore and Coquitlam, usual targets of the weather, escaped with few problems. Following heavy snow in December and three days of steady rain, earlier storm drains overflowed flooding basements up to 60 cm in several parts of White Rock and closing some roads. Aldergrove and the lowlands around the Fraser Highway were also hit by flooding. In Surrey and Aldergrove, shoulders of roads washed away and ditches and streams overflowed.

On February 13, near the end of the storm, about 30 debris avalanches and slumps occurred along steep gullies and bowls facing Semiahmoo Bay. The failures involved natural surficial deposits, soil veneers, landfill, and trees. They were caused by concentrated run-off from paved roads, parking lots, plugged storm sewers, and inadequate drains. Their volume ranged from a few tens of cubic metres to 600 m^3. West of White Rock, several debris flows swept across the railroad tracks, closing the Burlington Northern Railway at Crescent Beach (Eisbacher 1983; *The Daily News*, February 14, 1982).

White Rock was hit by a second series of rain-caused mudslides in a month. On the night of January 14, a mudslide in White Rock washed away the backyards of three houses and forced the evacuation of four or five houses on High Street. The slide washed away a garage and part of a house. One resident saw her neighbour's land slide away, hearing a "swoosh"-sound and then saw the bright light that lit up the sky when the hydro lines fell. Other neighbours, who had their basements flooded for the second time in four weeks, described hearing "a big thud and trees crackling." Three neighbouring houses were undamaged but their occupants were moved as a precaution. A neighbour said the houses were "teetering on the brink" of a

sheared-off bank of a ravine and could fall in any moment. The foundations of several homes on High Street were precariously undercut when headwalls of tributary gullies failed adjacent to or below the buildings.

Most of the damage to homes was on the west side of Duprez ravine. *2) On February 14, a mass of landfill, mud and trees (about 150 m^3) crashed into the privately owned Duprez Ravine. It demolished three unoccupied units of the Bellevue Court, a small motel built across the lower section of the gully. Residents in other suites were evacuated along with the families in the threatened homes.

According to Mayor Tom Kirstein, the run-off to the sewer did not create the instability on the slope. He blamed that building on till, which engineers have been predicting would not hold in heavy rain. Septic tanks were also to blame, he said, as they also weaken the soil. Kirstein also reported a 15-ft. (4.5 m) deep sinkhole formed near the Centennial Arena. The engineering department had unsuccessfully tried to clear a blocked manhole on February 12-13 and again on February 15. The city monitored the hole, which was increasing in size.

One of the hardest hit communities was Langley. Roads were closed and basements were flooded by water up to 60 cm deep. In parts of Langley, floodwaters were so deep that residents got about in small boats. Following the torrential rains, about 70 homes were flooded in the Brookwood subdivision of residential Langley. While residents sandbagged their properties, municipal work crews cut trenches through street to drain the water. *3) The cost to refurbish the 70-odd houses involved was estimated at $1 million. Some 80 ac. (32 ha) of a Langley dairy farm at 176th Street and Fraser Highway flooded. Residents blamed the widespread flooding on the storm sewers in the Brookwood subdivision in southwest Langley on 35A Avenue between 196th-198th streets. More than 100 homes in the subdivision were hit by flooding and least three streets were impassable by floodwaters drained from nearby fields.

On February 13 at about 6 p.m., a mudslide came down at Boundary Road between Rumble-Marine Drive. In North Vancouver on February 13, a minor mudslide came down onto the Low Level Road. On February 15, the road was still closed to all but emergency traffic. In Coquitlam, there was some flooding at Cape Horn on the Lougheed Highway on February 13, only closing one lane of the road.

On February 14, a minor mudslide in the 7000 block of 272nd Street in Langley closed the road. The next day, mud was still coming down off the hill postponing cleanup operations till the rains stopped. On February 13, the Nicomekl River flooded its banks closing part of 208th Street, which reopened the next day. In Surrey, 168th and 192nd streets were closed due of rain-caused problems. In Richmond, flooding was reported at Sixth and River Road and the 18000 block River Road. Water was running over the Westminster Highway. In Burnaby, storm sewers and ditches clogged and hundreds of basements were flooded. On February 13, Cariboo Road and Government Street were closed and reopened the next day at 1:30 p.m. Some ongoing construction in the area resulted in inadequate drainage flooding the road with 15-20 cm of water.

On February 15 in the Sicamous area, heavy accumulation of snow on roofs combined with recent rainfall caused a number of buildings to collapse. Damage was estimated in the hundreds of thousands of dollars. Early on February 15, a large boat shed at the Westisle Stratatitle at Swansea Point collapsed, "crushed as flat as a pancake." The value of the boats housed in the building was estimated at $200,000. Four hours later, the roof of the building known as "Grandpa Charlie's Museum" caved in. The 8,000-$ft.^2$ (736 m^2) structure owned by Kopec Enterprises of Vancouver was valued at over $100,000. Some newly constructed recreational vehicle shelters at Buena Vista collapsed at 2 p.m.

On February 14, three snowslides including a massive one at Three Valley Gap, 24 km west of Revelstoke closed the Trans-Canada Highway. Later a second slide at Three Valley Gap closed the highway again. Except for a few hours on February 15, the highway to Revelstoke remained closed due to the large number of avalanches in Eagle Pass. The closure left about 100 semi-units stranded in Sicamous. The heavy snowfall and highway closure left Revelstoke isolated. In two-and-a-half days, some 80 cm of snow fell in Revelstoke. By February 16, 110.8 cm of snow had fallen in the previous four days. This brought fears of further avalanches and perhaps roof damage. Snow was reported level with the top of a carport and in a school playground only the top of the basketball backboard was visible. *4) Late on January 14, the westbound lane of the Trans-Canada Highway reopened. Crews were still working on clearing slides blocking the Rogers Pass hoping to reopen this section on January 15.

---
*1) The record precipitation for February was set in 1961 with a total of 277.1 mm (*The Daily News*, February 14, 1982).

*2) Minor slides had occurred on the east side of the ravine where the mayor and some aldermen were supporting development of 79 condominiums (*The Province*, February 15, 1982).

*3) Some residents, having suffered water problems for years, threatened legal action. Residents complained that the flooding was caused in part because the township had not provided adequate drainage. An old-timer, who lived in the area long before the houses were built, warned about future water problems "because the fields were flooded every year." Langley Township Mayor Bill Blair disagreed and said that the municipality felt the drainage in the area was sufficient. "The whole subdivision is built on a gravel bed, with plenty of drainage." Blair blamed the problems on the abnormal amount of rainfall. He said council would probably commission engineering studies to look into the possibility of installing storm drains. Blair, who inspected the area, stated that the problem in the affected area was due to the shallow swales instead of deeper drainage ditches used elsewhere. Also many septic tanks overflowed due to a combination of the heavy rains, high water table and lack of storm sewers in the 10-ac. (2.5 ha) subdivision.

*4) According to a spokesman at the Revelstoke airport weather station, the average total snowfall is 450 cm. By the afternoon of January 14, already 530 cm had fallen. During the winter 1971-72 a record 790 cm of snow were recorded (*The Province*, February 15, 1982).

Late March-middle April 1982
(Spring runoff/flooding).
Source: *Eagle Valley News*, March 31; April 14 and 21, 1982; *The Sun*, April 14, 1983.
Details: At the end of March-early April, heavy runoff of water caused considerable number of rockslides on highways in the Sicamous area. At the end of March, a large boulder rolled down a mountain onto Highway 97A about 7 mi. (11.2 km) south of Sicamous. In the morning of March 30, it was blown up with dynamite. Later in April, along the mile-long stretch of road just south of Swansea Point due to the large volume of runoff water off the unstable slope large rockslides were coming down.

At the end of March-middle April, residents in the area to the south of Maclean and MacPherson Road, behind the D Dutch Dairy, experienced flooding problems. Particularly along Green Road basements flooded and sewage systems were disrupted. The heavy snowfall and the fact that Gillis Brook, which provides much of the drainage for the area, no longer provided adequate drainage caused the flooding. In the past few years, it had silted up considerably and bank cave-ins and debris had plugged it up. According to Scotty Houston, a long-time area resident, about 7-8 years earlier homeowners got together and paid each about $50-60 to have a section of creek dug out. Though "it helped a lot," the creek had only been excavated to a depth of about 3 ft. (90 cm). Houston thought it should have been 6-8 ft. (1.8-2.4 m).

The area most affected by flooding was bounded by Kappel Street to the south, Larch Avenue to the east and Highway 97A to the west. Local residents affected by the flooding got together and agreed to construct a network of interconnecting ditches and waterlines draining all the water to one central collecting point on Kappel Street. From there, using large pumps, the water would pumped through over 1,700 ft. (510 m) of irrigation pipe to its discharge point at Gillis Brook. To alleviate the problem in the future, a two-phase plan was drawn up. The first called for the construction of a drainage system following a route along Kappel Street west to Highway 97A. The water then would flow through a culvert placed under the highway to Poage Avenue to Mara Lake. The second phase involved the construction of deeper, properly excavated ditches throughout the entire area and for installation of culverts at each intersection of the subdivision.

In the spring, the basements of more than 100 houses in the Hedberg subdivision on the southeastern outskirts of Sicamous flooded. *1)
---
*1) Similar flooding occurred in February 1983 (*The Sun*, April 14, 1983). See February, 1983 event.

June 21, 1982
(Spring runoff/flooding and tidal flooding).
Source: *The Vancouver Sun*, June 21, 1982.
Details: On June 21, a combination of high tides and a large Fraser River runoff caused minor flooding in some parts of Langley. In the Derby Reach area, approximately 5 ac. (2 ha.) and a smaller area near River Road and 252nd Street were under water. A 15.6-ft. (4.7 m) high tide at 10 p.m. at Point Atkinson caused concern. Meanwhile at Mission, the Fraser River recorded its highest mark of the year at 20.4 ft. (6.1 m). As most of the snowpack had melted and run off, the river was expected to drop soon.

The rising waters of Shuswap Lake posed a flood threat. In Salmon Arm, about 200 sawmill workers at the Federated Co-operatives Ltd. plant were about to lose two weeks' work. Federated's low-lying lakefront property, housing a cedar mill and whitewood mill, was flooded up to 1 m in some areas. The mills themselves were on pilings and not in danger of flooding. A plywood mill, employing about 135 workers on higher ground continued to operate.

July 20, 1982
(Glacial outburst flood).
Source: Blown and Church 1985.
Details: On July 20, "MT" Lake, a small ice-dammed lake on the major west tributary of Nostetuko River, suddenly drained. The water was released in a sudden flood, or jökulhlaup, which drained the lake in two hours. It resulted in a small flood down the Nostetuko River (O. Mokievsky-Zubok, pers. comm. In: Blown and Church 1985). The drainage of water from "MT" Lake was through a 1.8-km long discharge tunnel located in or under the glacier (Blown and Church 1985).

September 22-25, 1982
Source: *The Journal*, October 5, 1982; *The Province*, September 28, 1982; *The Daily News*, September 28, 1982; Wallace 1987; Evans, unpublished data.
Details: On September 25, following three days of heavy rain, a 500-m wide slide came down the Thompson River Valley along the CPR mainline in the Black Canyon area, about 5 km downstream (south) of Ashcroft. *1) The slide occurred along the same stretch as the one in October 1880. (See: October 14, 1880 event) Tons of sand, clay and gravel were pushed 30 m into a 120-m section of the river. It caused the riverbed to come up about 8 ft. (2.4 m) because pressure resulting from the slide caused a downward pressure pushing it up. Other sources reported the riverbed in that area raised by about 6 m (*The Province*, September 28, 1982).

The movement was first noticed on September 22. Repair crews went to work when shifting caused a slight derailment for two cars of a train. During the night of September 22, the equipment brought in to stabilise the site was called out of the area. It was felt that the movement was creating a danger to the machines and their operators. The land continued to slide at a snail's pace until midnight September 24-25, when the whole area collapsed into the Thompson River. About 500 m of CPR track was torn out, leaving the rails torn up and "tossed around like bits of spaghetti." According to witnesses, it went with such a force that it tore up giant boulders out of the bottom of the river. Along with hundreds of fish, they were thrown onto the riverbank, rerouting the river.

Between early on September 25 and mid-day September 30, rail traffic between Kamloops-Basque, the first station south of the slide area was closed. During the interruption, CPR rail traffic was re-routed over CNR tracks. About 80 workers and engineers from Vancouver, Coquitlam and Montreal worked around the clock to build a temporary track. Later in the year, the section was to be completely rebuilt.

Aerial photographs of the slide area reveal that it was the site of a previous slide, date unknown. According to Liv Hundal, engineer in the Kamloops division of water management, it was an old slide sliding again. The whole area was very unstable. Though there has always been speculation, linking slides with irrigation, there was never any substantial evidence. *2) Originally it was feared that some 4,000 rearing Chinook salmon and other small fish might have been killed. However, according to fisheries biologist John Payne, the slide was not expect to hamper the first of an estimated 2 million salmon expected

for the Adams River run. At the time of the slide, the Chinook travelling upstream to Adams River were running near Boston Bar and only expected to pass through the slide area during the first two weeks of October.

---

*1) The land boxing in the Thompson River between Spences Bridge-Kamloops has a long history of landslides that date back to the formation of the area's fragile clay benches during the ice age. Cliffs above the railroad tracks were formed thousands of years ago by a backwash when the area was a glacial lake (*The Journal*, October 5, 1982).

*2) Almost 90 years after the litigation initiated in July 1895, the railway again alleged that the landslide was caused by the irrigation of the bench lands above the railway. Its claim for $1.1 million of damages was dismissed (Wallace 1987). But the railway was granted an injunction to prevent irrigation until it was demonstrated that irrigation did not apply water "in excess of the available water storage capacity of the soil." (Evans, unpublished data).

October 6, 1982

Source: Thurber Consultants 1983 (Appendix B).

Details: On October 6, 60 mm of rain fallen in a 24-hour period in the Lions Bay area caused heavy flows in Harvey, Newman and Magnesia creeks. At Newman Creek, a minor amount of material was washed from above the lower marina access road. The material washed over the road and down towards the warehouse (Thurber Consultants 1983).

October 24, 1982

Source: *The Province*, October 25 and 26, 1982; *The Tribune* (Williams Lake), October 26 and 28; November 4 and 9, 1982; *Times Colonist*, November 3 and 5, 1982; July 9, 1983.

Details: On the night of October 24, a heavy rock- and mudslide along Highway 4 about 15 km east of the Tofino-Ucluelet junction cut the Tofino to Ucluelet road and buried a passenger car. Highway crews hoped to have the road cleared late on October 25. The storm, which dumped 62 mm of rain, was accompanied by high winds. High-tension hydro lines were downed. An estimated 6,000 Tofino and Ucluelet residents were cut off power while repairs were being made. Two new poles had to be installed.

The Island Highway almost washed out at Royston, south of Courtenay. Late on October 24, one lane was open but the road was deteriorating quickly. A troop of Boy scouts managed to safely get out an area in the Cheakamus Valley when a gravel road washed out. The Upper Cheakamus Valley Road reopened on October 25, after being cut for 24 hours.

In October, the Cowichan River flooded some 200 ac. (80 ha) of farmland. The river was in the process of changing its course, threatening to wash out the highway. Water up to 1 m deep in places flooded the area just west of Tzouhalem Road south of the Pimbury Bridge. An unfinished dyke was keeping the water in on the flooded land. Elaine Blakely, who operated Tzouhalem Farms noted that the flooding usually occurs between December-February around their property and that they had built and floodgates. An estimated $50,000 was all that was needed to temporarily alleviate the Cowichan Valley flooding. *1)

On October 20, the residents of eight homes on Juniper and Paxton roads on the south shore of Williams Lake were urged to leave their homes as a precautionary measure as the hill on which their houses were built might slide into the lake. Evidence of shifting and cracking was found in at least four of the homes. PEP announced funds were available for relocation of the affected families. *2) On November 14, one of the home owners Jim Matthies discovered cracks developing on the steeply sloped property above five houses on Paxton Road. Of the several cracks some were up to 150 ft. (45 m) long, 1 ft. (30 cm) wide and 6 ft. (1.8 m) deep. Four years earlier when he purchased the house, Juniper Road resident Mike White noted hairline cracks in his basement foundations. White thought it was just normal house settling and cement shrinkage and did not notice much larger cracks until a couple of months earlier. Coming home from a camping trip after a particularly wet weekend in July, the White's discovered their sundeck sitting off kilter. In October 1982, the cracks were huge and the floor had dropped. During the summer, the house was

no longer level. A house mover said he could jack the house up but could not give a guarantee it would stay level because of the soft ground conditions.

Other Juniper Road residents were experiencing similar problems of cracking foundations but not as extreme. The McCarty family was warned about the dangers of the slide six years to the day they moved into the house they built. Like others in the area, the McCarty's noticed cracks developing in their foundation and driveway but shrugged them off as natural occurrences. The pony-wall in their basement was starting to bow and slant. But this had only become really noticeable over the previous two months.

Other evidence of earth shifting included the development of cracks in the roads and along driveways. In July, Paxton Road resident Bob Davis, whose trailer sits 20 ft. (6 m) from the bank of the sliding hill, had to hire and excavator to remove part of the bank that slid into his trailer. After cutting the bank perpendicular to ground level, Davis built a fence between the trailer and the hillside. Soon the bank started to give way again, pressing dirt against the fence. Early September experiencing difficulty mowing the lawn, next door neighbour Eileen Henry, whose house also sits within 20 ft. of the embankment, noted her whole backyard was sloping. "There were huge humps in the grass and the sidewalk was being pushed into the house." Early October, trying to have her septic tank cleaned out, the pipe coming from the tank was on an angle and the hose would not get through the tank. Other neighbours also had problems with their septic tanks shifting.

Cariboo regional Environment staff continued to monitor the hillside. Between October 19, when monitoring began and early November, the slide had moved over 5 in. (12.5 cm) vertically and horizontally. During October 30-31, it moved 5 cm vertically and horizontally, the largest single shift since the monitoring began. In all probability the slide would continue to move but not necessarily at its current rate.

The slide area appeared to be extensive, covering approximately 50 ac. (20 ha). It extended from Paxton Road up the hillside for about 500 m in a fan-like shape. There was no sufficient evidence of sliding below Paxton Road. The top end of the slide was just beyond a swamp at the top of Wheetman Creek, which en route to the lake runs through the slide zone. The way trees in the area had grown in a "drunken manner" indicted that the slide had been moving continually. *3) It was believed the slide accelerated in 1982 because of the record rainfall. *4)

---

*1) Duncan area residents blamed the premature flooding of the Cowichan River following only a moderate rainfall on work recently done upriver near the Trans-Canada Highway and on insufficient funding to Cowichan Indian Band to complete a dyke. Work near the highway had removed bends in the river, creating a chute for gravel to rush down and deposit on the Indian reserve. According to Cowichan Indian Band spokesman Cicero August, dredging was required on the lower reaches of the (north fork) river. Several agencies involved, particularly federal fisheries, did not allow dredging deep enough to solve the problem. Any extensive gravel removal was only allowed during June and July. One section of the riverbed was higher than the surrounding fields. A dyke started by the Native Indians with Provincial Emergency Program funds was only half finished when money ran out. If completed, the dyke should have run for about 1 km from Pimbury Bridge west to where the river forks. Ted Burns, provincial biologist connected with implementing the Cowichan Estuary Plan noted, "we have had a flood-control program for the whole of the Cowichan floodplain since 1967. But this has never been implemented." (*Times Colonist*, November 3, 1982).

*2) In July 1983, the provincial government set aside $530,000 in an offer to purchase the nine properties on the south side of Williams Lake where land shifts posed a hazard (*Times Colonist*, July 9, 1983).

*3) Geotechnicians from Victoria and Prince George determined that the slide was ancient with the last major shift occurring 80-120 years earlier. It was assumed the area had been moving ever so slightly since that time (*The Tribune*, November 4, 1982).

*4) The previous highest precipitation for Williams Lake in 1964 was exceeded in October 1982.

November 10, 1982
(Pipe burst/flooding).
Source: *The Vancouver Sun*, November 10, 1982.
Details: On November 10 at 7:30 a.m., the 12-in. (30 cm) Vancouver city water main burst on Clark near King Edward leaving a hole estimated at 20 $ft.^2$ (1.84 m^2) and 10 ft. (3 m) deep. The main was shut off by 9 a.m. The water flooded nearby streets and basements in the area. It was estimated it would take one day to repair the pipe. *1)

---

*1) A water district technician estimated the flow rate of a 12-in. pipe at about 10 million Gal. (45 million L) a day.

December 2-3, 1982
(Rain-on-snow and tidal flooding).
Discharge (m^3/s): Max. daily: December 3: Capil.: 159; Chem.: 412; Kok.: 170; max. instant.: December 3: Capil.: 279.
Source: *The Vancouver Sun*, December 3, 1982; *Times Colonist*, December 4, 1982; Thurber Consultants 1983 (Appendix B); Environment Canada 1992; Jackson et al 1985 (p. 4-18, 4-20).
Details: Between December 2 at 10 p.m.-December 3 at 4 a.m., the Vancouver International airport recorded 19.1 mm of rain. Other parts of Vancouver Island were hit harder. Tofino recorded 64 mm of rain while Campbell River, Port Alberni and Nanaimo reported 51.6, 56.4 and 44.6 mm, respectively. The freezing level at the south coastal mountains was up to 9,000 ft. (2,700 m), melting snow and causing avalanches.

On December 3 at 8:10 a.m., a landslide occurred on the Squamish highway north of M-Creek bridge. It happened following a week of heavy rain and warm temperatures that melted snow on south coastal mountains. The slide blocked the highway for about 20 minutes. The highway was opened briefly to one-lane traffic when another slide occurred further north. Northbound traffic was blocked off at Lions Bay and southbound traffic was halted indefinitely at Britannia Beach.

On December 3, a small debris torrent, or series of torrents occurred in the upper watershed of Alberta Creek. The event occurred after approximately 62 mm of rain were recorded at the Lions Bay works yard during a 24-hour period (Thurber Consultants 1983). Debris was deposited on the logging road at the creek crossing. There was also a logjam just upstream from the Lions Bay municipal water intake at 280 m elevation (Jackson et al. 1985). There was evidence that this minor debris was accompanied by a large flow of water in the creek (Thurber Consultants 1983). Behind the forestry road bridge/fill structure across Alberta Creek at an approximate elevation of 660 m, an estimated 350-450 m^3 of rock and log debris accumulated and partially removed the bridge/fill structure. An approximate 2 to3-m levee formed on the left (south) side of the creek. On the right side, a 0.5 to 1-m levee formed. The bridge/fill structure formed a log crib and debris "dam" approximately 4 m high (Thurber Consultants 1983).

On December 3 shortly after 8 a.m., a combination of heavy rain and high tide backed up storm sewers in Vancouver. A high tide of 16 ft. (4.8 m) was reported at Point Atkinson. Some basements, a few stores and underground parking lots flooded. As extensive flooding was reported in the area, Bellevue Avenue was closed between the 1300-1500 blocks near the waterfront. Minor flooding was reported on Great Northern Way. Flooding also occurred in White Rock where Marine Drive along the beach was flooded. In Burnaby, clogged water ducts caused flooding at Willingdon and Canada Way and on the Lougheed Highway near Lake City. In Coquitlam, large pools of water were reported on the Lougheed highway at Schoolhouse and on the Pitt River Road in Port Coquitlam between the former Red Bridge, recently destroyed in a traffic accident, and Shaughnessy Street. In low-lying parts of Richmond, Surrey and Chilliwack, roads were inundated. In Chilliwack, some garages were reported flooded. Elsewhere in the Lower Mainland, storm sewers backed up.

The severe rainstorm that hit Greater Victoria overnight December 2-3, forced the evacuation of residents and closed schools. During the 24-hour period ending 10 a.m. on December 3, Victoria recorded almost 67 mm of rain. Culverts overflowed, flooding basements and streets. Main floor residents of Redwood Apartments, 157 Gorge Road East were evacuated when water entered their suites. The Island

Plaza Hotel construction site at Blanshard and Bay when a storm drain running through the site broke. City public works dumped fill into the site to shore up Blanshard. A broken main at Finlayson and Douglas streets added to traffic problems. Royal Oak Elementary School was closed when nine classrooms, halls and a book storage area flooded with up to 8 cm of water from backed-up storm drains and surface runoff. On December 3, high tides uncovered a sewer pipe at Cordova Bay and moved a manhole.

December 16-18, 1982
(Storm surge/tidal flooding).
Source: *Times Colonist*, December 17, 1982; *The Province*, December 17 (18?), 1982; *The Vancouver Sun*, December 18, 1982; January 5, 1983; February 26, 1983; *Surrey Leader*, December 22, 1982; *Surrey-Delta Messenger*, December 22, 1982.
Details: On December 16-17, the west coast of British Columbia and Washington were hit by gale-force winds. It was the third storm in a week and "one of the worst in a decade." Winds gusted up to more than 118 km/h. The gale-force winds lashed high water tides over dykes and highways across low-lying areas of the Lower Mainland and Vancouver Island. Shoreline residents called it "the worst flooding they can remember." It would not be till the middle of January 1983 before the provincial government would be able to come up with a total of the flood damage.

On December 17, the high winds forced the cancellation of half a dozen ferry sailings between the mainland and Vancouver Island. Also cancelled was the service to the Gulf Islands. The storm set many pleasure boats adrift. Winds of 60 knots (111 km/h) and waves up to 9 m shifted the deck cargo of the 175-m freighter *Asian Anvil* and caused an 8-degree list.

Early on December 16, the combination of high tides, gale force winds and heavy rains flooded houses and farms on Westham Island, in Boundary Bay, at Crescent Beach and in the Nicomekl and Serpentine basins. Several homes were damaged and farmland harmed after the Westham Island dykes broke on December 16. Strong southwesterly winds gusting to 100 km/h during a high 15.4-ft. (4.6 m) high tide, above datum at Point Atkinson, ripped two about 3-m wide holes in the dyke.

Winds backed up the water in the rivers 2-3 ft (60-90 cm) higher than the tide level, pouring it over top of the dykes. Floodwaters started gaps in the dyke, letting in more water up to 3 ft. over the fields of Mud Bay and Colebrook farms, and drowned out Serpentine Fen. The private dykes on the south side of Nicomekl River were also overtopped, and water flooded the Nico Wynd golf course, tennis court, recreation clubhouse and threatened the sewage pumping station.

Worst hit by the flooding was Gordon Ellis' farm. Though the Ellis family had been farming there since 1914 and expected some flooding when the tides were running highest, they "could not remember it this bad." Ellis complained about the federal and provincial dyking authorities that told him that it was not worth building up Westham Island dykes to the standards used elsewhere in the Fraser delta. Ellis was told that "they'd rather pay him compensation for occasional crop losses than fortify the dykes." On the afternoon of December 16, the southwesterly winds forced back the floodwaters that should have been flowing out of the fields. Ellis' neighbour Ken Bates, noted "This is as bad as it's been since 1948." Then high tides, wind and rain wiped out whole sections of dyke lines that could still be seen 20-30 m west of the existing dykes. The Westham dykes were not only as strong and as extensive as elsewhere in the Fraser delta but also further weakened by burrowing muskrats. Inspector of dykes for the provincial environment ministry Ken Chisholm blamed the Westham farmers who "had not been inclined to form a dyking district the way other operators of dykes have." According to Chisholm, the dykes here were in good shape but just not high enough. *1) He blamed a freak tidal occurrence.

Water spilled over dykes in Mud Bay, Surrey and areas of Delta. Large areas of farmland were flooded in Surrey and Delta. Surrey sustained tidal flood damage after water swept an area between Colebrook Road and the Nicomekl River west of King George Highway. In some places, the waters were 3-4 ft. (90-120 cm) deep. Art Knapp's Plantland, 4391 King George Highway, was flooded when dykes along the swollen Serpentine and Nicomekl rivers broke early on December 16. Owner Peter VanderZalm estimated damage to equipment and machinery at $100,000. A house next to the nursery also sustained

severe flood damage, with an estimated damage in the "thousands of dollars." Fields of dyking trustee Gil van Keulen's Mud Bay dairy farm were under 1.5 m of water.

The strong waves stacked logs high on the seafront boulevard beach along Crescent Beach and washed over top of the low boulevard dyke onto front yards and foundations of some seafront homes. Damage was heaviest between the end of Sullivan Street and the wharf. The pounding waves brought in so much sand leaving the beach only a few feet lower than the top of the boulevard.

In Delta alone, $40,000 was spent to repair flood damage. About one third was spent on Westham Island dykes and the rest in Boundary Bay and east Delta. *2) Municipal Manager Dan Closkey estimated Surrey municipal costs for emergency repair work at $30,000 at Crescent Beach, $10,000 at the Nico Wynd condominiums, $25,000 for assisting at Mud Bay and $45,000 on the Colebrook dyke. *3)

On December 16-17, waterfront properties at Point Roberts, Wash. sustained widespread damage estimated at millions of dollars. The south shore of Point Roberts, facing straight into the southwesterly gales, suffered the worst damage. A 12-m deadhead thrown up on shore by 9-m high waves knocked down the pilings of a shoreline cottage, sweeping it off its foundations. In the 1400 block of Edwards Drive, hardest hit in the resort community, the yards of 20 seaside cottages and houses, most belonging to Canadians, were awash with seawater, mud, wood chips and logs. About 10 of the homes suffered flood damage ranging from mud in the living room to total demolition of one house. The wind-lashed high tides caused a saltwater pond, 15 m wide and 8 m deep, now separated a home at 1467 Edwards from the roadway. Nearby, at Lighthouse Park, the parking lot was flooded with water covering their hubcaps. A section of road on Bellview Drive near the beach was also wiped out, causing more than $500,000 damage. A spokesman for the Whatcom County emergency services department estimated the storm caused $1.8 million damage to private property and another $1.2 million to roads. An estimate for Port Roberts had not yet been made.

On Vancouver Island, the storm raised the already high tides by an estimated 2 ft. (0.6 m). Though the charts showed a tide of only 15.5 ft. (4.7 m), the tides were actually much higher.

On December 16 in parts of Greater Victoria, winds of 93 km/h with gusts up to 118 km/h measured at Gonzales snapped powerpoles and trees, causing power cuts and blocked roads. Homes in Gordon Head and Shawnigan Lake were without power for longer periods. At the Astrophysical Observatory on Little Saanich Mountain, winds ripped away a portion of an aluminum dome housing a telescope. Some areas of Central Saanich and Colwood were without power for more than 24 hours. A tree a fallen on the railway tracks at Langford halted E&N service. At Cedar Grove Marina in Sidney, a powerful gust tipped four boathouses on end. On December 16, much of Nanaimo was without power as high winds brought down powerpoles and fallen trees blocked roads.

---

*1) The Westham Island dyke, which was now "as good as it ever was," really needs total reconstruction, said Delta Engineer Jim Hamilton, and Boundary Bay would need a proper seawall constructed to provide good protection from high tides. Hamilton said he did not know what long-term damage salt leachates had done to farmers' fields (*Surrey-Delta Messenger*, December 22, 1982).

*2) The Fraser River Dyking Commission had completed dyking around Delta but ran out of federal-provincial money before Westham Island could be dyked. According to Westham Island farmer Gordon Ellis, bringing the island dykes up to commission standards would cost $3.3 million. For $500,00, improved and adequate dykes with roads on top to allow quick access for repairs could be built (*The Vancouver Sun*, January 5, 1983).

*3) Surrey would later receive $700,000 from the provincial government to cover damage and expenses to the municipality (*The Vancouver Sun*, February 26, 1983). Surrey had submitted a bill for $750,000.

Winter 1982-83

Source: *Times Colonist*, November 18, 1983.

Details: During the winter 1982-83, as many as 30 homes and three offices in Esquimalt suffered some form of flooding problems. To remove back pressure on the storm sewer system causing flooding from Tillicum Road back to Dominion and Devonshire roads, drainage work would be required through the Gorge Vale Golf course.

January 7-10, 1983

Source: *The Daily News*, January 10 and 11, 1983; Egginton, pers. comm.

Details: Heavy rain and snowstorms hit southern British Columbia, forcing closure of many routes. In the Fraser Valley thousands of hectares of farmland were flooded. Two areas had more than 100 cm of snow in 24 hours. One of them was the major southern route through the east Kootenay, the Salmo-Creston Skyway summit. It remained closed for most of the week until the avalanches were cleared and the threat of them passed. With that route blocked, the Balfour to Kootenay Bay ferry across Kootenay Lake was pressed into an hourly service. Heavy snow, more than 100 cm, also occurred 17 km west of Revelstoke.

Unseasonably high temperatures reaching the 1,828-m level caused major problems in the mountain passes. Highway crews from Hope to Revelstoke at the west end of the Rogers Pass worked round the clock, some of them for two days, to clear the Hope to Princeton sections of the Rogers Pass, and two sections of the Squamish Highway north of Vancouver. About 14 snowplows and other equipment worked on January 9 and 10 to clear avalanches, more than 60 cm of snow and a mudslide that blocked the Hope to Princeton highway, starting 6 km east of Hope. Work on the highway was hampered by water on the road. Crews had to punch holes in the snowbanks to let the water out. The 120 mm of rain that fell in the Hope area in 24 hours probably caused the Hope to Princeton mudslide. Slides that closed the Kaslo-New Denver highway were cleared, but the Kaslo-Trout Lake Road remained closed for most of the winter because a bridge had been removed for repairs. Most major highways through mountain passes in southern British Columbia were reopened later on January 10.

On the night of January 9, a massive traffic jam on Five Mile Hill just south of Whistler resulted in a minimum two-hour wait for skiers heading back to Vancouver. Several vehicles equipped with summer tires were caught in the blizzard conditions and blocked traffic in both directions for several hours.

On January 7 at 7:30 p.m., a rockslide came down in the salt shed area of the Cheakamus Canyon. It blocked the northbound lane and a portion of the southbound lane of the highway. Although the highway was not closed, traffic was delayed.

Between January 7-10, the Vancouver International Airport recorded temperatures up to 6^{o} C above normal and maximum wind gusts up to 72km/h. On January 9, at Hollyburn Ridge and Squamish A the daily mean temperature were 3^{o} C and up to 4^{o} C above normal, respectively. Whistler totalled 115.0 mm of total precipitation in the four days with 18.0 cm of snow falling on January 8-9 and 53 cm of snow was measured on the ground on January 10. Temperatures at Whistler were up to 5^{o} C above normal and above zero for the period. (Egginton, pers. comm.).

Early on January 10, two rockslides on either side of M-Creek closed Highway 99 for seven hours. The slides, coming down at 7:15 a.m. on the south side and at 8:30 a.m. on the north side were caused by heavy rain.

February 8-11, 1983

(Rain-on-snow).

Discharge (m^3/s): Max. daily: February 11: Chem.: N/A; Zeb.: N/A.; max. instant.: February 11: Chem.: 537 (extreme record for period of record); Zeb.: 510.

Source: *Alberni Valley Times*, February 11, 14, 15 and 16, 1983; *Times Colonist*, February 12; July 9, 1983; April 18, 1984; *The Vancouver Sun*, February 11, 12 and 17, 1983; February 22, 1984; January 29, 1987; *The Daily News*, February 14 and 15, 1983; *The Globe and Mail*, April 18, 1984; Church 1985; VanDine 1985 (pp. 67-68); Church and Miles 1987 (p. 70, 73); VanDine and Lister 1983 (pp. 9-11); Bayrock 1983; Thurber Consultants 1983 (Appendix B); Hungr et al. 1984; Lister et al. 1984; Jackson et al. 1985 (p. 4-11, pp. 4-18-4-20); B.C. Ministry of Energy, Mines and Petroleum Resources 1993; Environment Canada 1992.

Details: On February 8-10, an intense Pacific cyclonic storm approached the British Columbia coast from the west-southwest, drawing a strong southwesterly airflow onto the coast. There was substantial precipitation ahead of the low-pressure center, which fell as snow at higher elevations. Precipitation was heaviest on February 10 when the freezing level rose abruptly to near 2,000 m, causing significant snowmelt. The 24-hour precipitation for the area recorded at Hollyburn Ridge was 80 mm. In the seven days prior to this, another 175 mm of rain was recorded (Church and Miles 1987). In the 24-hour period ending 10 a.m. on February 11, the following amounts of rain were reported at Vancouver International Airport, 38 mm; Nanaimo, 67 mm; and Port Alberni 95.4 mm, respectively. Till 4 a.m. on February 12, 29.5 mm of more rain was recorded at the airport (*The Vancouver Sun*, February 12, 1983). Between February 8-10, almost all meteorological stations in the Howe Sound region reported heavy rain and snow at high elevations. The February 10-11 storm had a return period of about two years (Jackson et al 1985). On February 11, the Vancouver International Airport recorded winds of about 20-30 km/h with gusts up to 45 km/h. Until 5:30 a.m. up to 32.2 mm of rain fell, with higher rainfall in the mountains.

Warm moist air flowed into the area on the night of February 10-11, raising the freezing level to about 3,000 m and bringing fresh rain. Temperatures in the area reached 11^{o} C and remained high for the next couple of days (*Times Colonist*, February 12, 1983). Snow melted by warm weather and rain caused flooding in the Squamish area. In the Howe Sound area, debris flows occurred on Alberta, Newman and Turpin creeks, all within 3.5 km of each other.

On February 11 on Alberta Creek, a large torrent flow of more than 12,000 m^3 severed all bridges except the railway overpass right at the bottom. It severely damaged six houses and took the lives of 18- and 19-year old brothers. *1) On February 11, some 65 families were evacuated from Lions Bay and nearby Harvey Creek. Most of the people returned to their homes on February 13. Five access road crossings, and four houses were destroyed (VanDine 1985). Earlier that day, a woman was rescued from another trailer that was hit by a mud and debris slide. About 275 residents on the north side of the creek were cut off from the rest of Lions Bay. At 4 a.m., the highway bridge across Alberta Creek closed. A temporary Bailey bridge replaced the bridge. Highway 99 was scheduled to reopen late on February 14. *2) The BC Rail line was closed after two sections of track were buried by mud and debris. On a 100-m section, the debris was 2-3 m deep. BC Rail restored both freight and passenger service on February 11.

Debris from an earlier slide had blocked the Strachan (Charles) Creek bridge, 8 km north of Horseshoe Bay. At least 0.5 m of water covered some sections of the Squamish Highway. In the early hours of February 11, a saturated snow avalanche appeared to have occurred in the very steep, rockbound upper gully of the creek. Launched over a 6-m waterfall, it set in motion abundant earth and rock debris in the channel below (Church and Miles 1987). *3) Hungr et al. (1984) estimate the velocity of the Charles Creek debris flow at 4.6-8.1 m/s. The debris torrent was initiated at the forestry road, which crosses the creek at the elevation of approximately 2,000 ft. (665 m) above sea level. (Bayrock 1983). A snow deposit with admixed soil was found on the logging road crossing. Above and below the crossing, saplings were broken and stripped of bark, probably as a result of sliding snow. Immediately below the road, on a 30^{o} channel gradient, there was evidence of major erosion of channel debris. Two hundred metres below the crossing, both banks of the channel were scoured to heights of 8 m. Thus, part of the snow avalanche flowed below the crossing and impulsively loaded the debris in the channel, initiating the major debris torrent (Jackson et al 1985).

The debris torrent occurred in six surges; the first at 3:30 a.m., the second at 3:45 a.m. and the third 10 minutes later. The remaining three surges occurred by 6:20 a.m. (Lister et al. 1984; Jackson et al. 1985). Const. Doherty observed the last surge at the subdivision road crossing downstream of the highway and estimated its speed to approximate 2 m/s. (Thurber Consultants 1983). Flow velocities have been estimated to be near 9 m/s at the highway. Alberta Creek, which is normally a trickle during the dry season, turned into a “river of rock and mud.” According to Frank Smith, Works Manager for the Village, Alberta Creek seemed to be damming up from time to time and then the water surges out and caused further slides. *4)

At the Village of Lions Bay, the debris torrent was contained within the stream gully to below the highway bridge. At this stretch, the torrent damaged only roads and bridges. At a point below the highway

bridge, the debris torrent spread to the surrounding terrain from the gully. All damage done to houses and property was from the initial point of spreading downward (Bayrock 1983). The crashing of rocks on each other could be heard. An eyewitness described the event as “like thunder coming close.” Another local resident described it as “the sound of a jet plane overhead or strong winds,” which lasted about 30 seconds. Houses would shake “as if a train would go by the house.” (*The Vancouver Sun*, February 12, 1983). A total of five culverts, two above the bridge and three below, washed out. Further downstream, an unoccupied residential building on the fan delta near the BC Rail line was knocked off its foundations and pushed into Howe Sound.

Alberta and Harvey creeks, which run through Lions Bay, also supply the community of 1,000 with water. Consequently, besides losing power and telephone, residents also temporarily had to go without water. Though the telephone cable was damaged, only about 10-15 subscribers out of 460 were affected. One resident, who lost a large part of his backyard carved out by the slide, was left with a 20-m deep trench where the small creek was previously.

The Alberta Creek debris torrent displaced some 15,000 m^3 of debris (Ministry of Energy, Mines and Petroleum Resources 1993). About 10,000 m^3 of debris were deposited at the mouth of the fan commencing 75 m from the shoreline and out about 30 m into the sea. As some of the sediment flowed into Howe Sound, estimates of the total volume of the debris torrent could range as high as 20,000 m^3, though the actual value is probably much nearer 12,000 m^3. Many logs were floating in Alberta Bay on the following morning.

According to a preliminary report on the conditions in Alberta Creek and Harvey Creek prepared by geologist L.A. Bayrock, dangerous possibilities existed for future slides on Alberta Creek. Bayrock’s report on the “Lions Bay debris torrent” pointed out dangerous possibilities for future slides on Alberta Creek but also noted that “a debris torrent is highly unlikely to occur in the near future” on Harvey Creek. Bayrock’s conclusion was that the unstable soil conditions along the walls of the gully of Alberta creek, from the 2,000-foot (600 m) elevation where a forestry road crosses the creek down to the village of Lions Bay “may result in a new debris torrent in the near future.” If a new slide of the same proportions should occur, Bayrock noted, only a few additional houses would be affected (*The Vancouver Sun*, February 17, 1983).

At Newman Creek, a debris torrent deposited an estimated 7,500 m^3 of debris between the highway bridge and a waterfall 120 m upstream, and at the mouth of the creek. There was little evidence of forest debris, except towards the edge of the deposit upstream of the bridge. However, there was evidence of a former logjam at this location. The deposit at the mouth of the creek covered an area of approximately 700 m^2. The torrent partially blocked the highway bridge. A small amount of material ended up on the deck of a private wooden bridge immediately downstream, blocking access to the boat yard. Some of the debris came to rest against a mobile home and a combination house and office on the south side of the creek. The torrent blocked and overtopped two access roads and covered a parking area with debris (VanDine 1985). A helicopter reconnaissance showed a fresh scar on the side slopes of the creek at about an elevation of 1,000 m. The torrent may have initiated at this point. The marina owner stated that during the event large blocks of snow were observed mixed with the debris in the lower deposit. This suggests that a snow avalanche may also have played a role in initiating the torrent (Thurber Consultants 1983).

At Turpin Creek, a torrent deposited an estimated 1,500 m^3 of fine rock interspersed with logs. The debris filled up the depression of the upstream side of the highway to the top of the concrete barrier. The deposit diverted the creek to flow 100 m to the south, eroding a section of the road embankment on the downhill side approximately 15 m long. The debris from this washout terminated at the railway below (Thurber Consultants 1983).

Overnight February 10-11, record rainfall caused flooding in Port Alberni and elsewhere in the Alberni Valley. In the 24-hour period ending 7 a.m. on February 11, 95.4 mm of rain was recorded, breaking a record for the day as well as for the month of February. *5) Early on February 11, several Port Alberni streets were closed due to flooding. Third Ave. between Napier Street-Dunbar was closed after Dry Creek flooded its banks. Many basements were flooded and at least two businesses were closed by the floodwaters. Watson Street was blocked off and water covered streets and yards in every direction. Some 20 homes were reported affected by the flooding. Continuing rain and a high tide at 11:25 a.m. caused more problems later.

Hardest hit was the floodplain area, where Lugrin Creek spilled its banks flooding the surrounding area with “knee-deep” water. *6) Five days after Lugrin Creek flooded, knee-deep water still surrounded a home at 5236 Alexander at the intersection of Heath, a street corner invisible beneath murky water. The owner experienced his second major flooding since he purchased the house four years earlier. When the floodgates installed to protect the Margaret and Elizabeth St. area are closed, Lugrin Creek, about 100 yd. (90 m) from this home, would begin to back up. It flows through a city-owned field and then sweeps “like a tidal wave” down Alexander Street. On February 16, provincial cabinet met to decide whether or not there would be any emergency aid for Port Alberni flood victims.

An unconfirmed report had the Bamfield highway washed out.

---

*1) In July, the government authorised $364,000 in aid to residents of the four properties damaged or destroyed in the February 11 mudslide at Lions Bay (*Times Colonist*, July 9, 1983). Almost four years later, claims arising out of the torrent which claimed two lives on February 11, 1983 were settled out of court. Lawyers for all parties involved in the civil actions refused comment on the terms (*The Vancouver Sun*, January 29, 1987). (See also: December 2-8, 1990 event).

*2) Besides the 24-hour road patrols, the introduced safety measures also included bridge renewal and water course containment. As the old wooden bridges with footings in creek beds could easily be downed by floods, they would eventually all be replaced by concrete or concrete and steel bridges, which would be able to span creeks without footings (*The Vancouver Sun*, February 12, 1983).

*3) In December 1982, an abortive debris flow occurred in this channel (Church and Miles 1987).

*4) To protect Lions Bay, the highways ministry designed a massive catch basin and plans to divert Alberta Creek into Harvey Creek along a 1,500-m channel The combined flow will enter the catch basin, filtering out debris. The water is then directed into an 18-m wide concrete channel 10 m wide taking the water under the Squamish highway into Howe Sound. The highway between M-Creek and the southern boundary of Lions Bay would be widened to four lanes in a 10-year project (*The Sun*, February 22, 1984).

*5) The previous rainfall record was 87.8 mm set on February 24, 1979. The rain also broke the record for this date set in 1969 with 62.5 mm. The heaviest rainfall in a 24-hour period in Port Alberni was 127 mm on December 22, 1963 (*Alberni Valley Times*, February 11, 1983).

*6) Faced once more by flooding, upset floodplain residents in the long-controversial part of the city renewed their demands to get the problem solved. Many floodplain residents blamed Kitsucksus dyke and the city’s drainage system for their flooding problems. One of the residents noted that there was a provincial and municipal responsibility to allow water run-off to flow to its natural tributaries. “In this case, it’s being blocked by a federal and provincially built dyke.” According to Mayor Paul Reitsma, the dykes were not the problem but conceded that culverts along Mary Street might be inadequate. He believed two pumps from Lugrin Creek into Kitsucksus Creek could alleviate the problem, an option presented in the 1978 (tsunami) study. Some of the residents had raw sewage seeping into their bathtubs from their septic tanks.
The angry residents who formed the Lugrin Creek Flood Association to protest and lobby for improvements to their properties, claimed the flooding around Lugrin Creek had got worse during the previous two years. They blamed it on development higher up, authorised by the Regional District of Alberni-Clayoquot. In 1984, the Lugrin Flood Association reached an out-of-court settlement with the provincial government and Port Alberni for flood damage. Under the terms of the settlement, Port Alberni would contribute $200,000 and the government $100,000 towards repairing damage caused by flood in February 1983 (*The Globe and Mail*, April 18, 1984) Apparently, it was on Mary Street where the city spent most of the $350,000 outlined in the settlement agreement. The banks were cleaned and built up. The channel is about 25 ft. (7.5 m) wide here. A bridge was built across the road. The size of the culvert is adequate and this area does not flood any more (*The Alberni Valley Times*, January 10, 1991).

February 1983
(Spring runoff/flooding).
Source: *The Sun*, April 14, 1983.
Details: In February, the basements of more than 100 houses in the Hedberg subdivision on the southeastern outskirts of Sicamous flooded when ditches overflowed and covered the streets. *1) One of the residents, Bill Lim, said that when he built his house five years earlier, the water table was 0.5 m below the footings. Now it was very near the surface and every spring that his basements flooded. During the spring runoff, the water would be unable to get to the lake quick enough. A study done for the Columbia-Shuswap regional district concurs. It found that the highway was built without proper culverts and drainage systems from the subdivision to the lake.

Following the February floods, the highways department finally built a temporary culvert under the highway and promised a permanent culvert soon. However, it refused to accept responsibility for the flooding. William Budden, Salmon Arm district highway manager, denied that the highway acted like a dam. Instead, he said, the flooding was the result of a series of subdivisions, including Hedberg, "piece-meal, with no real over-all plan."

---

*1) During the previous spring similar flooding occurred. According to the residents, the flooding was caused by Highway 97B, which runs between the subdivision and Mara Lake. Groundwater in the area drains toward the lake. The residents claim that the highway, rebuilt and raised about three years prior, acted like a dam (*The Sun*, April 14, 1983).

February 24, 1983
(Fatal landslide).
Discharge (m^3/s): Max. daily: February 20: Cowich.: 355; max. instant.: February 20: Cowich.: 303.
Source: *The Alberni Valley Times*, February 25 and 28, 1983; *The Daily News*, February 25, 1983.
Details: On February 24, a small mudslide approximately 20 km east of Ucluelet killed a member of a logging crew while hauling logs. The victim, employed by Mill Stream Timber Ltd., was seen riding the top of the slide for a distance but ended up buried under mud and logging debris. A second worker narrowly escaped. Logging debris had blocked a culvert at the bottom of a draw. Run-off from recent heavy rains was diverted and seeped through the road at another point, creating an unstable bank on the steep ground where the loggers were working. A helicopter and a police dog were brought into the area from Courtenay to help search. The victim's body was found on February 25, 350 m from the road near where he had been working.

May 20-June 2, 1983
(Spring run-off/flooding).
Discharge (m^3/s): Max. daily: June 2: BC/BC: ?; max. instant.: June 2: BC/BC: ?.
Source: *The Sun*, May 25 and June 2 and 4, 1983; September 17, 1985; Environment Canada 1992.
Details: At the end of May, above average temperatures of 25-29 ^{o} C caused the Kalamalka and Osoyoos lakes to overflow their banks causing minor flooding. Near Vernon, the Kalamalka River exceeded its flood alert stage level. Okanagan Lake was rising slowly but the run-off flow out of Mission Creek at Kelowna into Okanagan Lake doubled since May 20 to 45.2 cfs (1.28 m^3/s), still well below the flood alert flow of 62.2 cfs (1.76 m^3/s). On May 26, Kalamalka Lake reached its peak level and started to drop slowly.

Since the warm weather started on May 20, the Similkameen River increased flow by 30% but was still not threatening to back up Okanagan waters. The Similkameen River was running at 20,000 m^3/s while the best the Okanagan is capable of is only 3,000 m^3/s. As a result, water from the entire Okanagan system was backing up, increasing flood levels. The Similkameen had peeked and was beginning to show signs of dropping. The Similkameen River, which joins the Okanagan River below Oroville, could complicate the situation. In flood conditions, the larger Similkameen River might cause the entire Okanagan water system to back up and thus increasing flood levels.

In early June, Okanagan Lake continued to rise steadily and was expected to reach the flood alert level of 342.45 m within four days. The lake was expected to exceed this level by about 25 cm, making it the fifth highest flood level on record. According to a spokesman for the Davis Cove Beach Resort in Peachland, the water had risen "a lot" during the previous week. Osoyoos Lake was already flooding, and flows from Okanagan Lake into Osoyoos Lake had been reduced to lower water levels by 10%. Many lakeshore homes had their lawns and basements flooded and several campgrounds had been flooded out. *1) The flood situation, caused by above average temperatures melting the snowpack in area mountains too quickly, was expected to last until about June 30.

On June 2, a cooling trend reduced the flood threat from melting snow packs. Okanagan Lake was expected to reach flood alert level within the week and was expected to peak at the end of June. Shuswap River near Enderby, which posed the greatest immediate threat, was expected to reach flood alert level around June 4-5. At 3.937 m on June 2, Shuswap River was well below its flood alert level of 4.72 m. But precautionary flood warnings were issued because Sugar Lake, the river's major water source, was expected to spill its banks on June 4, causing a rapid increase in the river's water level and possibly flooding the Enderby area.

---

*1) In September 1985, the provincial government allocated some $700,000 to be spent before next spring on flood control measures in Kelowna. The measures to reduce flooding on Kelowna Creek would cost $4.5 million over the next few years. Kelowna's share for the current year would be $300,000 and would include the widening and deepening of the creek, building bank protection and replacing some bridges and culverts (*The Sun*, September 17, 1985).

July 11-15, 1983

(Rain-on-snow?)

Discharge (m^3/s): Max. daily: July 12: Squam.: 1,390; max. instant.: July 12: Cowich.: 1,270.

Source: *The Province*, July 13, 14 and 20, 1983; *The Daily News*, July 13, 15, 18, 19 and 21, 1983; *Revelstoke Review*, July 20, 1983; *Times Colonist*, July 14 and 23, 1983; Coligado 1982; Schaefer 1983 (pp. 21-22); VanDine and Lister 1983 (pp. 9-11); Hungr et al. 1984; Evans and Lister 1984 (pp. 223-235). Church and Miles 1987 (pp. 68-69); Evans, unpublished data.

Details: During July 11-13, a weak low-pressure center developed over the coast. On July 12, westerly to southwesterly flows occurred onshore. The forced lift of air over the mountains triggered free convection aloft and produced very intense rain locally. For the 24-hour period ending July 12 at 8 a.m., the Agriculture Canada Research Station at Agassiz, 6 km to the west, recorded 84.5 mm of rain (Evans and Lister 1984). Though high, this figure is not excessive, approximating a 1:10-year duration for a one-day storm at any time of the year (Coligado 1982).

Overnight July 11-12, heavy rain occurred at Waleach. The heaviest precipitation was at the stations nearest the mountains on both sides of the valley (Mission, Agassiz and Rosedale). Following 100-150 mm of rain in three days, the CPR line and the Trans-Canada Highway washed out (Schaefer 1983). The heavy rain also caused severe damage to Fraser Valley vegetable crops and flattened hay crops. Within 10 km of each other, 18 debris torrents occurred. The close spatial distribution is circumstantial evidence for locally intense rain not picked up by the rain gauge network (Church and Miles 1987).

On July 12, severe rainstorms occurred in the Hope-Chilliwack and Revelstoke-Rogers Pass areas. Following a prolonged wet spell, a summer storm generated debris flows onto the Trans-Canada Highway near Agassiz. On that day, the Trans-Canada Highway west of Hope was closed due to washouts and slides. In the Jones Hill area about 30 km west of Hope, 20 residents had to leave their homes. During the early hours of July 12 in the Hope-Chilliwack area, at least 14 debris torrents reached the Trans-Canada Highway, some also blocking the tracks of the CNR tracks. Most of the deposition, which ranged in size from sand to boulders up to 1 m in diameter, occurred between the BC Hydro powerline and the highway within a zone 100-200 m wide. The torrents originated on the west facing slopes of Four Brothers Mountain (elevation 1,280 m) and Mount Ludwig (elevation 1,396 m). Some torrents did not reach the highway and others originating on the east facing slopes terminated in Wahleach (Jones) Creek. The tight grouping of the debris

torrents within a 4-km radius suggests that there was a high intensity rain cell within the storm and it is probable that the precipitation within the cell far exceeded that measured at Agassiz. The preceding period of July and the month of June had been characterised by cooler than average weather. Considering an approximate 1,500-m rise in the freezing level associated with the storm, there may have been additional run-off in the form of snowmelt (Evans and Lister 1984). The torrent channel immediately north of Wahleach Power Station was the site of multiple debris torrents, which were initiated in three locations at about 1,000 m elevation. The two southerly trigger zones were shallow debris slides located above an old logging road in a logged off area. The northern initiation zone is similar to the other two, but is located in an area of dead trees. The two southern zones both reached a single channel within 100 m. At 200 m downstream from a waterfall, a small secondary channel was blocked off from the main channel by a wall of debris about 3 m in height.

Downstream four more debris lobes were located. Three of these stopped only 150 m above the BC Hydro power station and switching yard. Each lobe appeared to represent a separate event or surge with the most southerly lobes resulting from the last or last few surges. Approximately 60,000 m^3 of debris was deposited. Some 25,000-35,000 m^3 of this material was the result of erosion and redeposition of pre-existing debris torrent and alluvial deposits downstream of the waterfall. Close to the highway, debris piled up behind the highway embankment up to 8 m thick and behind the access road to the power station. Crews ran into difficulties clearing debris from a large culvert. Debris completely blocked the 3 m-high concrete box culvert causing post-torrent water flow to erode the highway fill, severing the Trans-Canada Highway and requiring the installation of a temporary metal culvert at the top of the hill. Hungr et al. (1984) estimate the velocities of the Wahleach A and B debris flows at 9.4 and 7.9 m/s, respectively. Other debris torrents in the area had similar multiple initiation zones and terminated with more than one lobe. Volumes of other torrents were estimated in the order of 10,000-40,000 m^3 (Evans and Lister 1984).

The highway and the railway were severed for three days. The highway re-opened on July 14. Traffic was re-routed along Highway 7 on the north side of the Fraser River. Some of the slides also blocked the CNR main line at a number of locations within a 10-km section mid-way between Chilliwack-Hope. The cost of repairs and remedial work was estimated to have been in excess of $300,000. In the vicinity of Cheam Siding, one house was partially engulfed by a torrent (Evans and Lister 1984).

Between July 12-15, some 140 mm of rain fell in the Revelstoke-Rogers Pass area of the Selkirk Mountains. Most of the rainfall associated with the storm fell in the 24-hour period ending 7 a.m. on July 11. During this period, the Mount Fidelity Avalanche Research Station (elevation 1,875 m) recorded 93.5 mm and the Glacier National Park headquarters at Rogers Pass (elevation 1,325 m) 82.0 mm of rain. For both stations these amounts exceeded the previously recorded 24-hour maximums. Based on data prepared by the Canadian Climate Centre, the 24-hour rainfall measured at Mount Fidelity represented an approximate return interval of 220 years. This estimate was very approximate, since it was based on an analysis of only 13 years of record, but it was felt that it gave an indication of the significance of the event (Evans and Lister 1984). The effect of warm rain on a pregnant snow pack probably contributed to run-off. Consequently, the total run-off/slope moisture event is in excess of the 220-year rainfall event. Lower rainfall values recorded at Revelstoke Airport suggest that the boundaries of the regional rainfall event, which may have covered an area of up to 5,000 km^2, were quite sharp.

In the Revelstoke-Rogers Pass area, the heavy rain caused massive floods and widespread debris torrents. The heavy rains caused at least six bridge and road washouts, forcing indefinite closure of a 150-km stretch between Revelstoke-Golden. Mobilisation of sediment in river channels and materials in channel margins resulted in changes in both channel morphology and channel boundaries. Peak discharge data for streams in the area could only be estimated since in some cases Water Survey of Canada gauging stations were destroyed, whilst in other cases changes in channel geometry rendered existing curves obsolete. Discharge data for Illecillewaet River measured at Greeley, 11 km east of Revelstoke, gave an estimated maximum instantaneous discharge of 546 m^3/s on July 12. The Illecillewaet River bridge at Greeley was partially destroyed.

On July 12 in the Illecillewaet River Valley, the Rogers Pass section of the Trans-Canada Highway was severed by a slide that washed out the Woolsey Creek bridge 32 km east of Revelstoke. This 85-m

major bridge structure, constructed in 1959 and owned by Parks Canada in the Glacier National Park, was undermined. At 3:30 p.m., its west abutment partially collapsed. The highway remained closed until noon on July 22 when it was reopened on a temporary crossing of Woolsey Creek. The RCMP estimated the slide at Woolsey Creek, at 75 m long. On July 15, work started to construct access roads and a temporary wood and steel bridge upstream from the original structure. After Woolsey Creek rechannelled on July 18, going back under the main span of the collapsed bridge, crews started erecting a temporary bridge along the old one. Some 457 m of access road had to be constructed to link the temporary bridge to the highway.

Flooding caused by unseasonably heavy rain threatened the road by blocking culverts in at least six other places in the park. Some 30 campers at the Mountain Creek campsite were evacuated after the bridge connecting it with the Trans-Canada Highway started to collapse. Hundreds of tourists evacuated Glacier and Mt. Revelstoke National Parks campgrounds, Glacier Park Lodge at Rogers Pass summit and Canyon Hot Springs resort between the two parks. On July 12 just before the bridge collapsed, all staff and vacationers at Glacier Park Lodge were evacuated.

Many debris flows were initiated on the open slopes in the steep tributary watersheds of Akolkolex and Illecillewaet rivers. An important aspect of the material transported in the floods was the amount of logs and trees that made up the deposited debris.

On the 30-mi. (48-km) stretch between Revelstoke and the west portal of the Connaught Tunnel, the CPR suffered track breaches in at least 13 locations along the Illecillewaet River. Most of the track breaks occurred where the rail line was located at or near the channel margin of the Illecillewaet River and resulted from the erosion of the railbed. Deposits from debris flows and torrents also covered locations along the railway. *1) Service was first interrupted in the afternoon of July 12 and not re-established early on July 19, after a total closure of approximately seven days. Further breaks in service occurred between July 19-24.

On July 20, just 23 hours after the CPR line reopened, a 30-m section of roadbed and track collapsed and slumped into the Illecillewaet River, east of Revelstoke. Freight traffic was halted again and some 400 VIA Rail Trans-continental passengers were sent back to Calgary for the night to be flown to Vancouver the next day. The final re-opening of the railway through the Rogers Pass followed a massive repair operation by CPR. Traffic on the CPR line stalled and VIA Rail passengers of the two daily trains were flown between Calgary-Kamloops. In order to maintain freight train traffic, CNR and CPR were sharing each other's tracks. CPR reported 25 washouts along the 48-km section west of Rogers Pass. The washouts were of varying degree but six of the washout areas were major.

According to Don Bower, Public Relations official with CPR, more than 100 people were working on the more than 20 washouts over a 30-mi. (48 km) stretch of track. More than 2,000 cars of ballast and riprap rock (fill) were needed to repair the damage with crews of more than 100 working around the clock. In some places between Twin Butte-Albert Canyon, there was no track left. After having been shut down for a week, there was no estimate as to when the latest damage would be repaired. Three general freight trains were re-routed over CNR tracks. Transportation was interrupted for approximately 10 days. On July 20 at noon, the 24-year old bridge at Woolsey Creek reopened. As a result of the lengthy dislocation of these transportation routes, the economy of southern British Columbia suffered substantial indirect damage. *2)

The highway was cut off at three or four points after the heavy rains set off mudslides. On July 15, the Rogers Pass section of the Trans-Canada Highway between Revelstoke-Golden was still closed indefinitely. The washouts resulted in detours hundreds of kilometres south to Highway 3 near the U.S. border or north to the Yellowhead Highway between Jasper-Kamloops. Eastbound traffic was halted at Revelstoke. The Trans-Canada Highway re-opened on July 22.

In the 24 hours ending in the afternoon of July 19, 80 mm of rain fell in the area, causing washouts and slides in seven areas along the Trans-Canada Highway; three in Mount Revelstoke National Park and four in the Glacier National Park. A massive logjam blocked the entrance to the Revelstoke canyon Dam's diversion tunnel near Lauretta Creek. Other areas affected by flooding in Mount Revelstoke National Park included Clachnacudainn Creek where waters rose over the highway eroding part of the road. Lauretta Creek, adjacent to the Skunk Cabbage Trail, also overflowed, dumping debris onto the highway and the recently developed picnic area. Water also undercut the road, exposing culverts and broke up the pavement. In Glacier National Park, Bostock Creek, Moccasin Flats, a creek before Beaver River and Heather Hill all

overflowed onto the highway. Also affected by floods and washouts were numerous viewpoints and hiking trails and the domestic water supply at Rogers Pass.

On the Columbia River, logjams temporarily blocked the entrance to the diversion tunnel at the Revelstoke Dam construction site. On the Illecillewaet River a massive log jam in Box Canyon, approximately 5 km to the east of Revelstoke, temporarily blocked the river and threatened the south side of Revelstoke itself. According to Mayor Tony Coueffin, with the river at a point many old-timers claimed was the "highest they had ever seen," the flow of logs would surely have smashed the bridge that connects the city to Arrow Heights. Water later started flowing under the logjam, which would probably be burned at a later date. The cleanup with a crane and grapple of the logjam, estimated to be about 30 ft. (9 m) thick in some sections was expected to take a week to 10 days. The city also switched to the Hamilton Creek reservoir for a short time because the Greeley Creek bridge had its southern access collapse. The access road to the Revelstoke Hydro project's man camp was flooded with 16 in. (40 cm) of water at one point after a culvert became blocked. The culvert at Dead Man Creek washed out, causing mud and debris to spill into the Columbia River and temporarily blocking the water flow. Although the work on the earthfill dam section of the project stopped, concrete pouring went on as scheduled.

According to the Revelstoke Forest District manager Tom Harvie, damage to crown land due to heavy flooding was about $500,000. The total expected loss would probably exceed $2 million. The Downie Street Sawmill suffered $1.5 million damage and lost 15 bridges on their logging operations (*Revelstoke Review*, July 20, 1983). Hardest hit was the Akolkolex valley, where eight bridges were destroyed. Mica Dam Sawmills' only direct loss was the bridge crossing the track to the entrance of the mill. Though the washouts did not affect mill operations, over 90 people including contractors and truck drivers lost over a week of work.

After the water level of Brewster Creek rose higher than normal, Noranda Mines shut down its operations at the tailing section of the mine for two days. The move to shut down was only taken as a precaution and no other mine operations were affected. Only for a short time water covered the access road to the site and a slide at Highway 23 North on July 14, caused some delays for employees heading to the site.

---

*1) Between Revelstoke-Rogers Pass, both the Trans-Canada Highway and the CPR tracks follow the narrow floor of the Illecillewaet River valley. Similarly, in the Akolkolex Valley logging roads also follow the valley floor (Evans and Lister 1984).

*2) According to John Woods of Parks Canada, on an average summer day during the peak season some 18,000 people up to 25,000 people pass through the park.

July 19, 1983

(Glacial outburst flood).

Source: Matthes 1939 (pp. 518-523); Environment Canada 1992; Blown and Church 1985; Clague and Evans 1994 (p. 16, fig. 17); Evans and Clague 1994 (pp. 115-118); Evans, unpublished data.

Details: On July 19 at about 2 a.m., the moraine that impounded Nostetuko Lake, 230 km north of Vancouver, was breached and in less than five hours the entire lake emptied into the valley below. At about 2:30 a.m., a rancher living near the mouth of Nostetuko River was awakened by the roar of the river, and by 8 a.m. the flood was over. The very rapid down cutting of the channel and subsequent sudden drainage of the lake appear to have been the result of sudden erosion of the channel. It started when a large, single wave forced a much larger than usual flow into the channel. The most likely cause of the wave at Nostetuko Lake is an icefall from the Cumberland Glacier tongue. Part of the toe of Cumberland Glacier broke away and cascaded into the lake. Waves generated by the impact of the icefall moved down the lake, and overtopped, and rapidly incised the moraine at the opposite end. Within four hours, the moraine had breached to a depth of almost 40 m and about 6 million m^3 of water had been released. This produced a destructive flood that swept 115 km down Nostetuko and Homathko valleys to the sea. Most of this was deposited as a large fan on top of a former meadow directly downstream from the dam.

Farther downstream, floodwaters extensively eroded unconsolidated deposits in Nostetuko River valley. Large tracts of forest were damaged, leaving substantial piles of wood debris and coarse sediment on bars and channel margins (Clague and Evans 1994 p. 14). Nostetuko River has not yet recovered its pre-flood channel planform and morphology, suggesting that such rare flood events may effect streams for decades (Evans and Clague 1994). *1)

The lake was lowered by 38.4 m with a loss of 6.5 million m^3 of water. The moraine breach had a volume of 1.2 million m^3. A large fan of coarse sediment was deposited immediately downstream from the moraine and buried a former boggy meadow. Where the flood could not be accommodated within the channel, the high velocities and debris from the river overflowing its banks flattened trees. Large overbank accumulations of wood debris and riverbed erosion occurred along numerous downstream reaches.

The two Water Survey of Canada gauging stations closest to the Nostetuko River were damaged during the flood (Blown and Church 1985). On July 19, the Homathko River at Tragedy Canyon and at the mouth recorded maximum instantaneous discharges of 978 and 1,050 m^3/s, respectively (Environment Canada 1992). The hydrograph, situated 67 km downstream from the dam, showed an increase in discharge from 330 m^3/s to over 900 m^3/s. The hydrograph at the mouth of the river, a further 45 km down-valley, showed a somewhat attenuated flood wave (Clague and Evans 1994).

---

*1) On August 13, 1997, the moraine dam burst again (Evans, unpublished data). Nostetuko Lake, located at the head of the Nostetuko River, was dammed by a "Little Ice Age," a recent period of cooler climate that ended in the late 19th century (Matthes 1939), which is the last part of the Neoglacial period. The end moraine was deposited by Cumberland Glacier, which has since receded and now terminates on a cliff above Nostetuko Lake.

August 8, 1983
(Glacial outburst flood)
Source: Blown and Church 1985.
Details: On August 8, at approximately noon, "MT" Lake, a small ice-dammed lake on the major west tributary of Nostetuko River suddenly drained. The water was released in a sudden flood, or jökulhlaup, which emptied the lake in less than two hours. The drainage was through a 1.8-km long discharge tunnel in or under the glacier. It resulted in a small flood down the Nostetuko River. The water level during the flood observed at the junction of the Nostetuko and Homathko rivers was about 0.5 m higher than normal. The water was very muddy (Blown and Church 1985).

August 31-September 1, 1983
Source: *The Vancouver Sun*, September 2; November 16, 1983; *The Province*, September 2, 1983.
Details: On August 31-September 1, heavy rains caused West Vancouver's Cypress Creek to overflow its banks. On September 1, 37 mm of rain fell in the Lower Mainland. *1) Cypress Creek flooded yards when the creek crested late afternoon on August 31. The residents of three homes were evacuated. Houses beside the creek sustained some basement flooding and structural property damage. *2)

On September 1, an approximately 12-m wide and less than 1-m deep mudslide came down near Cougar Creek (Brook) in Mount Revelstoke National Park. The slide closed the section of the Trans-Canada Highway in the Rogers Pass for about five hours.

---

*1) The record rainfall for September 1 occurred in 1980 with 45.4 mm.

*2) Following the event, the municipality did some dredging while residents built structures to contain the water in the future. (*The Vancouver Sun*, November 16, 1983).

November 15, 1983
(Tidal flooding).

Discharge (m^3/s): Max. daily: November 15: Capil.: 544; Chem.: N/A; Nan.: 870; Kok.: N/A; L. Qual.: N/A; Sproat: N/A; November 17: Stamp G.: 256; max. instant.: November 15: Capil.: 393; Nan. C.: 638; Kok.: 195; November 16: L. Qual.: 90.1E; November 17: Stamp G.: 251.
Source: *The Province*, November 15, 1983; *The Daily News*, November 17, 1983; *The Vancouver Sun*, November 15, 16 and 17, 1983; *Totem Times*, December 12, 2006; Thurber Consultants 1983; VanDine 1985 (pp. 51-52); Hungr et al. 1987 (p. 209; pp. 212-214); Church and Miles 1987 (pp. 70-72); Environment Canada 1992; Egginton, pers. comm. 2004.
Details: On November 14-15, heavy rain and wind caused flooding in south Burnaby. The new Marine Drive by-pass was closed. In Surrey at the junction of Old Yale Road and Scott Road, traffic was reduced to one lane. Flooding also closed Cowichan Bay Road and Crofton Road. On the Sunshine Coast, Highway 101 was closed due to flooding 5 km north of Gibsons and at Roberts Creek. Several other Vancouver Island roads were flooded. In Surrey, a high tide combined with the already swollen Serpentine and Nicomekl rivers caused some low-lying roads to flood. The Nancy Green Highway near Rossland was closed due to snow.

On November 15, Cypress Creek flooded its banks a second time in a little over two months. *1) On the same date near Port Coquitlam, the Pitt River Road was closed after the Coquitlam River washed out one of the approaches to a temporary bridge just east of Riverview Hospital. This Bailey bridge replaced the Red Bridge, which had collapsed on October 20, 1982 after being hit by a vehicle. The road on one side of the bridge was flooded.

According to a Greater Vancouver Water District spokesman, slides into Cleveland Reservoir were responsible for the brown drinking water on November 15. In North Vancouver, Seymour River was also running very high that day. Abbotsford and Delta also reported flooding due to swollen creeks. On November 15, heavy rains caused slides on the Squamish highway, which was closed between Horseshoe Bay-Squamish at 2:30 p.m. In the Howe Sound area, debris flows occurred in Charles, Newman and Montizambert creeks, all within 2.5 km of each other. Twenty families were evacuated, including 14 from Strachan Creek, a tiny community at the mouth of Charles Creek, which was previously known as Strachan Creek. This damage marked the fourth time in two years, since October 1981, that residents had to be evacuated or lost their lives on this stretch of highway. *2)

The event occurred during a spell of very active cyclogenesis in the North Pacific Ocean. There was measurable precipitation in the region on every one of the first 19 days of November. At regional stations, the monthly total precipitation was between 190-240% of average. By late November 14, the Vancouver International Airport recorded 125 mm of rain and by November 17 over 170 mm since November 1. *3) Late on November 12, a double low-pressure center moved onto the British Columbia coast and persisted in the region through November 13. By November 14, it had moved eastward to Alberta as the very deep storm moved in. During November 15, the storm moved up the coast towards the Queen Charlotte Islands. Freezing level remained high during the storm, and no snow was involved (Church and Miles 1987).

The slide down Charles Creek demolished three bridges to local subdivisions. It damaged a fourth bridge and the bridge on the Squamish Highway, closing Highway 99. Two girders under the highway bridge's northbound lane had to be replaced. The highway bridges over Montizambert and Newman creeks also suffered damage but remained intact. On November 16, the Charles Creek bridge was open to one lane traffic, but no busses or trucks were allowed. A Bailey bridge was put into place while the bridge was under repairs (*The Daily News*, November 17, 1983).

In Charles Creek the main source of debris is rocky material derived from rapidly weathering quartz diorite cliffs above 500 m in elevation where the creek follows a fracture zone. The site probably represents the nearest approach to a purely meteorological controlled torrent in the region (Church and Miles 1987). During the Charles Creek debris torrent, a television crew filmed the flow of the last surge of this event. The velocity of this debris was estimated to be 7 m/s (VanDine 1985). The channel carried a maximum debris flow discharge estimated by eyewitnesses as 295 m^3/sec. (Hungr et al. 1987). The lining built to maintain channel alignment upstream of a bridge and protect the abutments suffered only localised damage. A similar unlined cross section upstream was subject to scour as much as 4 m deep (VanDine 1985). *4)

The BC Rail bridge below the highway was swept away. The 295-m^3/s discharge sheared off one of the reinforced concrete keys. The bridge deck then twisted out of the other abutment. The debris flow surge lifted it and hurled the structure into Howe Sound some 100 m downstream (Hungr et al. 1987). Charles Creek, which normally runs 4.6 m below bridge level, pushed the 15-m long, 70-ton steel box girder span off its concrete foundations. According to BC Rail engineers, it must have taken a wall of debris and water 25 ft. (7.5 m) high to knock out this bridge. *5) The BC Rail line was expected to be closed for at least two weeks. After a by-pass was built, trains were expected to running the following week. BC Rail freight traffic, mostly southbound lumber, was diverted on CNR tracks through the Fraser Valley. Passengers were bussed to catch trains to Squamish or Prince George.

---

*1) After the previous flood homeowners affected by the flooding formed a committee of residents to try to get the problems solved. Some of the homeowners blamed governments for not taking steps to protect their homes. They blamed the federal fisheries ministry for the flooding problems. The ministry claimed the creek as important to the salmon fishery and would not allow the municipality to do maintenance work in it. After the last flood in early September, the municipality had dredged the creek and some residents had built structures to contain the water. Though some dredging had been carried out, some residents claimed that what was needed was a 2-m trench (*The Vancouver Sun*, November 16, 1983).

*2) In Charles Creek six such events have occurred in 16 years. Between 1956-1986, 35 "natural" events occurred in 15 of the 26 creeks in the How Sound area between Britannia Beach-Horseshoe Bay. Twelve people lost their lives, including nine at M-Creek on October 28, 1981. Debris flows destroyed 17 structures (bridges, houses, and culverts) and blocked or damaged 24 more. Flooding destroyed seven structures and damaged five more (Thurber Consultants 1983; updated to December 1986 In: Church and Miles 1987 p. 73, Table 5).

*3) The average total amount of rainfall for November was 150 mm. Lions Bay recorded the wettest month in its 1983-2000 record and Hollyburn Ridge the third wettest November in the station's 1954-1995 record. Squamish A experienced the fourth wettest November in its 1982-2002 record and Port Mellon the wettest month in its 1942-1989 record with 1,090.0 mm. (Egginton, pers. comm.). Comox recorded 380.1 mm of rain, a record that still stood in November 2006 (*Totem Times*, December 12, 2006).

*4) A lower velocity low-discharge event on 1981caused no damage at all to the lining (Hungr et al. 1987).

*5) In comparison, when in 1981 the M-Creek highway bridge crashed down on BC Rail's bridge, identical to the one over Charles Creek, this steel span moved less than 1 cm (*The Vancouver Sun*). In the natural deposition zone of a debris flow stream, bridges should be designed after eventually buried by a debris flow to withstand its impact, so as to be serviceable immediately upon re-excavation. The low-massive bridges constructed by BC Rail on its line along Howe Sound are a good example of such structures. They consist of short, massive box girder reinforced concrete spans about 80 tons in weight, keyed into heavy concrete abutments. The keys are of reinforced concrete, 15 cm wide. They have resisted the impact of an approximately 300-m^3 discharge on M-Creek in 1981 and Alberta Creek in 1983, although in the latter event the concrete of the abutment keys cracked (Hungr et al. 1987).

November 23, 1983
(Fatal rockfall).
Source: *The Sun*, November 24 and 25, 1983; Evans, unpublished data.
Details: In 1983, a single rolling boulder crushed a house in Sunnybrae. On November 23, a rockfall about 17 km west of Salmon Arm killed two people and damaged a house and trailer on Begbie Road. During the previous month, the area had experienced heavy rain. The boulder, about 6 m in diameter and 2 m thick, rolled off Bastion Mountain, which rises behind the home. It sheared off one section of the house, plunged through a travel trailer and a small shed before coming to rest against a tree. The east half of the house was

wiped right out by the rock, which crashed down a 90-degree cliff face for about 1 km. A neighbour was awakened just prior to the incident by loud rumbling and groaning noises from the mountainside. The “loud noises” he heard lasted only 10-15 seconds; the mountain was so steep, it did not take long for the rock to roll down.

December 22-23, 1983
Source: *Burnaby Courier*, December 24, 1983.
Details: On December 22-23, over 2 in. (50.8 mm) of rain in 24 hours caused flooding in Burnaby. More than 150 workers battled clearing ditches and culverts. Eagle Creek severed Piper Avenue and Still Creek flooded Gilmore Avenue, closing it to traffic. *1) Co-operating tides lessened the flood conditions. The sanitary and storm sewers installed in 1962 and 1963 also contributed greatly to remove previous trouble spots in the Kingsway-Royal Oak-Burnaby Road section of the south slope.
---
*1) Still Creek runs from Vancouver to Burnaby Lake, and from there the water drains to the Brunette River. Much of the creek runs underground in culverts.

January 1-4, 1984
(Rain-on-snow and icejam/flooding).
Discharge (m^3/s): Max. daily; January 4: Capil.: N/A; Cowich.: 235; Kok.: N/A; Nan. C.: 573; max. instant.: January 4: Capil: N/A; Cowich.: 197; Kok.: 171; Nan. C.: 473.
Source: *Comox District Free Press*, January 2, 1981; *The Hope Standard*, January 4 and 11, 1984; *The Daily News*, January 5 and 6, 1984; *Times Colonist*, January 10, 1984; *Merritt Herald*, January 11, 1984; *The Province*, January 25, 1984; *The Vancouver Sun*, January 26, 1984; Schaefer 1984; VanDine 1985 (p. 65); Church 1988 (pp. 216-217); Church and Miles 1987 (pp. 67-68); Environment Canada 1988; Environment Canada 1992; Ministry of Environment files; Storm damage assessment Jan.1984 flooding Southwest British Columbia. O.I.C. 51/84. March 1984. File P84-2
Details: On January 2, extreme heavy rainfall caused extensive flooding in southwestern British Columbia. Between January 1-4, heavy rain caused widespread flooding and debris torrents over a substantial area in the Coquihalla and Nicolum valleys east of Hope. On January 1, a multi-front Pacific storm moved southeast, drawing in a strong southwesterly flow. Freezing levels rose to over 3,000 m and remained in the 2,500 to 3,000–m range for several days. Upper level winds associated with the front were westerly rather than southwesterly, as is often the case with significant frontal rainstorms in the area. The result was that extreme rainfall appeared to be confined to an area in the eastern end of the Lower Fraser River valley. Daily climate data indicated return periods of 55-60 years at Agassiz and Hope whereas short duration recording rain gauge data indicated return periods of 100 years or greater in the six to 12-hour duration range. It is likely that the west-facing watersheds in the vicinity experienced similar high intensities for those durations (Schaefer 1984).

Between January 2-4, there was substantial precipitation, culminating in very heavy rain in the early morning hours of January 4. Though the very short durations were not exceptional, the 6 to 12-hour precipitation intensity early on January exceeded the 100-year return period at Hope Airport (Church and Miles 1987). In Hope, where 147 mm of rain fell, 20 families were evacuated. According to weatherman Earl Coatta, the statistical probability of that much rain falling in a 24-hour period, is about once in every 50 years (*The Daily News*, January 6, 1984). Data for the storm in the Upper Coquihalla Valley was as follows: Total four-day precipitation: 175 mm; snowmelt: nil; storm run-off: 110 mm; greatest day precipitation (January 4): 112 mm; greatest two-day precipitation (January 3-4): 142 mm; instantaneous peakflow: 47.7 m^3/s; return period of instantaneous peakflow: 19 years; daily peakflow: 33.5 m^3/s; return period of daily peakflow: 11 years (Church 1988). Many rivers, including Cascade and Norrish creeks and Vedder and Coquihalla rivers recorded maximum flows.

On January 2, the Chilliwack River at Vedder Crossing recorded a maximum instantaneous discharge of 828 m^3/s (Environment Canada 1992). On January 4, the Vedder River recorded a maximum daily water level of 4.960, setting an all-time high for the period of record (Environment Canada 1988).

During the event, there was very little snow, but the ground was frozen (Church 1988). Air temperatures in late December were unusually cold, and freezing levels in southwestern British Columbia generally were less than 150 m above sea level. Little precipitation occurred, so the ground was deeply frozen and many streams were frozen or had very low residual base flow.

Early on January 4, a rainfall of 4 in. (100 mm) closed the Haig, Trans-Canada and Hope to Princeton highways. Slides and washouts forced the closure of the two main highways into Vancouver. Serious flooding between Floods-Popkum closed both east and westbound lanes of the Trans-Canada Highway west of Hope. The road flooded areas east of the Wahleach power sub-station, at McKay's sawmill and a section in between. In the mountains east of Mission many debris torrents occurred (Church and Miles 1987). On January 6, a section of the Trans-Canada Highway between Hope-Chilliwack was still closed. It was expected to open later that day. Highway 3 was closed indefinitely by a mudslide 25 (ft.?) deep 2 km east of Hope. Both lanes on Highway 7 were closed by a 300- ft. (90 m) long and 12-ft. (3.6 m) deep slide at Ruby Creek. Highway 1 remained open despite minor flooding, 3-4 in. (7.5-10 cm) in the Yale tunnel and in the Dogwood area.

In the south Skagit Valley, Hope Search & Rescue moved out two hunters trapped between two slides, and employees were evacuated from the Carolin Mine. The mine itself did not sustain damage. An 8-in. (200 mm) rainfall overnight January 3-4 at the mine caused the water level in the tailing pond to rise. During the flood, some operating time was lost after a power pole washed out and later ran only on a reduced workforce due to bringing workers in. Othello Road washed out in a few places and several Bailey bridges were damaged.

For the 24-hour period ending 10 p.m. January 4, Hope recorded 136.5 mm of rain. *2) On January 4, a record breaking temperature of 15^{o} C, torrential rain and freezing levels at about 6,000 ft. (1,800 m), caused flooding and mudslides in Hope, Silver Creek and surrounding areas. According to area PEP co-ordinator Ray Green, the damage total might go higher than the one during the 1980 flood. According to Keith Collins, meteorological technician at the Hope weather station, he could hear 300 to 400-pound (135-180 kg) boulders going down Silver Creek, which looked "like a dish of mud." Green stated that Hope was approaching a flooding situation similar to the 1980 Boxing Day flood and this time the rainfall was even higher.

Thanks to the new well built dyke completed on September 15, the Glenaire subdivision kept floodwaters out. Only one resident at the east end of the subdivision had to be evacuated. In the Glenhalla subdivision, an emergency dyke built by a town work crew at 100 Robertson Cres. saved the subdivision except for two residences that got flooded out. Smaller creeks and the Coquihalla River were reported "up above their banks." The Yale school closed and students on the opposite site of the Coquihalla River were sent home. The Coquihalla River and Silverhope Creek went on the rampage. During the height of the flood, the Coquihalla bridge to Kawkawa Lake and the Silverhope Creek bridges were seriously endangered. Silverhope Creek swept through the Riviera Motel on Silver Skagit Road. It isolated a log cabin on an island behind the lodge, sweeping one cabin down the road where it splintered when it hit the dyke. Picking another cabin off its foundations, the river pushed it into a neighbouring building and undermined the bank under two double motel rooms and the lodge. The Maple Leaf Motel and Restaurant on Nelson Street also suffered substantial damage. Four 300-L fuel tanks, three of which at least half full, floated downstream. Three homes on Silverhope Creek were condemned after water eroded 30-50 ft. (9-15 m) of frontage, leaving them hanging over the creek. Two houses would have to be moved. A 1000-ft.^{2} (92 m^{2}) residence with a swimming pool located south of the Riviera Motel was swept down the creek.

On January 4, debris torrents occurred on Two-Mile and Pattison creeks (D.R. Lister, pers. comm. In: VanDine 1985). The causes of the events were debris avalanches and logging road failures. One bridge was damaged and a culvert plugged (VanDine 1985). On January 4, a debris torrent also occurred on Cascade Creek and floodwaters damaged 45 homes and properties at Cascade Creek (P.J. Woods, pers. comm. In: VanDine 1985). Residents of Sylvester Road had several acres flooded by Davis Creek.

According to Transportation Minister Alec Fraser, the cost of clearing the highways and repairing bridges damaged by the floods, would reach $45 million. According to the Provincial Emergency Program, the flooding in southwestern British Columbia caused more than $4 million, including emergency relief

costs and all repairs to public and private property as well as farmlands and roads. It did not include repairs to the CNR bridge near Hope. Forests minister Tom Waterland rejected claims by residents of flood devastated Hatzic Valley that effects of clear cut logging in the surrounding hills aggravated the flooding. "In Hope, during the flooding event, 5.8 in. (147.3 mm) of rain fell in 24 hours on top of a heavy snowpack and warm weather." *3)

The rail links also washed out. In the Fraser Canyon 47 km west of Boston Bar, 60 m of the CNR track washed out. To replace the 56-m bridge over Hunter Creek west of Hope, would cut CNR's capacity to ship freight through British Columbia in half until January 26 (Al Menard In: *The Daily News*, January 6, 1984). CNR trains were re-routed along CPR tracks between Mission and a junction west of Kamloops. On January 4, the CPR main line also closed after it was cut in four places between Chilliwack-Mission. This line re-opened early on January 5.

Due to warm temperatures combined with the heavy rainfall ice flows and ice jams occurred, which caused considerable damage on the Coldwater, Nicola, Similkameen and Tulameen rivers. The total cost of restoration, log clearing and repairs to existing dykes and bank protection was estimated at $2.3 million. The estimated cost of damage sustained on the Nicola, Coldwater and Similkameen rivers were provisional as inspection had been impossible due to ice still laying on the banks and fields. The Tulameen River had been completely inaccessible. A contingency item of $100,000 was included for the Similkameen and Tulameen rivers (Ministry of Environment).

On January 4, ice flows moving down the Similkameen and Tulameen rivers caused direct damage to some properties and sporadic damage to dykes and riprap protection. Residue ice and snow pressed against both sides of the river stood vertically for most of the river's length. In the wider sections of the river or where built-up gravel bars had previously formed, the flowing ice apparently caught up and formed temporary jams that squeezed up and over rock riprap and dykes, in some cases grinding the rock to smaller sizes or carrying it along and dumping it at some other point. Ice also slid or flowed over open fields and in one case south of Princeton crossed the highway, taking with it irrigation pipes and fences. Considerable damage to pre-existing structures took place. Tulameen River, Coalmont and Tulameen townsite damage was unknown. When the Similkameen and Tulameen river's crests reached Princeton, water levels had subsided and no damage was reported. The approximately 200 people that were evacuated in Princeton January 4 returned to their homes the next day.

A mid-winter thaw with temperatures up to 15^{o} C following extremely low temperatures as low as -30^{o} C caused extensive flooding throughout the Nicola Valley and surrounding area. Heavy rain in the headwaters, warm temperatures and heavy ice blocks forming a 500 yd. (450 m) ice flow forced the Nicola River to take a new course. The high water broke up the ice flow on the Coldwater and Nicola rivers. Large ice chunks up to 18 in. (45 cm) thick formed jams in various places along river channels effectively blocking water flow and flooding as far as 1,000 m from the river channel. Overnight January 4-5, the Nicola-Coldwater system rose about 6 ft. (1.8 m) within a few hours. According to rancher Ken Gardner, whose property flooded with about 4 ft. (1.2 m) of water, the water came up 5 ft. (1.5 m). Rivers changed course, some being permanently. Spius Creek temporarily changed its course but later went back to its original channel. The icepacks threatened several bridges. Joe's Bridge, 14 mi. (22.4 km) east of Spences Bridge and only access to Highway 8 for five families living on the south side of the Nicola River, was totally destroyed. Many farmers in the Nicola Valley lost property, feed and equipment. Approximately three dozen cattle reportedly drowned or were killed by swift moving ice blocks. Some farmers were forced to helicopter-feed their cattle.

During early January, major ice movement, somewhat similar to the Similkameen/Tulameen River system icing, occurred on the Lillooet River near Pemberton. The magnitude of this event was considerable greater than anything experienced in recent years. *1) The ice formation and passage down the Lillooet River resulted in the removal of riprap river protection along a strip 1.8 m high and totalling some 975 m in length. Repair cost was estimated at almost $75,000. On Miller Creek, an estimated 5,000 m^3 of gravel was deposited in the reach adjacent to the highway bridge. Estimated cost of removal was $5,000. (Memo April 30, 1984. H.H. Nesbitt-Porter, File P84-2).

Preliminary estimates of restorative river work after the January 4 flooding (PEP clean-up) included: Cascade Creek ($105,000 and $845,000 enhancement including $350,000 for M.O.H. bridges); Carratt Creek ($10,000); Lagace Creek ($35,000); Deroche Creek ($5,000); Scowlitz I.R. ($15,000); Silverhope Creek ($400,000); Anderson Creek ($5,000); Frosst Creek ($40,000); Sumallo River ($30,000); Coquihalla River ($40,000 + gauge replacement); Chilliwack River ($200,000); Norrish Creek ($250,000); Nicola River ($50,000); Weaver Creek ($70,000) for a total of $1,255,000. Expenditures on flood repairs to November 18, 1985: Ryan River, Miller Creek, Lillooet River and One Mile Creek were $817,323.27 (Memo November 22, 1985 B. MacFayden to H.H. Nesbitt-Porter).

Summary of watercourses impacted by January 1984 flooding and estimated costs: Lagace and Pattison creeks ($45,000); Eng Creek ($1,000); Carratt Creek ($20,000); Cascade Creek ($80,000); Davis Creek ($5,200); Lost Creek ($30,000); Deroche Creek ($3,000); Siddle Creek ($6,000); Weaver Creek ($88,000); Unnamed Creek (Cheam View)($2,500); Lorenzetta Creek ($24,000); Unnamed Creek (Katz) ($7,000); Chawuthen Creek ($17,000); Trite Creek ($3,000); Sumallo River ($12,000); Silverhope Creek ($213,000) Norrish Creek ($578,000); Frosst Creek ($35,000); Cultus Lake ($20,000); Chilliwack River ($156,000); Dotzler Creek ($50,000); Vedder River ($430,000); Coquihalla River ($115,000); Coldwater River ($29,000); Nicola River ($11,000); Spius Creek ($2,000); Similkameen and Tulameen rivers ($284,000); Blue Creek ($20,000); (Storm Damage Assessment January 1984 flooding. O.I.C 51/84 File P84-2). The total estimated cost was $1,209,637; claimed cost was $968,667.80.

Description of some of the damage: Lagace and Pattison creeks: reduction of channel capacity due to deposition of bedload materials from Sylvester Road bridge crossing downstream to Hatzic Lake; Eng Creek (Hatzic Prairie): bedload deposition resulted in the diversion of flood flows onto private property and Sylvester Road. Carratt (Mechanics) Creek: bedload deposition and bank erosion resulted in an estimated 30-40% of the flow breaking out of its channel on the north side. Cascade (McConnell) Creek (Hatzic Prairie): severe deposition of gravel and boulder debris t the top of the fan resulted in a complete channel relocation down Ridgeview Road affecting numerous properties. Davis Creek (Hatzic Prairie): deposition of bedload caused a major overland flow affecting one house and one mobile home. Lost Creek (tributary to Stave Lake): major flow in north channel caused severe bank erosion on north side and destroyed one recreational cabin and one recreational mobile home. Siddle Creek (near Lake Errock): gravel accumulation reduced channel capacity causing overtopping and the threatening of several homes and two public roads. Weaver and Sakwi creeks near Harrison Mills: creek broke through adjacent berm causing private land to be inundated. Unnamed creek near Cheam View: bedload deposition caused the creek to change course, posing a threat to a home. Lorenzetta Creek near Laidlaw changed course. Unnamed creek near Katz: bedload deposition caused creek channel to be plugged, flooding the properties of a private individual and the Seventh day Adventist Church. The church's private road was also affected. Further downstream, the Chawuthen Indian Reserve experienced deposition of silt. Chawuthen Creek near Floods diverted through private property. Trite Creek near Sumallo River: a major debris flow followed the Trite Creek channel through Cedar Village Sunshine valley. Sumallo River (Sunshine Valley) at the stream end of the Sumallo Village Mobile Home Park, 30 m of riprap was eroded and the dyke damaged. Silverhope Creek: A significant logjam completely blocked the creek just above its inlet into Silver Lake. The jam consisted of 1,500 m^3 of material. The estimated cost of removal and disposal of this material was $10,000. Norrish Creek: assuming CPR would dredge the creek for an approximate distance of 1,800 ft. (540 m) immediately upstream of the bridge, PEP would have to dredge 2,800 ft. (840 m) of the creek. With an average depth of 6 ft. (1.8 m) for a width of 200 ft. (60 m), the quantity of material to be removed by PEP would be approximately 178,000 $yd.^3$ (137,000 m^3). Allowing for $3.25 per $yd.^3$ to excavate and stockpile, the cost was estimated at $578,000. In the Chilliwack River, significant logjams and debris accumulations were identified at 11 different locations above the Vedder Road bridge. Significant debris accumulations were identified in four different locations in the Vedder River downstream of the Vedder Road bridge. Debris removal and berm repair was estimated to cost $140,000. Cost of gravel removal was estimated at $350,000 and an additional $1.4 million for dredging. On the Coquihalla River, several small to moderate debris jams occurred on the north bank over a reach of about 0.5 km just above and below an access bridge across the river at Othello. A large accumulation of logs and debris was located on the south bank just above a narrow

bedrock constriction in the Coquihalla Canyon. Two small logjams were located about 0.5 km apart upstream of the confluence of Two Mile Creek with the Coquihalla River.

---

*1) According to long-time area resident Elmer Helivang, the most recent occurrence of similar magnitude occurred in 1953.

*2) The record temperature of 14.9^{o} C set in 1974 was broken but just missed was the highest 24-hour precipitation of 136.9 mm recorded at Hope, also set in February 1974 (*The Hope Standard*).

*3) Energy Minister Stephen Rogers later conceded that logging indeed had been a factor, thereby acknowledging that the provincial government, having permitted destructive logging practices, had a responsibility to help flood victims. Forests Minister Tom Waterland earlier had told Hatzic Valley residents that logging the surrounding mountain sides had nothing to do with the severity of the floods (*The Vancouver Sun*, January 26, 1984).

January 23-24, 1984
Source: *The Province*, January 25, 1984.
Details: On January 25, following two days of rainwaters of the Hatzic valley creeks rose again. Fearing a reoccurrence of flooding some families fled their homes. Bulldozing creek banks along a Ridgeview Road home may have saved the property.

June 28, 1984
Source: *The Squamish Times*, July 10, 1984; Evans 1986; Clague and Evans 1994; Jordan 1987; Cruden and Lu 1989; Evans 1992 (p. 76); Jordan 1994; Evans, unpublished data.
Details: On June 28, after a few days of heavy rain, a major rockslide from Mount Cayley that formed a debris flow down Turbid Creek dumped about 3 Mt of sediment in the Squamish River (Cruden and Lu 1989). A wall of mud and debris came down the bed of Mud [Turbid] Creek taking out the Weldwood bridge at the junction with the Squamish River. This bridge was at least 30 ft. (9 m) above the streambed. According to woods Superintendent Pat O'Brennan, the mud came down in waves, blocking the Squamish River, and then breaking loose, only to be followed by successive waves of mud, which again blocked the river. These waves were still coming down early on June 29. A portion of the logging road along the Squamish River was engulfed in the mud from the creek (*The Squamish Times*, July 10, 1984).

An eyewitness, R.O. Jaugelis, at the time a Water Survey of Canada technician heard a rumble from a distance and saw a tongue of mud flowing downstream. The momentum was enough that the flow crossed the Squamish River, travelling up the right bank against the rock face, and then back into the river. Enough mud and debris were carried down in successive to back up the Squamish River upstream from a distance (Jaugelis 1987 In: Cruden and Lu 1989).

The 1984 event initiated debris flows into the lower reaches of Turbid Creek, which entered in the Squamish River and temporarily dammed it (Evans 1986a; Jordan 1987; Cruden and Lu 1989). The volume of the slide was estimated at 0.5 million m^3. The event showed hyper-mobile characteristics, i.e. the debris distance of travel was typical of a debris avalanche an order of magnitude greater (Evans 1992). Jordan (1994) estimates the velocity of the Lower Turbid Creek debris flow at 8 m/s. The rockslide as transformed into a high velocity debris flow that flowed at between 22-48 m/s down Turbid Creek before stopping (Evans, unpublished data).

August 27-29, 1984
Source: *The Sun*, August 28 and 30, 1984.
Details: During the late afternoon on August 27, a rockslide on Mount Revelstoke halted CPR trains near Golden. Late on August 27, the Trans-Canada Highway was closed due to slides in the Boston Bar and Hells Gate area. At Hermit Creek, a culvert on the Trans-Canada Highway washed out. Early on August 28, the highway reopened to single-lane alternating traffic. The road between Hope-Spences Bridge remained

closed. Heavy rainfall caused the main slide, three other slides nearby and two more near Revelstoke and Rogers Pass. On August 27, the mudslide that covered a section of the road 24 km east of Revelstoket closed the Trans-Canada Highway for about eight hours.

On August 29, a debris flow occurred at Cathedral Mountain, Kicking Horse Pass. Seven members of a railway maintenance crew had a close call when their truck was engulfed by the mudslide near Field. It blocked the railway main line and the Trans-Canada Highway. The highway was expected to reopen on August 30. The rail line was cut for more than 10 hours.

October 6-12, 1984

(Rain-on-snow?)

Discharge (m^3/s): Max. daily: October 4: BC/BC: 389; October 7: Capil.: 309E; October 8: Squam.: 2,610 (extreme record for period of record); October 10: L. Qual.: N/A; Stamp G.: 319; Sproat: N/A; max. instant.: October 4: BC/BC: 369; October 7: Capil.: N/A; October 8: Squam.: 2,150; October 10: L. Qual.: 55.5; Stamp G.:311; Sproat: 170.

Precipitation: Port Mellon (283.4 mm/4 days), October 6-9, 1984; Squamish Upper (252.0 mm/4 days), October 6-9, 1984; Vancouver Intl A (49.6 mm/2 days), October 7-8, 1984; Port Alberni (146.2 mm/2 days), October 7-8, 1984; Squamish A (171.1 mm/2 days), October 7-8, 1984; Comox (70.6 mm/2 days), October 7-8, 1984; Pemberton BCFS (164.8 mm/2 days), October 7-8, 1984; Alta Lake (127.9 mm/3 days), October 7-9, 1984; Pemberton Meadows (119.8 mm/3 days), October 7-9, 1984; Alert Bay (93.6 mm/3 days), October 7-9, 1984.

Source: *The Coast Mountain Courier*, November 7, 1984; *Times Colonist*, October 9, 10, 11, 1984; *The Province*, October 9, 10, 11, 1984;*The Daily News*, October 9, 10, 11 and 12, 1984; *The Sun*, October 9, 10, 11 and 13, 1984; January 23, 1985; *Times Today*, October 23, 1984; *Crown Forest News*, 4(2) p. 2; Jones et al. 1985; Clague and Souther 1982; Jackson et al. 1985 (p. 4-9); Evans 1986; Talbot 1986; Smith and Vallieres 1986; Jordan 1987; Church and Miles 1987; Lu 1988; Hickin and Sichingabula 1988; Hickin and Sichingabula 1989 (p. 337); Cruden and Lu. 1989 (p. 336); Brooks and Hickin 1991; Environment Canada 1992; Ministry of Environment files.

Details: On October 8, heavy rainfalls caused major flooding in the Pemberton, Whistler and Squamish areas The "Thanksgiving Day Flood" came early as the major flooding events usually occur in late October or early November when a heavy rainfall combines with a high water level and high temperatures to melt the early snow to create flood situations. *1) Considerable damage occurred to existing dykes and bank protection and a number of creeks and rivers were filled with an accumulation of logs, debris and bedload. The estimated cost of repairs amounted to $1,738,700. The storm also affected the Gold Bridge area where logs and debris accumulated in the Hurley River. The cost of some minor clean out was estimated at $5,000.

This major storm created large floods in the watersheds on the east side of the Coast Mountains between the Squamish River to the south and the Dean River to the north (Jones et al. 1985). An earlier rainstorm preceded this Thanksgiving Day flood event. Between September 16-17, Bella Coola recorded 82.9 mm of rain. This amount equals about 63% of the long-term average rainfall for the month of September. The Ape Lake basin probably received a similar amount of rain during this storm (Jones et al. 1985). Between October 6-10, during the second storm, which was widespread and caused large floods throughout southwest British Columbia, Bella Coola reported 102 mm of rain.

Heavy rainfall, which covered the entire Lillooet River Basin above Pemberton, caused the flood of October 8. The heaviest precipitation during the rainstorm of October 6-9 was concentrated in the Squamish area and central Vancouver Island. An extreme value analysis of the one-day storm rainfalls indicates that the storm had a return period of five years or less in the Pemberton-Squamish area. However, if the three-day rainfall is examined, the return period of the storm becomes more significant. The 119.8 mm at Pemberton and the 127.9 mm received at Alta Lake for October 7-9 result in the three-day storm having a return period of 20 years for these two sites. The three-day total at Squamish was 180.2 mm but the return period remained low at 6.5 years for short term rainfall rates. (Smith and Vallieres 1986)

On October 8, at least 10 homes near Squamish had to be evacuated because of heavy flooding. The flood destroyed roads and bridges and inundated many homes in the Squamish Valley, causing millions of

dollars in damage. The heavy rainfall in the Squamish-Pemberton area was a result of the persistence of the most active portion of a frontal system over the area. The system itself was neither abnormally large nor active. The rather unusual orientation of the frontal in an almost north-south direction for most of the storm period may explain the extreme water levels on the Lillooet and Squamish rivers. One possible explanation is that with this frontal orientation, low-level winds would be channelled directly up-valley along these two river systems, resulting in substantial geographically induced rainfall for both watersheds.

The circulation was fairly zonal as the system developed. The warm air associated with the front was not subtropical in origin so that the precipitable water values were not extreme. The very slow moving nature of the system was due to the very large wavelength of the trough behind it, which did not move significantly until forced by another system from upstream. (Smith and Vallieres 1986)

On October 8, a 30-year return period flood changed the channel of the Squamish River. On October 8 at 9:35 p.m., the Squamish River near Brackendale recorded a maximum instantaneous discharge of 2,610 m^3/s, surpassing a previous high of 2,270 m^3/s and a maximum daily discharge of 2,150 m^3/s (Environment Canada 1992). *2) On October 8, several other streams also set new record highest instantaneous flows (previous highs in brackets), including Cheakamus River above Miller Creek 269 m^3/s (114 m^3/s), Place Creek near Birken 7.02 m^3/s (4.33 m^3/s), Lillooet River near Pemberton 1,310 m^3/s (933 m^3/s), Bridge River below Bridge Glacier 203 m^3/s (75 m^3/s) and Homathko River below Nude Creek 609 m^3/s (269 m^3/s).

Despite its large size, the flood accomplished little more floodplain modification than had previous smaller floods of similar duration. In contrast, in the braided reach the flood caused floodplain erosion and major reorganisation of the channel to an extent previously unrecorded, apparently here exceeding a threshold for channel stability. The channel changes caused by the October 1984 flood were quite dramatic in comparison with the geomorphic activity of the preceding four decades. There are indications that changes before the October flood may have taken place as a result of the June 28, 1984 debris flow into the Squamish River (Hickin and Sichingabula 1988).

Although debris flows are at least annual events in Turbid Creek, the distinguishing condition of the October flood was the enormous discharge of the Squamish River. Empire Logging crews had to replace the culvert washed away at the road crossing of Turbid Creek (Hickin and Sichingabula 1989). Historic debris avalanches from Mount Cayley (Squamish River drainage basin) have occurred in 1963 and 1984, but these have not descended from the amphitheatre-shaped basin. Nevertheless, they did trigger debris flows that travelled down Turbid Creek to Squamish River (Clague and Souther 1982; Evans 1986; Jordan 1987; Lu 1988; Cruden and Lu 1989).

A section of dyke along the Cheekye River to the Cheakamus River, which crested approximately 4 p.m. on Thanksgiving Day, caused a main problem. The dyke started to give way behind the Black Bear Restaurant by Alice Lake. Temporary repairs were made. Had the structure give way, floodwaters would have run the BCR track to Axen Road and Brackendale. *3) The Cheakamus River blew out the bridge across it, which was expected to cost $300,000 to be replaced with a concrete one. For the time being, a 120-ft. (36 m) Bailey bridge replaced the lost structure. In the Eagle Run Drive area, water was starting to collect behind the Petrocan station and in the nearby trailer court. A ditch was dug from the court to the nearby pump house, which relieved the problem. It was recommended to install a permanent pump in the sump on Eagle Run.

Floods caused by heavy rain ravaged the Pemberton Valley. Some 100 mm of rain fell in 24 hours or 200 mm in three days. Dykes around the village broke in 15 places. In the Pemberton district, flooding on the Lillooet River and its tributaries Ryan River and Miller Creek forced the evacuation of more than 300 people. Some people were trapped overnight on the upper floor of flooded buildings. Water levels in Lillooet River and its tributary Ryan Creek climbed as much as 4.5 m in 48 hours, flooding low-lying farmland and houses. For one family who had lived in a two-storey home in the Tantalus Acres, about 17 km north of Squamish, for 10 years, this was the fourth flood-caused evacuation. They were also flooded in 1975, 1980 and 1981. The first floor of their house had 2 m of water inside when they left.

The dyke breached along two reaches of the Lillooet River allowing floodwaters to pour into the upper and lower valleys. Ryan River, a tributary, was over its banks carving new channels and spreading out over the fields. Old-timers called it “the worst flooding in 40 years.” Said Toy Van Loon, “I’ve been here

over 40 years – I've never seen anything like this." Rev. Tom York of St. David's said the flooding was the worst in the area since 1944. "We have floods from time to time," he said. "But the last big one was in 1944. It was almost this big." He noted the only accessible piece of high ground nearby was about 16 km north of Pemberton.

On October 8, runoff from heavy precipitation produced an estimated 150-year flood on the Lillooet River. In the 24-hour period ending 8 a.m. on October 8, some 110 mm of rain had fallen in the area. An instantaneous maximum discharge of 1,440 m^3/s was estimated by the slope-area method at the water Survey of Canada gauging station "Lillooet River near Pemberton." This value is 10% higher than that obtained from the extended rating curve. *4) On October 8, the Lillooet River recorded extremely high peakflows of a maximum daily of 1,110 m^3/s and a maximum instantaneous flow of 1,310 m^3/s. (Environment Canada 1992) The WSC water level recorder on Lillooet River near Pemberton peaked at 6.029 m at 12:20 PST on October 8. Had the dykes not breached, WSC estimated peak stage would have occurred at 6.488 m at 16:00 PST on October 8. The gauging station located just upstream from the water stage recorder showed considerable change in depth from 1969-1985. *5) Large quantities of bed material are carried through this reach during high flows and the channel was eroded to undetermined depths. The flood caused considerable personal loss, suffering, and inconvenience for over 200 people (Smith and Vallieres 1986).

Pemberton Valley Park flooded after Meager Creek overflowed its banks. At least 100 residents fled the area on October 8 and more were expected to leave as flooding continued. Near the entrance to town, Highway 99, main access to Pemberton was flooded by at least 2 m of water. According to Milt Fernandez, spokesman for the Pemberton fire department, about 40% of the valley was under water. *6) Miller River and Ryan River were also flooding. Another tributary, Meager Creek, was also a torrent of water and debris. The Ryan Creek bridge in Pemberton threatened by a mass of logs and debris pressed against it.

On October 9, the village council voted to declare Pemberton a disaster area and to request aid from the provincial government. No human deaths or serious injuries were reported. However, thousands of livestock, including pigs, cattle, and chickens, as well as cats and dogs drowned. One individual lost two hundred sheep valued at $10,000. Winter supplies of grain and hay were lost. There was also damage to the sewage system in Pemberton. Mayor Shirley Henry said: "I've lived here 20 years and seen some floods in the past but this could be the worst.... damage could run in the millions."

Flooded out residents claimed that the dyke carrying the BC Rail line should have been breached because it was acting as a dam. The water on the upstream side of the track was 5 ft. (1.5 m) higher than on the lower side. Mayor Henry disagreed and thought rather than man-made the flooding was a natural disaster and that they could not have prevented the devastation. Hugh Porter, the environment ministry senior engineer who made the decision not to break it, admitted the dyke undoubtedly worsened the situation. But breaching it would have meant worse flooding downstream and a possible loss of a BC Hydro power station subsequently regarded out of danger.

All passenger and freight traffic on the BC Rail line was halted after a BC Rail southbound freight train hit a washed-out section of track immediately before a rail bridge just east of Pemberton. The accident left between 15-17 wrecked lumber and wood chip cars partially submerged along the bank of the Lillooet River. As washouts prevented repair crews and heavy equipment to reach the site, the track could not be repaired for at least 48 hours. *The Province* reported earlier 13 BC Rail cars toppling over and spilling their loads of lumber and wood chips 1.6 km south of Pemberton where the track was under water.

Damage estimates varied widely. The cost to repair the dykes, which had a $3 million upgrading two years prior, was estimated at $5 million. On October 10, the Provincial Emergency Program co-ordinator pegged the first firm dollar estimate of damage at $10 million while environment minister Tony Brummet estimated the damage at $6-7 million. The final cost of flood damage totalled close to $4.5 million. Floodwaters damaged 177 homes and their contents, while another 47 were "touched" by the flood (i.e. they suffered damage less than $10,000). In Pemberton, there was damage to stores and offices. On the Mount Currie Indian Reserve, the Lillooet River breached a dyke built in 1982 and 60 houses were "surrounded" by water. The Pemberton Secondary School was severely damaged after floodwaters reached halfway up the walls. There was damage to cars, trucks and other vehicles. One family alone suffered major

damage to four vehicles and another individual lost a log loader valued at $80,000. It was swept off the road and disappeared. In the Meager Creek area, 40 cars were swept away.

On October 10, homes at the Native Indian village of Mount Currie remained flooded at the lower reserve and the village's only road link with Pemberton to the west was threatened. The valley's water system, plugged in several places by debris, was back in service on October 11. During the several days the sewage treatment plant was shut down, untreated sewage had flowed into the river.

On October 10, Thanksgiving Weekend picnickers who had been stranded by high water near Lake Lovely Water, northwest of Squamish, and two canoeists stranded on the Squamish River were airlifted to safety. Dozens of campers stranded in Meager Creek Hot Springs Park, just north of Pemberton, were evacuated. Here, boulders and debris, which accompanied the wall of water smashed more than 30 cars. Damage to the vehicles was estimated at $100,000. *The Province* reported disaster officials stating the flood occurred after a chunk of glacier broke off and blocked Meager Creek, forcing it to jumps its banks.

By October 10, floodwaters receded in the Lillooet River valley by as much as 2.5 m in the most severely flooded areas north of Pemberton. On the morning of October 10, the Lillooet River, which caused much of the damage by breaching its dykes in many areas and running through the town, was down 2 m.

On the afternoon of October 11, the Lillooet River started rising again, backing up from overflowing Lillooet Lake, downstream from Pemberton. By midnight, the rain tapered off and the water levels started to drop again. On October 12 (?) at around noon, the Lillooet River fell 2 m. But the lower end of the valley was still experiencing flood problems. The worst area was a stretch of road connecting Pemberton with Lillooet. The body of a man drowned was found on October 11 near the cabin he rented near the outskirts of town.

On October 12, Ryan River started rising causing fears of new flooding. Late that day, the river that had risen 2 ft. (60 cm) by 11 p.m., was still flowing outside its channel. By October 13, the rain eased off. At Pemberton, the Lillooet River had not started to rise but only had to rise a few inches to have the river flowing through Pemberton again.

The Thanksgiving weekend flooding in Squamish and to the north added to the problems of an already depressed logging industry in the area. According to Weldwood general manager Carl Rathburn, damage to washed away logging roads and bridges was estimated at $750,000. The repairs would delay the company's spring start-up by about two months, keeping about 140 employees out of work longer than expected. The immediate affect of the flooding was minimal, as Weldwood had closed down its Squamish logging operation just a week earlier because of poor market conditions.

On October 8, a debris torrent occurred at Sclufield Creek in the Howe Sound area. On the same day, flooding occurred on Harvey Creek (Jackson et al. 1985). The 24-hour precipitation for the area recorded at Hollyburn Ridge was 26 mm (plus significant snowmelt), and for the seven days prior to that 154 mm (Church and Miles 1987). Jackson et al. (1985) gives precipitation amounts for above as 31 and 136 mm, respectively).

The "wall of water" on Harvey Creek washed away six weeks of work on the flood control dam under construction. Project supervisor Rick Boudreau said a "torrent of water came tearing down, like a huge wave" on the afternoon of October 8 causing damage estimated at $300,000. The wave shot through a partially constructed dam, buckling metres-thick reinforced concrete slabs and undermining the whole project. On October 10, the 40-man crew at the site started to rebuild the dam about 60 m above the Squamish Highway. The purpose of the dam is to slow floodwaters and remove debris.

In Vancouver, rain combined with a broken water main sent water pouring onto Heather between 70th-South West Marine Drive. Traffic was halted for more than an hour as city engineering crews laboured to get the problem under control.

Summary of watercourses impacted by the October 8 flooding and estimated cost: Lillooet River ($277,500); Ryan River ($562,000, including $240,000 for extra bank protection to make the new structure safe from washout); Miller Creek ($83,000); Pemberton Creek ($ 2,000); Squamish River ($205,000); Mamquam River ($6,700); Stawamus River ($115,000); Cheekye River ($160,000); Cheakamus River-Squamish area ($136,200); Culliton Creek ($149,800); Cheakamus River-Whistler area ($85,000);

Fitzsimmons Creek ($18,000). (Talbot 1986). Overall total (allotted) $1,946,700 and (expended) $1,632,493.36 (as per January 10, 1986).

Description of some of the most costly repair costs of the flood damage: Lillooet River: overtopping of the North Arm Plug and Dyke to Lillooet River bridge (Miles 8.7-10.0 in Tempest Report) resulted in the washout of about 70 m in length together with minor damage at other locations. Overtopping of the Airport Dyke (Mile 8.4 in Tempest Report) caused minor damage to the dyke/road in two locations. At the right bank (Miles 8.9 and 24.6, respectively in Tempest Report) estimated cost to repair loss of bank protection over 150-m lengths each was $50,000 in each location. Ryan River: at the upstream end of dyke (west of Lillooet River Mile 21.0 in Tempest Report) bedload deposition, estimated at 100,000 m^3, resulted in overtopping and destruction of the rock-protected left bank dyke over a distance of 400 m. A large quantity of wood debris was also deposited in this area. Total repair cost was $495,000. Squamish River: Cost to replace washed out bank protection along a 250-m length of overbank about 200 m upstream from Judd Slough floodbox was $120,000. Stawamus River: cost to replace toe rock along 450 m of riverbank upstream from Valleyview Elementary School was $115,000. Cheekye River: Cost of gravel removal from streambed about 300 m upstream of BC Rail bridge was $80,000. Culliton Creek: right bank downstream from Jack Webster bridge, cost to replace toe rock, reconstruct dyke in section where dyke washed out was $110,000.

Flood damage at Whistler: Cheakamus River (crested approximately 4 p.m. on Thanksgiving Day): severe erosion occurred over a reach of some 250 m above the municipal sewage treatment facilities, resulting in migration of the Cheakamus River channel and loss of about 1 ha of land. Permanent protection would require construction of a riprapped training dyke over the affected reach at an estimated cost of $150,000. Large logjams completely blocked the Cheakamus River in its canyon section downstream the treatment facility. Cost to remove and dispose of the blockages could range up to $75,000. Fitzsimmons Creek: between Blackcomb Way bridge and the Blackcomb Creek confluence, two footbridges washed out. Minor local accumulations of logs and debris were scattered over the reach from the Blackcomb Way bridge to the Nancy Green Drive bridge on Fitzsimmons Creek. Creek overflows were reported to have entered the day parking area. (Talbot 1986?).

---

*1) Statistical studies done by Earth Science and Math students at Howe Sound Secondary School indicated that local fall floods could occur anytime from September to December but that by far the most likely time for the Squamish River to reach its maximum was from October 22-November 4. Ten of the previous annual high water periods occurred during this period. It was also noted that at present the river seemed to have higher flows more often than in the 1950s. Three of the five previous years saw peak daily flows over 2,000 m^3/s. Prior to that, there were 25 years without getting flows of that high volume.

*2) The highest previous levels were an instantaneous flow of 2,270 m^3/s on September 6, 1958. In comparison, the disastrous floods of December 27, 1980 had only peak flows of 2,180 (instantaneous) and 2,110 m^3/s (*The Times*, October 22, 1985).

*3) Contributing to the problem is the fact that these dykes are built in 1974 to a one in 50-year standard. All the other dykes built in 1981 were built 1:200-year standard (*Times Today*, October 23, 1984).

*4) The instantaneous peak of 1,440 m^3/s obtained by the slope-area method could be underestimated for two reasons: the channel conveyance values may be underestimated since the channel area could have been larger during peak flow, and the water surface slope may have been underestimated as the flood wave was receding at the time the profile was measured (Smith and Vallieres 1986).

*5) In comparison, extremely high daily peakflows for the Lillooet River were for June 27, 1968 (627 m^3/s); November 5, 1975 (858 m^3/s); December 27, 1980 (993 m^3/s); November 5, 1984 (897 m^3/s) and January 5, 1984 (ice damage) (134 m^3/s). The average runoff from the Lillooet River near Pemberton for the 65-year period was 126 m^3/s. The highest measured flow prior to October 8, 1984 was obtained November 5, 1975

with a discharge of 705 m^3/s at a gauge height of 5.15 m. The next highest was on June 10, 1969 with a discharge of 637 m^3/s at gauge height 3.26 m (gauge heights not related). The maximum instantaneous gauge heights were 5.535 and 3.417 m, respectively. (Smith and Vallieres 1986)

*6) Angry Pemberton residents formed a ratepayer's association to deal with compensation to flood victims (*The Daily News*, October 12, 1984). The provincial government offered Pemberton residents who suffered flood damage up to $95,000 ($75,000 for damage to principal residence and a maximum $20,000 for its contents) after a $12,000 deductible. Some Pemberton residents blamed the BC Rail track for heightening the flood effects. They claimed a raised BC Rail track on a dyke running across the valley was responsible for backing up the rampaging Lillooet River. The study of the Pemberton Valley flood, which caused as much as $9 million damage was due in April 1985. It looked at railway culverts which were asserted to have increased the flooding, logging practices in the 2,160-km^2 Lillooet River drainage area and the possibility of dyking tributaries and reducing the level of Lillooet Lake (*The Sun*, January 23, 1985). A 1984 Thurber Engineering study of debris torrents along the Squamish highway found no correlation between streams susceptible torrents or floods and logging. Many Howe Sound fall floods are caused by combined runoff of heavy rains that wash away early snowfalls at higher elevation. If this early snow is in the trees rather than in a clearcut, it will be washed away that much more quickly. (*The Times*, October 22, 1985).

October 20, 1984
(Glacial outburst flood).
Source: *Crown Forest News*; Jones et al. 1985; Ryder and Thomson 1986; Desloges et al. 1989; Desloges and Church 1992; Clague and Evans 1994 (p. 23, 26); Evans and Clague 1994 (pp. 120-121); Church and Miles 1987 (p. 73); Canadian Hydrographic Service 1983.
Details: On October 20, Ape Lake, 50 km southeast of Bella Coola, drained in less than 24 hours beneath the snout of Fyles Glacier. The lake at 52º 05' N, 126º 10' W, lies at an elevation of 1,395 m a.s.l. on the drainage divide between the Noeick and Talchako-Bella Coola watersheds in the Coast Mountains. Prior to the draining of Ape Lake, the area was subject to two major storms.

The sudden release of approximately 55% of the Ape lake volume (Desloges et al. 1989) or 45.8 million m^3 of water formerly stored in the lake created an unusually large flood on the Noeick River. It is believed that most of the lake volume drained into the 50-km long, ungauged Noeick River within 24 hours and possibly in 20 hours or less. This would put the average discharge at the exit of the 1.9-km long ice tunnel beneath Fyles Glacier at between 540-650 m^3/s (Jones et al. 1985). *1)

The two distinct peak discharges were probably in the range of 985-1,500 m^3/s. The flood caused extensive erosion, transport and deposition of sediments stored on and adjacent to the floodplain of the Noeick River. Recreational fishermen from Bella Coola who had driven from the Nusatsum basin across Oldegaard Pass into Noeick Valley first observed the flood damage at 11:00 a.m. on October 20. At a point 30 km from South Bentick Arm, a rapidly disappearing road turned them back. At 5:30 p.m., a fast rising flood crest blocked vehicular traffic 5-6 km upstream at 35 km. The flood waves flowed over the floodplain, bypassing Purgatory Lake at 36 km. Peak discharge at the river mouth probably occurred between 8:00-9:30 p.m., roughly synchronous with the occurrence of high tide at 9:15 p.m. (Canadian Hydrographic Service, 1983). Consequently, water levels at the mouth of the Noeick River were increased further, flooding nearby terraces and the airstrip to a depth of 0.75 m. The lake was probably close to empty by 10:00 p.m. on October 20. (Jones et al. 1985).

This flood can be characterised as "catastrophic," because it destroyed the normal (climatic) regime of the river (Desloges and Church 1992). The flood destroyed more than 200,000 newly planted trees and some merchantable timber was lost. Two bridges across the Noeick River were damaged and more than 1 km of a newly constructed forestry access road and several kilometres of spur road were destroyed. The cost of road and bridge repair was estimated at around $200,000 (*Crown Forest News*). The flooding also affected the productivity of the local fisheries on the Noeick River downstream from the lake. Debris from the flood covered South Bentick Arm, affecting access by water for several days. Immediate upstream from

Purgatory Lake flood waters undercut the high lateral moraine formed by Purgatory Glacier. Eyewitnesses reported watching large volumes of the bank, which is 30-50 m high, falling into the floodwaters to be transported downstream. Up to 3 m of sediment was deposited upstream from the lake, while immediately downstream the river scoured and greatly enlarged its channel (Jones et al. 1985).

---

*1) A second event occurred on August 1, 1986, one year after the tunnel had sealed. Following tunnel closure the lake refilled in 150 days and drained again (Desloges et al. 1989; Clague and Evans 1994. Ape Lake appears to have been stable for several centuries until gradually changing ice conditions led to the sudden draining of the lake (Jones et al. 1985). The presence of undamaged trees as old as 300 years on the floodplain below Fyles Glacier before the first flood indicates that the two recent outburst events are unique in the Little Ice Age history of the Basin (Evans and Clague 1994). Many glaciers such as Fyles Glacier may have been fully advanced as early as the 12th century and remained close to these positions until the late 19th century (Ryder and Thomson 1986). The full Ape Lake then would only have existed for the last 80-100 years (Desloges et al. 1989).

December 10-17, 1984

(Rain-on-snow).

Discharge (m^3/s): Max. daily: December 14: Chem.: N/A; December 15: Shaw.: N/A; max. instant.: December 14: Chem.: 189; December 15: Shaw.: 8.44.

Source: *The Vancouver Sun*, December 15 and 17, 1984; Jackson et al. 1985; Environment Canada 1992; Hungr et al 1987 (pp. 205-206 and 211); Evans, unpublished data.

Details: On December 13, a Pacific storm caused avalanches, road closures and power failures. Heavy rains melted the snowpack in the south coastal mountains. On the night of December 13, the freezing level was at 300 m. The storm dropped 26 mm of rain on the Lower Mainland and 32 cm of snow in parts of the Interior. Early on December 13, winds up to 50 km/h knocked out power in the Lower Mainland communities from White Rock to Whistler.

On the night of December 13, the Trans-Canada Highway was closed east of Revelstoke and Highway 97 to Prince George closed due to avalanche and blizzard conditions and were reopened on December 15. The highway west of Revelstoke, closed due to an avalanche at Three Valley Gap was expected to reopen at noon on December 15.

On December 14, a debris torrent occurred in Sclufield Creek in the Howe Sound area. It came down during light rain following a week of cold weather with substantial snow accumulation. Snowmelt provided the run-off that generated the debris torrent, which started at a relatively low elevation. The torrent yielded some 5,000 m^3 of debris. About 60% of the large material was timber, and 55% by volume of the smaller than 50 mm material was organic (15% by weight). The torrent filled the natural basin upstream from the highway and spilled across the road to deposit some material on the slope to the railway (O. Hungr, pers. comm. 1985 In: Jackson et al 1985).

The lower part of the indirect impact zone was saved by the presence of several cross ditches, which contained much of the debris, diverting the flow to the right. (Hungr et al. 1987). The torrent was unusual among other Howe Sound events in the very high proportion of organic debris. It is probable that the torrent began at the logjam in the channel above the cliff (Jackson et al. 1985).

Peak discharge estimates made form super elevation observations after the event on Sclufield Creek ranged from 390 m^3/s at the base of a steep reach to 280 m^3/s on a flatter reach 100 m downstream, to 180 m^3/s at the crest of a waterfall 100 m further downstream. It appears that the surge contracted in length at a reduction in the slope angle, producing a higher peak, then spread out again at a convex channel reach (Hungr et al. 1987).

On December 15 at 10:15 a.m., a mud and rockslide blocked a culvert at Sclufield Creek, 5 km north of Horseshoe Bay and closed the Squamish highway. The slide, about 100 m wide and with an average depth of 1.5 m, also covered the BC Rail tracks. The highway was reopened by 4 p.m. BC Rail had to wait for the highways department to contain the flow of water before the railway company could start to repair

the damage caused by the slide. After the highway culvert blocked, the railway one also blocked. Though the track was left intact, about 50 m were covered by water, mud and logs. The line reopened at 3 p.m.

In West Vancouver, the road down to Sunset Beach was closed and 12 people were temporarily evacuated from the immediate area.

Heavy rain caused a slump in Buller Ravine east of Royal Oak near Marine Drive in Burnaby. The damage to two properties was estimated at $300,000. The creek running down the ravine was fed by the drainage from a storm sewer that ended at the top of the ravine. For more than a week, the raging stream had eroded the landfill. Mudslides along Buller Ravine threatened about six Burnaby homes. The landfill consisted mostly of topsoil and there were no retaining walls to protect the homes. The residents at 5679 Patrick Street, Robert Leese and family, lost about 32.5 m^2 (350 $ft.^2$) during the previous week. Leese, who had moved into the house seven months earlier, was angry and suggested to have all the concrete from the old B.C. penitentiary into the ravine and restore the property he lost. Neighbour Steve Reader's property at 5686 Patrick Street was the first to go. Nearly 7 m^2 (75 $ft.^2$) of his property disappeared into the ravine and left his balcony now hanging over a newly created cliff. The residents estimated the combined damage to their properties at between $250,000-300,000.

January 1985
Source: *The Sun*, January 16, 1986.
Details: In January, a slide at Charles Creek closed down the Squamish highway for about 90 minutes.

February 11, 1985
(Storm surge/tidal flooding and rain-on-snow).
Source: *Campbell River Upper Islander*, February 12, 1985.
Details: On February 11, high tides and gale force winds caused damage to the Campbell River Foreshore Park and brought trees down on houses and power lines. Early on February 11, the gale reached a peak velocity of 37 knots (68.4 km)/hr. The rare 15-ft. (4.5 m) tide hurled large rocks from the seawall into Foreshore Park. Debris and 40- to 80-lb. (18-36 kg) rocks were scattered for hundreds of feet along the walkway along the outer perimeter of the park. The Heritage Pavilion was flooded. At 9 a.m. the high tide caused flooding around Cedar Street and 14th Avenue for about two hours. Nunns Creek also backed up, flooding 16th Avenue and Maple Street. At Willow Street minor flooding occurred due to a plugged storm sewer. Warm rain caused snow to melt.

February 18, 1985
(Fatal avalanche).
Source: *The Province*, March 24, 1987.
Details: In February, an avalanche on Mount Duffy in the Monashee Range northwest of Revelstoke killed two heli-skiers. The victims, clients of Mike Wiegele Helicopter Skiing company were part of a party of 13 heli-skiers caught in the slide. *1)

---

*1) The accident prompted coroner Ian McKichan to recommend that the Mike Wiegele ski operation make more frequent tests of snow to gauge avalanche risk (*The Province*, March 24, 1987).

July 1985
(Subaqueous slope failure).
Source: Luternauer et al. 1994; Chillarige et al. 1997.
Details: In July, a large subaqueous slope failure occurred at the mouth of the Main Channel on the Fraser Delta involving a minimum of 3 million m^3 of delta sediment. Slope retrogression exceeded 350 m and the failure scarp extended to within 100 m of the Sand Heads Lighthouse (Luternauer et al. 1994). An analysis (Chillarige et al. 1997) of the failure indicated that it occurred as a result of flow liquefaction triggered by a complex interaction between large drawdown associated with low tide, interstitial gas and the geotechnical

behaviour of loose, sandy collapse-prone deltaic sediments. The effects of rapid sediment loading during the spring freshet and wave action were not found to be key factors in this failure.

October 21, 1985
Source: *Nanaimo Daily Free Press*, October 24, 1985.
Details: On the late afternoon of October 21, a rockslide occurred in downtown Nanaimo. An estimated 4-5.5 (45.5?) tonnes of rock fell onto Front Street from the Piper Park rock outcropping. It cut one lane of Front Street for the remainder of October 21 and part of October 22. As a precautionary measure, the city's public works department dug out and removed a further 40-50 tonnes of rock.

This was not the first time rocks fell from the outcropping known as Scotsman's Bluff. According to John Pike, public works general superintendent, pieces have been falling off over the previous 10 years. This continued rain and frost spur along movement. To prevent further slide debris from falling onto the road, a concrete wall would be built in front of part of the bluff facing Front Street.

November 1-4, 1985
Discharge (m^3/s): Max. daily: November 3: Cowich.: 86.6; max. instant.: November 3: Cowich.: 86.4.
Source: *The Sun*, November 4 and 5, 1985; *The Province*, December 17, 1985; Environment Canada 1992.
Details: On November 1 at 3 p.m., a landslide washed away a 70-m section of the Barnet Highway. The closure affected the stretch between Inlet Drive in Burnaby-Johns Street in Port Moody. Early on November 4, one lane was reopened between 7-9 a.m. to westbound traffic only in order to reduce traffic pressure on other roads. The highway was expected to reopen at 3 p.m. on November 4.

On November 4 at 1:10 a.m., a northbound BC Rail freight train hit a small rock and debris slide in Cheakamus Canyon 4 km north of the Daisy Lake dam and derailed. The head engine slid about 30 m down the embankment, landing on its side. The second engine slid about 18 m and the third engine came down on top of it. Two cars also went down the embankment and a third one was derailed. About 60 m of track was torn up in the incident. The crew who rode the engine down during the slide escaped injury. BC Rail recovered the three locomotives valued at $4.5 million during the first half of December.

November 26, 1985
Source: *Times Colonist*, December 1, 2006
Details: On November 26, with 16.4 mm the Victoria International Airport recorded the most snow, a record that still stood in November 2006.

1986
Source: Evans 1987; Evans 1992 (p. 76).
Details: Sometime during 1986, a rockslide came down from the north side of Mount Meager. The detached mass of Pleistocene rhyodacite had an estimated volume of 0.5 million m^3 (Evans 1992).

January 15-18, 1986
Discharge (m^3/s): Max. daily: January 18: Chem.: N/A; Kok.: N/A; January 19: L. Qual.: N/A; Shaw.: N/A; Sproat: N/A; January 20: Cowich.: 447; max. instant.: January 18: Capil.: 206; Chem.: 445; Kok.: 271; January 19: L. Qual.: 910; Shaw.: 18.1; Sproat: 185; January 20: Cowich.: 400E.
Source: *The Sun*, January 16, 1986; *The Citizen*, January 16 and 23, 1986; Environment Canada 1992. Ministry of Transportation and Highways, Rockfall notification summary.
Details: On January 15 at 8 p.m., a slide at Charles Creek poured rock onto the Squamish highway. It covered about 50 m of the highway. An estimated 1,000-1,500 m^3 of rock (or "about 100 to 150 truckloads") slid from the face of the mountain. It was not until midnight that clearing of tons of debris began. Highways department district manager Ron Winbow hoped to clear the last of the slide during the regular daily closing hours of 10 a.m. to 2 p.m. and have both lanes open after that. *1)

On January 15, 150 m^3 of rock came down onto Highway 99 (at 7.1 km) between Strip-Charles creeks.

The January 16 edition of *The Citizen* showed on its front-page pictures of a train derailment. As the text was illegible, location and details are unknown.

On January 18, heavy rains combined with frost in the ground resulted in minor flooding in a number of areas in the Squamish Valley. Problems were reported in Brackendale, some in Garibaldi Estates and minor ones in Valleycliffe.

In January, a section of unprotected bank along the Mamquam River started to develop erosion, threatening the dyke. By the middle of February, the river had already taken away up to 100 ft. (30 m) of sandy bank. According to Squamish Mayor Egon Tobus, the erosion started at the lower end of the existing rock riprap bank protection, which was put in place in 1970. *2)

---

*1) The regular four-hour closure was to allow work on a new bridge at nearby Newman Creek.

*2) In a letter to the Director of the Water Management Branch, Mayor Tobus appealed the Ministry of Environment to share the cost of the construction of bank protection along the left bank of the Mamquam River dyke from the existing rip-rap (*The Times*, February 25, 1986).

February 3, 1986

Source: *The Sun*, February 3, 1986.

Details: On February 3 at 1:50 a.m., a rockslide 16 km north of Whistler derailed a northbound BC Rail train. Four locomotives derailed but remained upright, blocking the line. Passengers were bussed between Mons near Whistler-Pemberton.

February 12, 1986

(Non-fatal avalanche).

Source: *The Golden Star*, February 19, 1986; Bowers 1994 (p. 25); Jamieson and Geldsetzer 1996 (pp. 170-171).

Details: On February 12 at 1 p.m., a slab of glacial ice broke loose from Mount Stephen about 1,500 m above the Trans-Canada Highway near Field. It set off an avalanche, which broadsided a semi-truck and pushed it off the road into a parking lot, about 150 m below. The truck was partially buried and the highway and CNR rail line were blocked. The driver, who could not see it coming in the darkness, only sustained minor injuries. He noted, “It was bad but I’ve been beat up worse in a bar…”

By 7 a.m., one lane was pushed through the avalanche debris and by 1 p.m. the Trans-Canada Highway was again in full operation. The CNR rail line reopened at about the same time.

The size 4 avalanche released from the top of the mountain near the face of the glacier, plummeting 1,500 m down the mountainside. An icefall either triggered it or released and triggered an icefall from the glacier as large amounts of glacier ice were found in the deposit. The avalanche had cleaned out the avalanche path *1)

---

*1) Remedial measures involved creating diversion channels and dams above the railway and highway, as well as establishing an explosives stabilisation program (Jamieson and Geldsetzer 1996).

February 25-26, 1986

(Rain-on-snow and spring run-off/flooding).

Discharge (m^3/s): Max. daily: February 24: Capil.: 305; Nan. C.: 781; max. instant.: February 25: Nan. C.: 595.

Source: *The Sun*, February 26 and 27, 1986; Environment Canada 1992.

Details: On February 25, heavy rains and warm weather melting snow caused widespread flooding in Cranbrook. Joseph Creek, which runs along the periphery of the downtown area, forced families from their homes and caused raw sewage to back up into basements. The problem was caused by a warmsnap that melted the top layers of snow on the ground producing a high runoff. Inadequate culverts caused the actual flooding. Overnight February 25-26, the backed-up water around culverts dropped 1-2 m. Although some

homes and businesses flooded, lot runoffs caused a big percentage of the flooded basements. Hardest hit were six cabins close to a culvert partly blocked by ice. The swirling water rose above their porches. Cranbrook was among three British Columbia centres posting record high temperatures. On February 25, the high in Cranbrook was 11.5º C breaking the previous high of 11.1º C set in 1980. *1)

The warm weather caused at least 28 avalanches between Revelstoke-Golden, many of them onto the Trans-Canada Highway. On February 25, one snowslide knocked five cars of an eastbound 60-car CPR freight train off the tracks near Revelstoke. The avalanches marooned more than 100 truckers and other travellers in Golden. On the night of February 26, the Trans-Canada Highway closed for nine hours due to a mud- and rockslide at Albert Canyon, 60 km east of Revelstoke, reopened. The slide came down just one hour after the highway had been reopened from being closed by a previous slide.

---

*1) Comox had a record high temperature of 15.6º C compared to 15.5º C in 1977 and Quesnel recorded 15.1º C against the 1980 mark of 15.0º C. The high for Vancouver was a record 14.9º C breaking a previous record of 12.4º C. The warmest day ever in February in Vancouver was set in 1943 with 15.0º C (*The Sun*, February 26, 1986).

Late March 1986

Source: *The Vancouver Sun*, April 1, 1986.

Details: At the end of March, the unusually rainy winter caused a family out of their nine-year old $200,000-riverfront home outside Princeton. The backyard of the property and the deck of the house dropped down towards the Tulameen River.

On the Hope to Princeton highway, one lane sunk a few cm. According to South Okanagan Highways District manager Charlie Hutchins, there was no immediate danger of the highway washing away.

May 30-June 1, 1986

(Spring runoff/flooding).

Discharge (m^3/s): Max. daily: May 26: Squam.: 1,240; Stamp G.: 273; max. instant.: May 26: Squam.: 273; May 27: Stamp G.: 256.

Source: *The Vancouver Sun*, May 30; June 2, 1986; Environment Canada 1992.

Details: At the end of May, continuing warm weather was melting mountain snowpacks quickly causing flooding. *1) Late on May 30, flooding was reported in the Rocky Mountains in Radium (Hot Springs) and Golden. After gravel, boulders and debris from fallen trees clogged a culvert, Highway 93 south to Radium was closed. Chief park warden at Kootenay National Park Peter Whyte hoped the road would be reopened by late on May 30. In Golden, residents were sandbagging the banks of Hospital Creek.

Around June 1, “porridge-like mud” slumped off a hillside in Albert Canyon near Revelstoke closing the Trans-Canada Highway indefinitely. The slide covered an estimated 150-m stretch with about 3.5 m of mud. The mud also covered the CPR line below the highway. Though mud was still coming down the next day the rail line was cleared on June 2.

---

*1) In May, Vancouver recorded 100.6 mm of rain, about twice the normal average of 51.6 mm (*The Vancouver Sun*, June 2, 1986).

August 1, 1986

(Glacial outburst flood).

Source: Desloges et al. 1989 (pp. 349-354); Desloges and Church 1992 (pp. 551-564); Clague and Evans 1994 (p. 26).

Details: On August 1, Ape Lake in the southern Coast Mountains 50 km southeast of Bella Coola drained again. *1) The first historical outburst flood from this lake occurred on October 20, 1984. High discharges during these floods (up to 1,600 m^3/s) damaged forestry roads, bridges, a logging camp, and an airstrip, and caused widespread channel and floodplain erosion.

This second, and fractionally larger, outburst flood caused mobilisation of sediment and some channel infilling but further morphological changes were minimal (Desloges and Church 1992). The flood followed a near-normal July, in terms of temperature and precipitation. Because of rapid retreat of the ice margin following the 1984 outburst flood, the ice tunnel, which developed under the northeast edge of the ice dam, may have been more easily activated this time. Observations made from the air and in the lower valley showed that the peak flow passed through in approximately 20 hours. Due to instrument problems, the water level recorder failed to confirm the timing of the flood. But eyewitness accounts provided sufficient detail for an approximate reconstruction of the flood event (Desloges et al. 1989).

Following the 1984 flood several of the remedial road works undertaken proved to be effective during the second flood, but in locations where roadways could not be re-routed away from the valley bottom, new damage was sustained. In the lower reaches of the river, salmon spawning grounds were lost and some reduction in the strength of salmon runs was expected for the next several years (Desloges and Church 1992).

Retreat of Fyles Glacier after 1986 allowed drainage around the north edge of the ice dam and prevented the lake from refilling (Clague and Evans 1994). Since Fyles Glacier is in continuous retreat, drainage around the margin of the ice dam which began in the summer of 1987 is expected to continue and no further floods are anticipated (Desloges et al. 1989).

After each draining of Ape Lake, the unsupported and near-vertical ice dam was subject to icefalls, which have contributed to the rapid recession of Fyles Glacier along the lake margin. This allowed for the formation of a stream channel around the margin of the ice dam and a reduction in the level of the lake (Desloges et al. 1989).

---

*1) The presence of undamaged trees as old as 300 years on the floodplain below Fyles Glacier before the first flood indicates that the two recent outburst flood events are unique in the Little Ice Age history of the basin (Clague and Evans 1994).

November 22-23, 1986

Source: *The Province*, November 24, 1986; *The Vancouver Sun*, January 2, 1987; *Times Colonist*, January 7, 1987.

Details: On November 22-23, heavy rains hit the lower Mainland. In Coquitlam, two streets (Schoolhouse and King Edward Avenue) and the Pitt River bridge were closed due to flooding. In Vancouver, McGill Street temporarily closed due to flooding. In Surrey, a tree fell through the roof of a home on 99A Avenue. A Coquitlam home sustained $10,000 damage when a tree toppled through its roof. The tree also knocked out the hydro and telephone lines.

In late November, torrential rains caused Frosst Creek to overflow its banks and damaged dozens of properties. *1) The damage caused by the flood originated in Washington State and was due to the logging practices condoned by the state's department of natural resources. On the American side of the border, massive amounts of stumps and debris were washed off a clear-cut logged area and strewn across properties in the Lindell Beach area. In the process, an $80,000 water system feeding more than 40 lots in a 38-ac. (15.2 ha) trailer and recreational park on Frosst Creek near Cultus Lake was destroyed. Also so much debris was washed into Cultus Lake that a ring of stumps and logs was left on beaches of lakefront properties. Authorities felt that unless salvage operations were mounted soon, the tourism potential in the area would be damaged. Initial repair cost to the homes and water system was estimated at more than $200,000. But by the time the creek would be cleaned out on the American side to prevent it from recurring, could exceed $500,000.

Though initial repairs were funded by British Columbia's Provincial Emergency Program (PEP), hydrologists estimated that up to 98% of the debris in the logged area of Frosst Creek had yet to come down. Though Georgia-Pacific Ltd., the logging company involved, had offered "a small amount of money in relation to what it would cost to clean up," the more important issue was how to prevent a similar "catastrophe" in the future. Lloyd Forman, chairman of the Fraser-Cheam regional district, estimated it

would cost about $500,000 to dredge the creek, clean out a 3-m high dam of debris at the creek, repair the water system and remove potential debris from the U.S. slopes.

The logging company stated that many experts believed that by leaving the logs and stumps, the creek velocity or speed could be trimmed to prevent washouts downstream. “If we clean the creeks out, water runs at about 30 mph (48.3 km/h), and we get a lawsuit from someone who says we should have left the creek the way it was. If we leave it that way, we get a lawsuit from someone whose house has just been hit by rampaging stumps.”

---

*1) Before emptying into Cultus Lake near Chilliwack, the small creek crosses the Canada-U.S. border. As no international policy existed to determine about was responsible for paying damage to Fraser valley properties, Frosst Creek created jurisdictional problems for state, provincial and local governments.

*2) Georgia-Pacific later promised to clean out the creek on the U.S. side of the border and contribute $57,000 to repair damage on the Canadian side. The provincial government kicked in $210,000 PEP funding to rebuild destroyed dykes and creek banks and to dredge out the entrance to Frosst Creek at Cultus Lake.

December 21, 1986

Source: *The Province*, December 22, 1986.
Details: On December 21, torrential rains and high winds lashed the Lower Mainland. Roads and basements flooded, including Great Northern Way and near Lumberman’s Arch in Stanley Park.

January 3, 1987

(Storm surge/tidal flooding).
Source: *The Province*, January 4, 1987.
Details: On January 3 (?), high tides caused flooding near the mouth of the Fraser River and flooded basements in the Ambleside area of West Vancouver. CPR crews had to move 130 freight cars after 1m-deep water covered the tracks in the company’s yard near 76thand Hudson in Vancouver. The same tide was pushed higher by moderate southeast winds. Cars were swamped and lumber floated off at the Silvertree Division of Whonnock Industries on St. George. The water came right up to the Seawall and into some basements. In 1500 block Argyle, low-lying roads in the Ambleside area were closed a couple of hours. Some flooding occurred in 1300 block.

White Rock was the only other Lower Mainland area affected. A two-block stretch of Marine Drive between Kent-State was closed for three hours due to flooding.

March 23, 1987

(Fatal avalanche).
Precipitation: Not applicable.
Source: *The Province*, March 24, 1987.
Details: On March 23, an avalanche near Blue River in the Cariboo Range in Wells Grey Provincial Park killed seven heli-skiers. *1) Another five skiers, who were trailing behind the group, escaped the 400-m (1,300 ft.) wide slide by a few seconds. “the whole side of the mountain came down,” said an eyewitness. Rescuers had to dig 15-20 ft. (3.5-6 m) to get to the bodies, most of which were located within 20 minutes.

The skiers were at the top of the 1,280-m (4,200 ft.) “Mike’s Warm-up” slope, a run named after the heli-ski owner Mike Wiegele. The dead skiers were part of a group of more than 50 people mostly from Europe and the U.S. who had bought a ski holiday package.

The cause of the avalanche was not given. Blue River residents said the temperatures at the time of the slide hovered around 8º C.

---

*1) The accident was the second to hit Mike Wiegele Helicopter Skiing company in two years. On February 18, 1985, two men died on Mount Duffy in the Monashee Range while heli-skiing with the same outfit,

prompting coroner Ian McKichan to recommend that the Mike Wiegele ski operation make more frequent tests of snow to gauge avalanche risk (*The Province*, March 24, 1987).

April 29, 1987
(Earthquake?).
Source: *The Vancouver Sun*, April 30, 1987.
Details: On April 29, rockslides, attributed to an earthquake on April 8, came down onto the Squamish highway. Boulders from the first slide, which came down at 8:30 a.m., hit a northbound car with two passengers. The second one, which came down an hour later, punctured the tires of a truck that run over some of the rocks. The 3.7-Richter scale earthquake could have destabilised the high bluff area between Lions Bay-Britannia Beach where the slides occurred.

November 8-10, 1987
Source: *North Island Gazette*, November 11 and 18, 1987; *The Daily News*, November 12, 1987; *Times Colonist*, January 5, 1988.
Details: On November 10, two debris slides came down near Port Alice, blocking the road between the town and the pulp mill. Heavy rain had been falling in the area since early on November 8. Almost 50 mm fell in the 24-hour period ending at 10 a.m. on November 10. During the last four hours of that period, the rain was the heaviest, recording 35 mm.

The first debris slide, about 60-ft. (18 m) wide, came down the municipal road at 7:50 a.m. Two men had been standing on the road directing traffic when a second slide came down at 9:08 a.m. in almost the same spot. This second slide, which was 35 m wide and 2 m deep, swept Port Alice alderman Ian Ford into Neroutsos Inlet.

If the slide had occurred a few minutes earlier, 20 other people might have been caught in it. These people had been on the site helping with the clean up of the first slide or watching the crews working. The second man, Public Works Foreman Pete Noult, stated, “Fifteen feet separated us; I heard a crack on the hillside and saw a tree coming down. He (Ford) was running the other way. He ran right into the slide.”

According to eyewitness Stan Winkle, two men were “trying to do something with the ditch line when all of a sudden the whole side of the hill let go.” A car was pushed right off the road. He said it looked like one man was buried underneath 15 ft. (4.5 m) of mud on the road. On December 31, the body was found floating 1.6 km off shore in Quatsino Sound.

This was the first slide of any consequence in the area since the November 1975 slide in Port Alice. Never before had there been a slide in this particular area. An old culvert on a logging road up above had collapsed or plugged redirecting the run-off from the heavy rains. The area above the highway had been logged about 4-5 years prior. According to Mill Manager Bernie Garrood, a 300-yd. (270 m) stretch of the hillside overlooking the road was not stable. He stated, “We certainly warned them there might be a problem.”

December 8, 1987
Source: *The Times*, December 15, 1987; Ministry of Transportation and Highways, Rockfall notification summary; Mike Dowdle, pers. comm. December 11, 2006.
Details: On December 8, 80 m^3 of rock came down onto Highway 99 (at 24.6 km) near the Porteau Bluffs. *1)

---

*1) On the 1-mi. (1.6 km) stretch near Porteau Bluffs, a “gigantic” rock face badly sheared towards the highway was slowly sliding towards it. The highly fractured rock, its upper layers shifting and overriding the lower layers indicated a slow movement of a large rock mass under extreme stress. It might not have taken much for the unstable Porteau rock formation to tumble down. Such an event might not only have caused fatalities but would also cut the Sea-to-Sky corridor without a highway connection for days or weeks. This part of the mountain was considered to be a slumbering time bomb, not only during heavy rainfall, but all year round. Dismantling the entire rock face would be very costly. Another option would be the

restructuring of the highway onto a draw above. (Hans Jost In: *The Times*, December 15, 1987). Throughout the 1990s, Porteau Bluff has undergone several phases of slope stabilisation work (Mike Dowdle, pers. comm. December 11, 2006).

December 31, 1987
Source: *The Vancouver Sun*, December 31, 1987 and January 4, 1988.
Details: Around December 31, a series of rockslides covered about 100 m of BC Rail track, cutting the line north of the Seton-Portage area to passenger and freight service for five days. Lumber shipments to the coast were stranded. On January 3, the line reopened.

January 9, 1988
Source: *The Golden Star*, January 13; February 3, 1988.
Details: On January 9 at 7 a.m., a westbound CPR grain train derailed about 7 mi. (11.2 km) east of Golden on the bank of the Kicking Horse Pass. *1) Two locomotives, unmanned slaves, in the mid-section of the 100-car train derailed taking 13 cars on each side as well. They all tumbled down the low bank towards the low bank towards the river, spilling grain and diesel fuel along the way. Though the rail line was operational again on the afternoon of January 11, repair work would continue for another two weeks. On January 9-10, VIA passengers were bussed between Golden-Calgary. The cause of the accident was the recent extremely cold weather that might have snapped the rails.
---
*1) A snowslide had caused a derailment in the same area few years earlier.

March 22, 1988
(Fatal avalanche).
The Vancouver Sun, March 23, 1988; *The Times*, March 29, 1988.
Details: On March 22, an avalanche in the mountains 27 km north of Revelstoke claimed the life of a visiting heli-skier. The victim died as she and two companions triggered a second slide to come down on Sale Mountain when thy skied down to locate the buried ski guide. *1) A helicopter ski guide survived being buried under snow for nearly 90 minutes. The two other surviving skiers were partly buried. The area where the avalanche occurred, at an elevation of approximately 2,300 m, is a regular spot for heli-skiing. The area had received about 50 cm of snow during the previous three days and the temperature at the time was –4^{o} C. Jim Bay, an avalanche technician with the highways ministry, said the snow in the slide area was 40-60 cm deep and 100 m wide, piling up to about 2 m deep as the slope levelled out. Though it was not a large avalanche, for skiers it was a significant one.

On March 22 at 11:30 p.m., a massive rockslide came down just south of Strip Creek, blocking the Squamish Highway. The slab of rockface came down as a result of heavy rains. An estimated 2,500 m^3 blocked both lanes of the highway, which reopened to traffic at 7 a.m. the next day. No damage or injuries were reported. Some of the debris also fell onto the railway line.

According to Ministry of Highways and transportation spokesperson Tucker Forsyth, the slide occurred in a construction zone, where construction at Strip Creek had just commenced. Forsyth also stated that a recent slide in the same vicinity had been the result of the ongoing blasting operation.
---
*1) It was the second fatality this year involving Selkirk Tangiers Heli-Skiing, based in Golden. This incident brought the British Columbia heli-skiing death toll since 1972 to 29. For 1987, the total number of people killed in avalanches was 17 for the U.S. and 11 for British Columbia (*The Vancouver Sun*, March 23, 1988).

August 25-26, 1988
Source: *The Vancouver Sun*, August 27, 1988.
Details: Heavy rain caused a gravel- and mudslide into the Kicking Horse River, “pinching” it and to overflow its banks. Flooding started on the night of August 25. About 20 people were removed from one camping area shortly after 11 p.m. when water started to overflow their campsites. It also left almost 300

campers trapped in Yoho National Park near Field after the access road flooded. The road was covered knee to waist deep in water. Three stretches of the Trans-Canada Highway were partially flooded with flowing water and mud. Mudslides also covered parts of the CPR tracks outside Field. The railway company hoped to reopen the line on August 27 after clearing the mud, which covered about 20 m of track.

February 7, 1989
(Waterline burst/flooding).
Source: *The Campbell River*, February 9, 1989; *Courier Times Colonist*, February 9, 1989.
Details: On February 7 at 1:30 p.m., a burst water pipe caused a mudslide in Campbell River. The slide, which was the worst slide to hit Campbell River in years, left a 42-year old woman seriously injured and levelled a duplex at 1231 Spruce Drive. It was pushed about 40 m and collapsed. The slide demolished the house within seconds, leaving only the roof intact. The force of the impact carried the building about 50 ft. (15 m) off its foundations. An adjacent duplex only metres away was moderately damaged and coated with mud. The mudslide came down from the steep about 20-m high embankment behind the two duplexes. The man, who first raised the alarm said, "the sound of a cracking tree and a distant rumble were the only indications that he had that something was up." He saw one house come down and then the slide hit the other.

The break occurred on the boundary bisecting the lot between the municipality and the regional district. The broken main waterline found gushing high atop the hill belonged to the Quinsam Waterworks, under the jurisdiction of the Comox-Strathcona Regional District, while the houses were within Campbell River.

February 16, 1989
Source: *The Kamloops Daily News*, February 16, 1989; *The Vancouver Province*, February 17, 1989.
Details: On February 16 at 3:20 a.m., a 1-ton boulder bounced through a trailer home in Kamloops. The big flat rock came down the cliffs along Ord Road. It crossed the road and entered the trailer by smashing through the aluminum wall on one side, bounced through the trailer over a spare bed and out the other wall. It created large holes on both sides of the trailer. No injuries occurred.

May 25, 1989
(Controlled dam burst/ flooding).
Source: *The Province*, May 28, 1989; Bland 1992 (pp. 4-6).
Details: On May 25, the Park Lane dam above the community of Britannia Beach collapsed and caused flooding in Britannia Beach. The accident happened when contractors mistakenly blew a hole into the dam three times bigger than they had intended. The environment ministry had ordered Copper Beach Estates, the owners of the 74-year old dam, to knock a hole in it as a precaution against an earthquake rupturing it. When the charge blew a hole 10 m wide, instead of 3 m, the creek rose almost 4 m instead of the expected 0.5 m. As a precaution, the community's 120 homes, 8 km downstream, had been evacuated and Highway 99 closed.

As the dam collapsed, the creek rose, ripping out trees and spewing debris as the water rushed toward Howe Sound. An eyewitness noted, "We heard it coming before we could see it. It rumbled like a train, we could see trees swaying and feel the ground shaking." At peakflow the flood wave was estimated at 255 m^3/s. The lower creek was partly infilled with gravel. The dam break flood deposited an estimated 10,000 m^3 of bed material in the creek downstream of bridge B5. *1) The torrent lasted about an hour. It washed away two footbridges and cut off the water supply to most of the town. The Red Door Art Gallery was the only building to suffer major damage. According to the owner, sculptor Edward Beaulieu, he was actually lucky. "Two more feet (60 cm) of water and half the building would have been gone."

---

*1) High flows in the creek on October 23, 1989 subsequently cleaned out the gravel deposits upstream and downstream of the highway bridge. The Tunnel Dam at 606 m elevation built in 1916, which was almost filled with gravel was completely filled after the 1991 flood (Bland 1992).

August 31, 1989
Source: *The Province*, September 3, 1989.
Details: During the evening of August 31, a "three-minute" mudslide buried dozens of tents at the Holiday Hills Resort campsite at Penticton. Employees got the camper off the 2.4-ha. campsite within 10 minutes. According to campground employee Dave Millichamp, "the slide just shot out of the mountain all at once. It started off with a heavy downpour and small rivers of mud started flowing to the back of the campground. It turned into chunks of mud, big rocks and logs." About 10 vehicles had to be hauled away on flatbed trucks. Another 30 cars just had to have mud scraped off.

Campground owner Ted Allsopp estimated it would probably take all winter to repair the damage. The slide, which was brought on by the heaviest rain in 44 years, left the campground 5 ft. (1.5 m) higher than it was before. In the main store and office, the floor was covered in mud, which had moved the big freezer 10 ft. (3 m). In the 72-hour period ending 5 p.m. on September 2, 51.4 mm of rain fell, 37.2 of which fell in the 6 hours between 5-11 p.m. *1)

At nearby Skaha Lake, Wright's Beach Camp lost half its beach to the flash flood. Fifteen campers were evacuated to motels.

---

*1) The previous 24-hour record of 44.5 mm was set in 1945 (*The Province*, September 3, 1989).

October 21-25, 1989
Source: *The Vancouver Sun*, October 25, 1989; *The Squamish Times*, October 31, 1989; Bland 1992 (pp. 4-6).
Details: Heavy rains on October 21-22 caused gravel to form a delta at the mouth of Britannia Creek, clogging about half the channel. About 1 m of gravel had been deposited in the channel since May. The gravel was probably the result of a dam demolished on May 25. After the channel shifted high water washed away some of the riprap protecting the BC Rail bridge across the creek. High flows in the creek on October 23, 1989 subsequently cleaned out the gravel deposits upstream and downstream of the highway bridge. To avoid flooding, some emergency dredging was carried out during the last week of October. The Provincial Emergency Program put up $4,000 to clear some of the gravel.

On October 25 at 4:30 p.m., a rock and mudslide covered the BC Rail track in Cheakamus Canyon. The slide was 45 m long, 12 m high and 9 m deep. The line was expected to reopen on October 26 at 3 p.m.

November 3, 1989
Source: *The Vancouver Sun*, November 10, 1991; *The Sounder*, February 1993 Vol. XX No. 5 Fisheries and Oceans, Pacific Region; B.C. Ministry of Forests 1990a.
Details: On November 3, Vancouver recorded 65 mm of rain in 24 hours, setting an all-time record (*The Vancouver Sun*, November 10, 1991).

Severe flooding caused extensive damage to the banks of the Chilliwack River. According to Jim Wild, Head of New Projects for Salmon Enhancement Program (SEP)'s Development Division: "Every time the water hit an outside curve, it cut into the bank, exposing large clay deposits which then eroded into the river. This made the Chilliwack River, the heaviest fished river in British Columbia, cloudy and unfishable." (*The Sounder*). *1)

---

*1) Following the November 1989 flooding, which was the second highest flood on record, an independent consultant study by P. Jordan & Associates on the Chilliwack River concluded that "logging in the Chilliwack River had no effect on total runoff during the storm and probably had a negligible effect on the timing and peakflow of the flood." (B.C. Ministry of Forests 1990a).

November 8-10, 1989
(Rain-on-snow).

Discharge (m^3/s): Max. daily: November 9: Capil.: 409; Sall.: 7; November 10: Squam.: 1,530; max. instant.: November 9: Capil.: 250; Sall.: 103; November 10: Squam.: 1,170.
Source: *The Vancouver Sun*, November 10, 13 and 22, 1989; December 15, 1989; *Times Colonist*, November 10 and 21, 1989; November 10, 1990; *The Province*, November 12, and 14, 1989; *The Chilliwack Progress*, December 5, 1990; Miles et al. 1979; Rice et al. 1992; Di Cenzo 1990; Andrews 1993; Evans, unpublished data; Nesbitt-Porter 1989; Ministry of Environment files.
Details: On November 9, torrential rains and gale-force winds occurred throughout British Columbia. The rainfall broke many records. In the 24-hour period ending 10 p.m. on November 10, Hope received 118 mm, an all-time 24-hour record for the area in November. In the three days between November 8-10, Hope recorded a total of 249 mm, more than the average rainfall for the entire month of November. Chilliwack and Abbotsford recorded about 150 mm during the three days, and Vancouver 50 mm.

As a result of the extremely heavy rain, in some areas falling onto melting snow, many coastal areas of southern British Columbia experienced flooding or near-flooding situations. Reported 24-hour precipitation of 312 mm at the Village of Tahsis was the highest ever recorded, exceeding the calculated 1:100 year event. Lower Mainland was the greatest in the Chilliwack area, where the Chilliwack River experienced a 1:15 year flow but tributary flows were considerably greater. Slesse Creek flow, for example, peaked at 227 m^3/s, the greatest flow during the 34-year period of record (Nesbitt-Porter 1989).

The record-breaking rainfall throughout much of southwestern British Columbia caused localised flooding and washouts in many areas. Damage to protective works was mostly concentrated in the Lower Fraser Valley where extensive erosion resulted along the Chilliwack and Coquihalla rivers. The total cost of channel restoration, log clearing and repair work was estimated at $2.23 million. This amount excluded urgently required enhancement work estimated at $586,000 and recommended additional improvements by other than the Ministry of Environment to cost some $884,000.

During the devastating three-day storm, hundreds of homes mainly in the Lower Fraser Valley were flooded. Hardest hit were the Chilliwack area, Port Alice and Rivers Inlet. More than 500 Fraser Valley residents went without heat and gas for three days. In the Fraser Valley, 19 people were evacuated. Solicitor-General Russ Fraser said that the storm had “created extreme problems throughout the province by generating severe flooding, mudslides and washouts of highways and railway bridges, breaking power and utility lines and making necessary an air evacuation of one community in the north central part of the British Columbia mainland coast.” By mid-November, flood damages were estimated at $13 million, including $2 million for road damage (*The Chilliwack Progress*, December 5, 1990). *1)

According to Chilliwack’s operations manager Gary Wicham, due to a combination of warm wind and heavy rains melting snow in the Chilliwack Valley, high water on the Chilliwack and Vedder rivers was the worst in about five years. *2) The dyking systems, put in place following a severe flood in Yarrow in 1975, worked well and minimised water damage to properties. In the rural farming community of Yarrow, basements and barns were flooded. Half a dozen Lumsden Road homeowners experienced flooding when the floodgate allowing Street Creek to empty into the Vedder River was closed at 8 a.m. on November 9. The Vedder River peaked at about noon. By 4:30 p.m., it had subsided enough to allow the floodgate to be reopened, thereby draining water from around residents’ homes. Elsewhere in the area, municipal crews shored up the bank next to a park board campsite on Giesbrecht Road. A private highway crew repaired Chilliwack Lake Road about 3 km upstream from the Vedder Bridge. Personnel from Canadian Forces Base Chilliwack also helped shore up the Soowhalie Indian Reserve near Cultus Lake. Some residents were removed from their homes. In Chilliwack, cleaning efforts were centered on shoring up riverbanks. In the Chilliwack area, some 500 residents were left without power since November 10. BC Hydro hoped to have power restored to residents on the north side of the river by late on November 12 and to the south side late on November 13. Roads that remained closed due to flooding on November 11 included Chilliwack Lake Road, Hemlock Valley Road and the eastbound lanes of the Trans-Canada Highway near Chilliwack.

During the heavy rainfall, Cypress Creek overflowed twice, causing extensive property damage. On November 21, West Vancouver council instructed its staff to form a plan to reduce future flood risk. The plan should give clear statement of culvert and channel deficiencies and their hazards and design solutions. *3)

On November 10, heavy rains caused a debris flow at Harrison Hot Springs. Three homes were damaged by "mudslides." On the same day, another debris flow demolished a home in the Chilliwack Valley (Evans, unpublished data). Mud 2 ft. (60 cm) deep pushed a house on East Yale Road off its foundations, destroying and cracking the new home in half. About midnight, when the three occupants were asleep, the steep hill behind the house gave way leaving the house at a 60-degree angle.

Emergency workers were unable to estimate how many houses were hit by mudslides but at least three were damaged in the Rockwell Drive area of Harrison Hot Springs. One house, unoccupied for the night, was hit by tons of shale and mud after a culvert above the house jammed.

On November 12, Southern Railway of British Columbia's (SRBC) 225-km railway line to its western terminus at Chilliwack was severed when a 16-m sidespan and a length of embankment of the Vedder River crossing's south side washed out. A 36-car SRBC freight train with two diesel engines en route from New Westminster to Chilliwack narrowly avoided disaster when it crossed the swollen Vedder River only minutes before a partial bridge washout.. The washout affected about a 20-m section of gravel railway bed immediately south of the steel bridge. It left a sagging section of rail line suspended about 3 m in mid air. The company was unable to estimate how long it would take to replace the crossing until floodwaters would recede.

On November 9, the highway to Port Renfrew closed due to flooding at Loss Creek, midway between the village and Jordan River. The road was expected to reopen on November 10. On November 9 at 7 a.m., floodwaters closed the Tahsis-Gold River road. It was expected to remain closed till noon on November 10.

Early on November 10, the Trans-Canada Highway was closed between Chilliwack-Hope because of three separate rock- and mudslides. Traffic was re-routed via the Rosedale Bridge to Highway 7 on the north side of the Fraser River. During the late afternoon on November 9, another section of the highway was reopened to single-lane traffic. Mud- and rockslides near Revelstoke and north of Chilliwack closed the Trans-Canada Highway till November 12. Chilliwack Lake Road, closed earlier about 3 km east of the Vedder Crossing bridge because of a mudslide, reopened as far as the Tamihi bridge. Here, a crew continued to rebuild the bridge knocked out by flooding on the Chilliwack and Vedder rivers. Highway 14 between Victoria-Port Renfrew was reopened to only single-lane alternating traffic.

As water levels in the Upper Squamish and Cheakamus rivers rose rapidly, RCMP warned about 75 Squamish residents to prepare to flee their homes.

In November 10, a large flood event occurred on the Coquihalla River. *4) The 610-mm oil pipeline was exposed and slightly damaged by scour in the riverbed at a crossing at 996.2 km, approximately 15 km upstream of Hope. Due to high water levels in the river, the damage was not discovered until August, 1990. The exposed pipeline became a serious operating and environmental concern to the Trans Mountain Pipeline Company Ltd. (TMPL). Temporary repair and protection was carried out during September, 1990. The river was routed around the site by excavating a diversion channel and constructing a cofferdam. Subsequently the instream work was carried out (Rice et al. 1992).

On November 9, a debris torrent occurred at a creek near Quatsino on the west coast of Vancouver Island (Andrews 1993). The mudslide smashed a home off is foundations onto the beach below. The damage was estimated at $80,000. The roof was the only part not destroyed.

A debris avalanche on the west slope triggered the torrent that occurred on Little Creek. This avalanche comprised a failure of the thin veneer of soil and organics together with the tree cover sliding over the underlying conglomerate bedrock. The avalanche was located on the north boundary of a small block that apparently was cleared (clearcut) in the 1950s. It extended up to elevation 300 m but was a little more than 20-30 m wide. The total of debris, including trees, deposited on the fan above sea level was estimated at 20,000-30,000 m^3. Discharges as high as 200-400 m^3/s (10-20 times the estimated 200-year flood) could have occurred upstream of the fan during the event. The debris torrent deposited gravel on the alluvial fan and destroyed two houses. A third house, located on the left bank, was not destroyed but deemed unliveable by the District.

The prime cause of the torrents on Little and Green creeks appeared to have been the lengthy period culminating in high precipitation. In Owikeno, which was flooded, an unfinished house was demolished.

After the Wannock River burst its banks on November 9, fifteen residents were evacuated from the tiny Rivers Inlet Indian village. As it falls under federal jurisdiction, the provincial government would not cover the damage in the Native Indian village of Owikeno. *5)

A debris torrent event also occurred on Green Creek. This torrent terminated at a bend in the creek. It resulted in the deposition of a substantial quantity of wood debris (logs) as well as sand, gravel and boulders up to 0.5 m. Some floodwater overflowed the creek banks, flowing down a water supply ditch excavated in October 1989 and through a cleared area adjacent to a house. *6) The channel of the creek was completely infilled with gravel. Also a community water supply was damaged.

In the aftermath of the November 9 storm, some Colwood residents found subterranean water bubbling through floorboards. The heavy rains had built up water in the soil bank behind the one-year old subdivision off Sooke Road on Cecil Blogg Drive. The water flowed through the soil, bubbling up in springs on new lawns and through the floorboards of the new homes. Engineer Gary Smirfitt noted a "tremendous bubbling of water even one-and-a-half days after the rain stopped." He said there had never been water problems in the area for 20 years (*Times Colonist*, November 21, 1990).

In November during heavy rains, three mudslides took out road sections northwest of Sooke (West Coast Road? / date event unknown) (*Times Colonist*, November 10, 1990).

Summary of watercourses impacted during the November 9, 1989 flooding and costs: Blue Creek; Carratt Creek ($10,000); Cheakamus River ($4,000); Chilliwack River ($882,200 and $350,000 enhancement); Coquihalla River ($189,500 and $25,000 enhancement); Deroche Creek ($35,000); Frosst Creek ($80,000); Hereford Creek ($5,000); Lorenzetta Creek ($5,000); Munroe Creek ($15,000 and $18,000 enhancement); Norrish Creek ($1,000 and $26,000 enhancement); North Alouette River ($17,000); Pattison/Lagace creeks ($57,500 and $39,000 enhancement); Pye Creek ($3,000); Scott Creek (slide at 2622 Uplands Court); Siddle Creek ($10,000); Silverhope Creek ($142,000); Squakum Creek (outlet of Lake Errock); Stawamus River ($5,000); Vedder River ($211,000); Sumallo River; Whonnock Creek ($45,000)(Nesbitt-Porter 1989).

Some of the damage included: Blue Creek (culvert blockage under Maple Falls Road); Cheakamus River (Outdoor School: South Dyke: loss and dislocation of riprap slope); Chilliwack River (At "Corrections Camp" development several of the about 30 buildings were lost; at Soowahlie I.R. No. 14, involving protection for Lumchen Village Trailer Park off the reserve, development of a left bank channel directed major flows across the Department of National Defence rocket range and other Indian lands, flooding Indian homes necessitating evacuations); Coquihalla River (debris deposits along highway at Glenhalla subdivision due to blockage of Thacker Creek culvert); Morton Creek (overflowed isolating one dwelling); Hatzic Island and Prairie (flooding of Everglades Resort and adjacent, mostly recreational properties caused significant damage); Lake Errock (Erroch) (inadequate CPR box culvert caused flooding of road and houses at western end of the lake); Silverhope Creek (at and upstream of Silver Lake, cost of removal of six logjams was estimated at $100,000); Squakum Creek (inadequate culvert through railway embankment or downstream channel);

---

*1) On December 13, the provincial cabinet approved $8 million flood assistance for damage incurred in November. But the Provincial Emergency Program later announced that only about $2 million would be available to individuals and municipalities with the remainder going to provincial ministries. In late December, an additional $700,000 funding would be announced for eight projects in the Chilliwack Valley that required immediate action (*The Chilliwack Progress*, December 5, 1990; *The Vancouver Sun*, December 15, 1989).

*2) According to Dr. N. Todd, the recent flood on the Chilliwack River, which wrecked the Tamihi Bridge and caused other severe damage, "was due in good measure to the very extensive clear-cut logging carried out in the surrounding areas." (*The Province*, November 24, 1989).

*3) In the mid 1970s, the firm of Dayton and Knight Ltd. had recommended a $14 million water management plan for the municipality but this was never undertaken (*The Vancouver Sun*, November 22, 1983).

*4) Significant changes in river morphometry had been observed in recent years in the Coquihalla River (Miles et al. 1979). Factors included increased sediment load introduced by tributary streams and channel shifting; localised straightening of the river channel due to highway construction resulting in increased river slope and greater potential for channel incision; and channel confinement between long linear riprap banks placed to protect the various right-of-ways which tends to increase water velocities and scour potential (Rice et al. 1992).

*5) Though these two watersheds had been partially logged, this occurred some 30 years prior. Forest researchers have shown that the root strength in the organic layer will have been virtually re-established over such a period. Also, the debris torrent/flood event that affected the Owikeno Village on that same day occurred in an unforested watershed. It is thus reasonable to conclude that past logging of these creeks was not a significant causative factor.

*6) Similar debris torrents have previously occurred on Green Creek. The 1980 aerial photographs, taken prior to the recent logging on privately owned land, showed distinct evidence of a recent torrent, which terminated at approximately the same location. Two debris avalanches and a rockslide area were observed in the headwaters of the creek.

November 22, 1989
Source: *East Kootenay Newspapers Weekly*, November 29, 1989; Evans, unpublished data.
Details: On November 22 at 6:30 a.m., a gigantic coal mine waste slide occurred in Kilmarnock (Evans, unpublished data). *1) The 100,000-m^3 failure at Greenhill near Cataract Creek slid outside the approved dumping areas, covering three settling ponds.

According to a Westar Mining press release, due to the indication that the dump might fail, the company had ceased dumping in the area. Of the 270-m high and 800-m wide dump area about 400 m was being used for dump purposes. The dump area was about 4.5 years old. Of the 400 m that were active, about 150 m slid. The spill stopped the flow of Cataract Creek, described as “about three garden hoses strong” before the failure, stopped. *2)

---

*1) A similar slide occurred at this location on May 31, 1993 (Evans, unpublished data).

*2) Due to a waterfall at the junction with Fording River, the creek is non-fish bearing (*East Kootenay Newspapers Weekly*, November 29, 1989).

Early 1990s
Source: *The Squamish Chief*, October 17, 1995.
Details: In the early 1990s, a major slide occurred into the Stawamus River. At the time, a natural gas pipeline was installed through the watershed. With only anecdotal data about the level of sedimentation in the river before the pipeline, it is hard to quantify its impact.

January 22-30, 1990
(Fatal avalanches).
Source: *British Columbia Report*, February 12, 1990.
Details: Starting January 22, following several weeks of above average temperatures and below normal precipitation, heavy snowfalls occurred in southern British Columbia. At least 36 cm fell on cities from Nanaimo to Nelson. Mountain passes like the Kootenay along the Salmo to Creston highway received nearly 100 cm in nine days.

Between January 28-30, avalanches claimed the lives of three skiers. On January 28, a Toronto computer executive was buried alive under 10 ft. (3 m) of snow near Fernie. Three other people trapped by the cascading snow were saved. On January 30, an avalanche some 12 km north of Nelson in Kokanee Provincial Park killed a father and son.

April 9, 1990

Source: *The Daily Courier*, April 10, 1990; Evans, unpublished data.

Details: On April 9 at 6 a.m., mining operations caused a rockslide at the Brenda Mine west of Peachland. A drill and other mining equipment were damaged and the mine as closed by the slide. With an estimated volume of about 2 million m^3 this was one of the largest open-pit failures documented in the Cordillera. It took place in a 333-m high slope at the open pit mine (Evans, unpublished data).

The mine had been closed since April 4 after engineers documented movement in the west wall, which had never moved before. *1) The slide not only came straight down the west wall but also swept towards the south wall throwing a 50-ton power shovel 50-75 m into a drilling rig. Also a smaller rockslide occurred on the northwest wall. Minor rockfalls were expected to continue for some time. The force of the rockslide was so great that it measured 2 on the Richter scale. According to Bob Horner, seismologist at the Pacific Geoscience Centre in Victoria, the most significant readings occurred at Penticton, Haney, Vetter Mountain and Whistler but the slide was also recorded at other stations scattered around the Lower Mainland.

---

*1) The mine opened in 1970. It had a life expectancy of about 20 years. Brenda Mines had planned to go down one more step, or another 13 m, to recover another 2 million tons of ore. But the bottom of the pit was now covered with waste 45-140 m deep. At a cost of $1 a ton to excavate the waste rock, it was no longer deemed economical to mine that ore. Consequently, the mine would close three weeks earlier than planned, throwing 340 people out of work (*The Daily Courier*).

May 1990

Source: *The Daily Townsman*, May 29; June 1, 1990; *Nelson Daily News*, May 30; June 1, 1990; *Creston Valley Advance*, June 4, 1990; VanDine 1992.

Details: On May 29, St. Joseph's Creek near Cranbrook had "swollen to its highest point of the year." The City of Cranbrook warned children to be wary when playing near the creek. *1)

Early May 30, a small mudslide came down onto Highway 6 between Cape Horn Bluffs-Silverton. The slide in the Red Mountain area knocked logs and boulders on the highway and closed it to traffic was still moving at 10 a.m.

In May, four debris flows/torrents came down in the Slocan Valley. Associated with logging, they blocked the highway in four locations, destroyed a small hydro plant, water supply, and went on both sides of a residence.

In May, a series of low-pressure systems caused record amounts of precipitation. in Nelson, Creston Valley and Cranbrook. *2) The "wettest May ever in the Arrow Forest District" interrupted logging operations in the area. The wet weather in May caused three (other) slides near Cape Horn Bluffs; at Memphis Creek, Van Tuyl Creek and Cory Creek. According to the *Nelson Daily News*, there were no forestry operations in these locations. Overnight May 31-June 1, 1 ft. (30 cm) of snow fell in the Kootenay Pass.

---

*1) During the spring runoff more than 10 years earlier, a pre-schooler had slipped into the creek and drowned (*The Daily Townsman*, May 29, 1990).

*2) Nelson with 139.2 mm broke the previous record of 102.8 mm. In the Creston valley it rained 20 out of 31 days, totalling 114.9 mm. With an average of 45 mm, only two months of May were wetter since record keeping began at the Creston station: 1961 and 1942 with 141.2 mm and 105.9 mm of rain, respectively. Precipitation in the east Kootenay region set a new record, breaking the previous one set in 1981 with 90.9

mm by more than 30%. In May, Cranbrook reported rain on 22 days out of 31, totalling 118 mm (*The Daily Townsman*, June 1, 1990; *Nelson Daily News*, June 1, 1990; *Creston Valley Advance*, June 4, 1990).

June 11-13, 1990
(Rain-on-snow?).
Source: *The Vancouver Sun*, June 13, 14, 15, 16 and 22, 1990; *The Province*, August 2, 1990; *The Globe and Mail*, August 3, 1990; *British Columbia Report*, February 25, 1991; Beal 1990; Anderson et al. 1992; VanDine 1992; Cass et al. 1992; Evans, unpublished data; Ministry of Environment files.
Details: During the early part of June, four large areas (Okanagan, Kamloops, and Prince George including Williams Lake and Dawson Creek) experienced flooding. Heavy rains caused flood and erosion damage to properties along many Okanagan River tributary systems. The Okanagan River also experienced widespread damage and flooding.

In June, unprecedented rainfall in the Enderby area led to a large number of debris flows and debris avalanches along a 4-km stretch of the southern end of Hunter's Range, 20 km east of Enderby. Debris flows partially or completely destroyed four BC Hydro transmission towers, each with a replacement value of $500,000 in 1992 dollars (Anderson et al. 1992), temporarily disrupting power transmission from the Revelstoke Dam (Evans, unpublished data). During the same storm event, 61 debris avalanches and debris flows occurred near Enderby. Twelve of the tracks reached the highway (VanDine 1992). Homes were damaged and a hydro line severed (Evans, unpublished data). A Stone Creek house tipped over into the river and floated away. Four houses were hit and destroyed by a mudslide in the Fall Creek area about 40 km north of Vernon. Bill Arcand, whose house was hit first, described the event as "there was a huge rumbling noise and all hell broke loose." The first rumblings came on the afternoon of June 11 when neighbours heard trees snapping.

Between June 11-13, six debris failures occurred on the hillside above Philpott Road in the Okanagan community of Joe Rich, about 30 km east of Kelowna. The community of about 20 families lies in a small valley surrounded by mountains. Most of these failures crossed Philpott Road at the base of the slope. The largest, a debris avalanche with an estimated magnitude of 23,000 m^3, engulfed a house and outbuildings and caused the death of three people and $10 million worth of damage (*British Columbia Report*). *1) Though the other five flows were channelled, the main event occurred on a hillside with no previous record of debris failure.

The debris avalanche/flows occurred during a 1:100-1:400 year storm event. There was no known geological evidence or history of previous events but was associated with logging (VanDine 1992). *1) The events occurred near the end of a long period of above average precipitation between May 22-June 12. For most of May, an offshore ridge of high pressure maintained a fairly moist northwesterly flow over most of British Columbia. Conditions were generally unsettled with showery precipitation (Beal 1990). The 42 days preceding the slide were the wettest on record.

Though the events occurred in June, some of the precipitation fell as snow and rain-on-snow at the higher elevations. The hillside on which the debris avalanche occurred was heavily forested, but parts had previously been selectively logged and recent clearcut areas were present on the lower slopes and on the plateau above the failure. The slide was triggered in a timbered area about 300 m below a clearcut.

The debris avalanche travelled 800 m down the hill slope above Belgo Creek on an average slope of 18 degrees. It took an estimated period of 45-60 seconds between elevations 1,250-975 m and speeds were estimated to be in excess of 10 m/s. For most of the length of the avalanche, the dense tree growth was entirely removed except for some stumps that remained in their growth position. At an elevation of 1,020 m, possibly as a result of reduced energy levels at a change of slope the avalanche split in two, leaving an island of standing trees. The 23,000 m^3 debris avalanche was a first time event, but examination of the terrain above Philpott Road showed that it was a likely area for debris flow and debris avalanche activity.

Following the slide, the road was closed and residents from about 12 homes in the area were evacuated. Ede Axelson, one of the neighbours said she heard a load roar at about 2:30 p.m. "I ran to the window and saw trees flying like match-sticks and power lines whipping. It took all of a minute and a half." Axelson and a few others tried to help search for the people but the mud was too deep. "We were up to our

waists in mud. And once you put your foot in, it stuck fast like cement." The slide also cut phone and power lines in the area.

Mudslides also washed out about 8 km of the 40-km Enderby to Mabel Lake road. According to an RCMP officer, the "mountain was coming down, basically. Apparently in places the mud is up to 5 ft. (1.5 m) deep across the road." A helicopter rescued more than 30 residents stranded by the slide.

Washouts and slides also closed sections of three highways and reduced the Trans-Canada Highway near Revelstoke to one lane. A mudslide on Highway 97A blocked all traffic between Grindrod-Sicamous.

On June 11, two people were killed at Vavenby, 20 km north of Clearwater. The father and son were trying to clear a blocked culvert when a mudslide hit them. The slide blocked Highway 5, which remained closed on June 13.

Late on June 12, some 50 residents near the Big White Mountain resort southeast of Kelowna were moved to an arena in Rutland as a precaution of them being trapped by floodwaters. Most of the damage around Kelowna was due to the rising waters of Okanagan Lake, which were projected to rise even higher during the next week (*The Vancouver Sun*, June 22, 1990). Even residents owning waterfront property relatively high above the rapidly rising waters of Okanagan Lake were watching their docks disappear. One resident noted, "normally my dock would be about 15 in. (37.5 cm) above high water in June. Right now the water is lapping over it." On June 15, Okanagan Lake rose another 2.7 cm. Weather forecasters were predicting the lake to continue to rise about 3 cm/day until it would peak in about a week. Lakeshore residents continued to sandbag their properties. One residence at the mouth of Mission Creek, which drains the snowmelt from Big White Mountain into the lake, already had the basement flooded.

On June 16, the Fraser River was still rising steadily; it was not expected to rise above its initial flood warning level of 6 m within the next few days. At Mission, the river depth was now 5.5 m. During the spring runoff, the Fraser River debris trap collected an unusual large amount of debris. According to Bob Bowden, a sub-contractor for the B.C. Debris Control Board since its Fraser River debris trap was constructed in 1979, there had only been a few other years when the channel was so full of debris (*The Vancouver Sun*, June 14, 1990). *3)

Summary of sites damaged by the June 1990 flood: (Okanagan sub-region): Okanagan Channel ($189,911); Vaseaux Lake ($17,008); Mission Creek ($69, 240); Falls and Joe Rich creeks (228,003); Shuttleworth Creek; Naramata Creek ($54,856); Ashton Creek ($7,735); (Thompson-Nicola region): Deadman Creek ($28,673, $16,286 and $1,742); Bonaparte River ($24,653, $40,447, $20,073 and $13, 599); Big Bar Creek ($15,321); (Williams Lake area): Moffat Creek ($18,591); Australian Creek ($11,387).

---

*1) Floods in northern and interior parts caused an estimated $10 million damage. On June 21, the provincial government approved its initial $10 million fund for emergency assistance to flood victims in southeastern British Columbia (*The Vancouver Sun*, June 22, 1990).

*2) A British Columbia Forest Service report on the fatal mudslide concluded that clear-cut logging was one of the five factors that combined to trigger the event. The two main causes were heavy rainfall and inherently unstable terrain in the area. "Clear-cut logging increased the peak rate of water flow by about 20%," said Forests Minister Claude Richmond. Other contributing factors were water from a small stream that was redirected down an old logging road and road construction, which increased the drainage area that fed the mudslide. (*The Globe and Mail*, August 3, 1990).

*3) The Fraser River debris trap is a man-made 1-km long log boom, which guides floating debris into an artificial channel that parallels the river. It was designed and built to capture the floating logs and other debris that would otherwise plague boaters farther downstream and in the Strait of Georgia and litter the Greater Vancouver beaches (*The Vancouver Sun*, June 14, 1990).

July 6, 1990

Source: *The Province*, July 8, 1990; *Revelstoke Review*, July 11, 1990.

Details: On July 6, two mudslides and a washout about 25 km west of Revelstoke hit the Trans-Canada Highway. At 2 p.m., a mudslide 13 km west of Victor Lake reduced traffic to single-lane. At 4 p.m., a larger slide 50-60 ft. (15-18 m) wide and 2-6 ft. (0.6-1.8 m) deep came down in the same location. It pushed a car off the road. The mud rose about 2 ft. up the side of the car. There were no injuries. The Trans-Canada Highway closed for two hours. After that, the highway reopened to single-lane traffic until cleanup was finished on July 7 at 1:40 p.m.

October 4, 1990

Source: *The Vancouver Sun*, October 5, 1990; *Hope Standard*, October 10, 1990; *Times*, January 23, 1991.
Details: In early October, Hope reported record rainfalls. On October 3, 33.1 mm fell (breaking the 1947 record of 25.1 mm) and on October 4, 109.6 mm (breaking the 1939 record of 30.0 mm). *1) By November 5, a total of 193.0 mm had fallen, surpassing the monthly November average of 180.2 mm. Though 118.2 mm of rain was recorded in the lower Fraser Valley, no major flooding was reported.

Heavy rains caused three landslides about 70 km north of Pemberton. Early on October 4, the debris flows blocked the Meager Creek bridge to the parking lot leading to the hot springs. Five stranded tourists were later taken out. A slide at nearby Canyon Creek damaged a maintenance shed of CRB Logging of Squamish.

During the Thanksgiving weekend flood, the Nooksack River caused flooding in the Abbotsford area. Otto Dykman's dairy farm on Vye Road lost 300 ac. (120 ha.) of forage. In compensation for having to move his hundreds of cattle to safety, damages to barn and machinery he received about $100,000 from the Provincial Emergency Program. For the $28,000 damages to his house, Dykman only qualified for about $13,000. Nearby on Kenny Road, Farmer Ted Faber suffered a flooded basement and lost three semi trucks of hay and 600 tonnes of alfalfa pellets. Abbotsford's "immediate response costs" for the flooding totalled $68,000.

---

*1) On November 4, Hope also recorded the highest rainfall for any day in October, breaking the record of 101.3 mm set on October 25, 1945 (*Hope Standard*, October 10, 1990).

October 20, 1990

Source: *Prince Rupert Daily News*, October 23, 1990; *The Vancouver Sun*, October 22; November 3 and 7, 1990; *PEP Talk*, December 1990.
Details: On October 21 at 12:49 a.m., an estimated 10,000 m^3 of rock and debris came down on Highway 99 north of Lions Bay. Other sources put the volume of debris of the slide that covered 100 m of the highway 9 m deep at between 5,000-7,000 m^3. (*The Squamish Times*, October 24, 1990). The debris slide closed the Squamish Highway 4 mi. (6.4 km) north of Lions Bay for several days. The highway was closed at about 11 p.m. after a few boulders fell in the Tunnel Point area. An hour later, the main slide, which was attributed to recent rainfall in the area, buried the highway. The BC Rail main line beneath the road was also put out of service when debris fell on 30 m of track.

The slide trapped thousands of Lower Mainland residents attending the weekend Oktober Fest at Whistler. Because the only other passable road to the area was the site of a blockade by Mount Currie Indians, the slide effectively cut off Squamish, Whistler and Pemberton.

The Squamish PEP set up an emergency operations centre. The Ministry of Forests brought in mobile kitchen and toilet facilities from Kamloops. During a single day, meals to as many as 1,600 people were served. The slide created a bonanza for water taxi and helicopter operators. Harbour Ferries sent their chartered 495-passenger cruise ship *Britannia* to take stranded people back to Vancouver's Coal Harbour. On October 21, Vancouver Helicopters Ltd. had six of their helicopters making 64 trips to Vancouver from Squamish and Whistler. On October 23, BC Ferries established a free ferry service between Darrell Bay-Vancouver. Their *MV Nicola* and *MV Vesuvius Queen* pressed into service carried a total of only 46 vehicles, making round trips to Horseshoe Bay about every five hours.

On October 25 around 1 p.m., five men working on clearing the slide were hit by another rockslide. The slide struck shortly after six scalers had gone to the slope to clear loose rocks following a dynamite

blast. The men had been working in a gully at the slide area. Some rock fell from 800 ft. (240 m) above the workers. A huge slab of rock broke free above them, shattering as it fell and dislodging other debris. One of the scalers found unconscious with his head wedged between two boulders was flown by helicopter to the Vancouver General Hospital emergency ward.

The highway, which had been scheduled to reopen at 6 p.m. that same day, was now closed indefinitely. The slide area began near the base of a sheer rock face about half way up the mountain. Falling rock and debris had created a steep smooth chute that reaches its narrowest point just above the highway. The road was covered in a rubble swath about 30 m wide.

By midday on November 2, the Squamish highway reopened after a 13-day closure (*The Vancouver Sun*, November 3, 1990). Over the next two weeks work continued to stabilise the slope and putting a new permanent road surface. During the 13-day highway closure, Maverick Coach Lines, most of whose business was between Vancouver-Whistler/Squamish had two buses operating north of the slide The company saw its ridership fall from approximately 400 per day to just 25, most of whom rode from Pemberton to Whistler.

November 6-13, 1990

(Rain-on-snow).

Discharge (m^3/s): Max. daily: November 12: Squam.: 2,060; Stamp G.: 328; max. instant.: November 11: L. Qual.: 77.9; November 12: Squam.: 1,720; November 13: Stamp G.: 315.

Source: *The Vancouver Sun*, November 20, 1989; November 9 and 10, 1990; *Times Colonist*, November 10 and 17, 1990; *Alberni Valley Times*, November 13 and 15, 1990; *Prince Rupert Daily News*, November 13, 1990; May 14, 1993; *The Province*, November 12, 13, 14 and 21, 1990; *The News/Abbotsford, Sumas and Matsqui News*, November 14, 1990; *The Squamish Times*, November 14, 20 and 27, 1990; *The Chilliwack Progress*, November 14 and 21, 1990; December 5, 1990; December 1, 1995; *The Fraser Valley Record*, November 14, 1990; *News Record Weekend*, December 8, 1990; *Abbotsford Times*, November 14 and 21; December 5 and 19, 1990; *Times Colonist*, December 22, 1990; *Goldstream Gazette*, December 12, 1990; *British Columbia Report*, November 26, 1990; *PEP Talk*. Vol. 2 No. 1, Spring 1991; *The Sounder*, February 1993 Vol. XX No. 5. Fisheries and Oceans, Pacific Region; Memorandum Re. Lower Mainland Remembrance Day Flooding. P.J. Woods, November 15, 1990; B.C. Ministry of Forests 1990a; McMullen 1990; Fannin et al. 1992 (pp. 311-318); Rice et al. 1992 (pp. 347-354); Bowman 1992 (pp. 23-25); Andrews 1993; Bland 1992 (p. 3); Egginton, pers. comm.; Evans, unpublished data; Ministry of Environment files 55.4803(02)/P90-10 and 280-20/ADM; File 280-20/204-20/FEP; Memorandum Re. Lower Mainland Remembrance Day Flooding. P.J. Woods, November 15, 1990.

Details: On November 6 at 11:30 p.m., the highway closed again only four days after reopening. At the same site 16 km north of Horseshoe Bay, another slide consisting of all small rock came down (*The Vancouver Sun*, November 7, 1990).

On November 8, torrential rains caused flooding in large areas in southern British Columbia and northwest Washington. The worst of the flooding was concentrated in the Fraser Valley and on Vancouver Island. In the Fraser Valley, 12 in. (300 mm) of rain fell, causing floods at Sumas Prairie, Hatzic Prairie, and the Chilliwack River Valley. At least seven traffic deaths were attributed to the storm. In the Fraser Valley some 17,000 turkeys and chickens drowned. The storm beginning November 8, caused heavy damage on Vancouver Island, the Coast Mountains and the Lower Mainland, up the Fraser Valley into Hope. *1) The sub-tropical mass of warm, moist air from Hawaii became lodged in the area for almost a week. The storm was a high-intensity, long-duration storm. It exceeded the 25-year records at Whistler and Abbotsford and the 100-year record at Hope. Rainfall data for east Vancouver Island indicated a five to 10 year record and a 25-year record for the west coast of Vancouver Island (B.C. Ministry of Forests 1990a).

In November, both Squamish A and Squamish STP Central weather stations experienced very heavy precipitation achieving their wettest months on record (Squamish A 1982-2002, Squamish STP Central 1986-2002). Squamish A had the most precipitation with 916.9 mm compared to the November normal of 410.3 mm. This station also recorded three days of greater than 100 mm of rain in 24 hours: on November 10 with 164.4 mm and on November 22 and 23 with 123.8 mm and 101.6 mm, respectively. Squamish STP

Central also recorded heavy precipitation on these days, with the greatest amount for the month falling on November 10 with 113.8 mm.

Seymour Falls experienced the wettest month with 1528.2 mm for their 1927-2002 record. This is nearly three times the November normal of 565.5mm. Squamish A, Pemberton A and Whistler also reported their wettest month in their 1982-2002, 1984-2002 and 1976-2002 records, respectively. Abbotsford A reported the second wettest November and fourth wettest month overall on its 1944-2002 record and Chilliwack its the third wettest month and wettest November on its 1879-2002 record. Hope A, recorded the wettest month for the 1934-1995 period. (Egginton, pers. comm.).

On November 10, Vancouver recorded 34.6 mm of rain, setting a record for that date. On November 9, Langford recorded 114 mm of rain. Between November 9-11, Stave Lake recorded 13.5 in. (342.9 mm) of rain. Since the beginning of the month, Pemberton A had seen rain almost every day for 16 days totalling 219.7 mm. Daily mean temperatures at all of the climate stations throughout the area were up to 7-8^{o} C above normal for the period. On November 9, Whistler and Pemberton A reported 20 cm and 14 cm, respectively, of snow on the ground. By November12, the snow at both locations had completely melted. (Egginton, pers. comm.)

During the November 9-12 period, heavy rain combined with snowmelt caused extensive flooding throughout the Hope-Chilliwack area and Vancouver Island. In the Lower mainland, extensive erosion took place along the Chilliwack and Vedder rivers. In the southern Interior, flooding occurred in the area around the Village of Tulameen.

On November 9-10, record rainfalls hit the Fraser Valley, causing “some of the worst flooding in memory.” The extremely heavy rainfall throughout much of southwestern British Columbia melting snow in some areas caused localised flooding in many areas. In the Lower Mainland, extensive erosion damage occurred along the Chilliwack and Vedder rivers. For the second year in a row, the Chilliwack River flooded its banks, washing out roads and carrying away houses and vehicles (Bowman 1992). High Fraser River levels also affected pumping through the Barrowtown pump station. Hundreds of homes/farms were affected through lost access and/or direct flood damage. During the flood response, some $2.3 million was spent. (Ministry of Environment).

While most Chilliwack River valley residents had electricity and telephone service during the recent floods, other valley areas were without services for up to five days. Residents above the Tamahi Bridge, including provincial correction camps, a fish hatchery and a seedling nursery were affected. A road washout about 0.5 km beyond the bridge prevented telephone and hydro crews from repairing damage till late on November 14. About seven poles in a row were washed out in the flood and there was no ground left to install new lines. After highway crews were able to repair the road, it was discovered that more lines were down further up the road.

In the Upper Fraser Valley, the flooding Chilliwack River destroyed three homes and one was “in jeopardy.” On November 9, the Chilliwack River rose 2-2.5 m, flooding the Chilliwack Lake Road. A home on Chilliwack Lake Road was expected to be lost as the river, that had flowed more than 200 m behind the two-storey house, stripped away trees and property and toppled a balcony that once overlooked the backyard. The Chilliwack Lake Road washed out in two sections. Early on November 10, it washed out about 2 km east of the Vedder River bridge and further east another washout took out both lanes of the road for several hundred yards. At Wilson Road, workers laboured through the night to raise the dyke level 3-8 ft. (0.9-2.4 m) in places. The river threatened to break through the dyke at Osborne Road and to send a new river channel towards more homes and the On The Way store. Chilliwack Lake Road reopened on November 12.

Chilliwack River valley residents were struck with floods again almost to the same day as the previous year. *2) The November 1990 flooding, however, was worse; floodwaters washed away at least two homes on Neville Road and leaving another clinging to the riverbanks. The only difference was that in this year’s Chilliwack River flooding electricity and telephone service were maintained and an emergency response plan, still in its draft form, gave some measure of preparedness. On November 10, Chilliwack Search and Rescue members led three people to safety when floodwaters completely surrounded the Walker residence at 48300 Chilliwack Lake Road near Ryder Creek. The elderly resident was evacuated from a

mobile home in the property's backyard. The river rushed over its banks with enough force to push the mobile home off its foundations. Jack Coutts' Chilliwack River Valley Honey business lost most of its buildings as the river eroded away at least 6 ac. (2.4 ha.) of ground the operation stood on. A recreational vehicle park was flooded. There were also reports of residents moving mobile homes to escape floodwaters. Debris was also a problem in the river. Severe flooding caused extensive damage to the banks of the Chilliwack River. On November 11, two-thirds of Vincent O'Hanley's property of 0.33 ac (0.13 ha) along the Chilliwack River vanished.

The Chilliwack River came close to destroying millions of fish at the Chilliwack River Hatchery. Besides knocking out power and telephone lines, the unpredictable Chilliwack River changed course, threatening to leave the hatchery without water. *3) The river moved away from the hatchery's intake channel, forcing workers to use an excavator to clear debris and build an emergency channel back to the river. According to local fisheries officer Wayne Furness, early estimates indicated that at least half of that year's salmon run could have been destroyed. "Sixty to 70 per cent of our spawners were already in and most of that is lost," Furness noted. According to Otto Rapp, senior project engineer with SEP, the ongoing erosion widened and shifted the main channel of the river. It triggered eight serious landslides, which deposited hundreds of thousands of cubic metres of clay, silt, sand and gravel into the river. It resulted in a cloudy, unfishable river. Of the eight landslides identified, three required immediate short-term remedial works.

On Hatzic Prairie, farmers moved livestock to higher ground. Long-time Hatzic Prairie resident Doug Anderson said it was the "worst flooding he had experienced" and it was the first time he had to consider moving his cattle to safety. Highway maintenance crews had to cut the pavement on the Lougheed Highway to replace gravel that had been washed away from the abutments of the bridge over Hatzic Lake. Water rushing towards the Fraser River had eroded the bridge approaches. By the afternoon of November 12, the Fraser River had dropped almost 3 ft. (90 cm), enough to allow the flood control gates to open and release the accumulated water from the Hatzic Lake system. According to June Froese, co-manager of Everglades Resort, Hatzic Lake rose about 1 m, the highest it ever came up in the 15 years she had worked here. At Hatzic Lake, the Everglades Trailer Park once again flooded. By November 20, many homes at Hatzic Lake were still flooded. *4)

Near Mission, low-lying areas flooded and two landslides came down on Pattison Creek, above an existing slide. During the storm, one bridge washed out, isolating Stave Lake prison camp. A logjam threatened a second bridge. In Mission itself, the most serious flooding occurred in the Hatzic Estates area where Hatzic Lake rose to more than 4 ft. (1.2 m) above the summer water level. Several houses on Benbow Street were isolated, flooding basements and homes. Elsewhere in Mission, several minor floods occurred and some streets were closed till drainage could be improved. A beaver dam was removed from Lane Creek to allow the free flow of water out of the industrial area. Another beaver dam was taken out next to Dewdney Trunk Road near Steelhead. Several embankments collapsed and blocked roads, particularly on Stave Lake Street near Knight Avenue and on Hayward Street and Silverdale Avenue. On Townshipline Avenue, a new driveway was being blamed for blocking a ditch, resulting in some flooding and damage to the roadway.

The extensive flooding that occurred through the Remembrance Day weekend in Sumas Prairie was due to high flows on the Sumas River coupled with overflows from the Nooksack River in Washington. *5) Overflow from the Nooksack River in Washington resulted in flooding of the western Sumas Prairie area. On November 9, flooding occurred in the downtown area of Sumas (Andrews 1993). Sumas Prairie West near Abbotsford was flooded after the Nooksack River in Washington broke its dyke. A wave of water swept across a railway track and flooded at least 50 low-lying farms and houses. The water also poured across Highway 1 just east of Abbotsford, cutting off the main highway link with the east. The Nooksack's "natural overflow" into its tributary Johnson Creek flooded Sumas. The flooding started at 9 p.m. on November 10 and reached its peak early on November 11. A burst Nooksack River dyke also caused floods that closed the highway near the Whatcom Road exit on November 11.

Abbotsford farmers lost millions of dollars in livestock, feed and equipment when water broke through a 50-m section of the Southern Pacific railway track and swept across Sumas Prairie to the freeway.

At least 300 head of cattle and 1,000 pigs were evacuated from farms in rural Abbotsford. Sumas Prairie farmer Henk Arends lost 4,500 turkeys. Arends was one of several farmers in the Angus Campbell area whose farms were devastated by floodwaters. The previous year's floodwaters had swept past the tracks but not reached his property. Ben Doerksen lost 200 piglets and other farmers lost 12,000 chickens. Al Fadden, operating Sadholm Farms on Whatcom Road and one of two dozen farmers hit by the flooding suffered damage when his barn flooded. It was the first time since Fadden's grandfather suffered flooding in 1935.

The District of Abbotsford sustained up to $500,000 damage to water mains and roads. Rural residents were warned to boil their drinking water after four water mains broke. Sumas Way, Old Yale Road and Delair Road were closed after sections of these flooded. On the evening of November 10, Barrowtown and Yarrow residents were stranded from getting home. Areas around Hatzic Lake were also under water. The basement of the Huntingdon Canada Customs building flooded, destroying customs records. On the night of November 12, Sumas' main street remained closed. Pending examination for structural damage, bridges also remained closed. In the Vedder River area, the railway was cut after a large logjam washed out half of the blocked culverts. But the set back dykes prevented flooding.

At the about 200-m long Ranger Run cutbank, located just downstream from where Slesse Creek joins the Chilliwack River, the old channel was plugged and a new channel cut after the river diverted. The new channel, along the left side of the mid-channel bar was the historical main channel prior to the flood of November 1989. Slesse Park was covered with logs and debris. During the diversion project, the Chilliwack River had to be blocked during a fairly high water period. In August 1991, the banks of the diversion channel were riprapped and additional spur dykes were constructed (*The Sounder*).

On November 8-9, the Hope weather station recorded 333.6 mm of rain. On November 9, a total of 173.1 mm fell in 24 hours, breaking the single day record of 142 mm set on December 2, 1975. An additional 130.5 mm fell during the next 12 hours. Several roads leading to the hub-town of Hope were blocked. At one point over the Remembrance Day weekend, all major routes were closed. On November 10, a mudslide covered the eastbound lanes of the Trans-Canada Highway near Bridal Falls. On November 9, the Trans-Canada Highway was closed by a rockslide north of Hope. Mudslides and washouts closed sections of the Trans-Canada Highway, Hope to Princeton highway and the Coquihalla Highway. On November 8 at 3 a.m., triggered by the heavy rains a rockslide came down that blocked the Trans-Canada Highway north (east) of Yale (Evans, unpublished data).

The Hope to Princeton Highway, flooded east of Hope, later reopened to intermittent single-lane traffic. The Coquihalla Highway, closed because of a washout just north of Hope and a mudslide about 27 km north of Hope, reopened late on November 9. The Trans-Canada Highway in the Rocky Mountains reopened to single-lane traffic in the late afternoon of November 9. The Revelstoke mudslides occurred after the city received 28.2 mm of rain during a 24-hour period. At one point, the highway was closed in both directions at Victor Lake, 15 km west of Revelstoke. Landslides also caused havoc on highways near Vancouver. Highway 1 was flooded near Abbotsford. Flooding in the Lillooet area closed the Duffey Lake Road from Pemberton-Lillooet.

By November 13, the Hope to Princeton Highway 3 and Highway 11 from Vye Road to the U.S. border at Sumas remained closed. The Coquihalla Highway was open again but southbound traffic should expect intermittent closures. Though the Trans-Canada Highway reopened, there were still periodic delays at Laidlaw and at Jones Creek east of Chilliwack. At Lagace Creek, sedimentation occurred due to large-scale landsliding in the Pattison Creek headwaters.

The Squamish area was hit by 164.6 mm of rain on the morning of November 10 and 68.8 mm on the evening of November 11. An additional 71mm were recorded the next morning. On November 10, high water on the Green River damaged BC Hydro's 500-Kv powerline south of Pemberton. The river took out three transmission towers, one of which had the foundations washed from underneath. When it brought down 3,300 ft. (990 m) of line down a second tower was buckled and a third one was damaged. On November 12, BC Hydro warned Vancouver Island pulp mills their power could be endangered after flooding caused two towers carrying four 500-Kv power lines to collapse into the Green River between Pemberton-Rainbow on the mainland.

Late on the afternoon of November 10, high water caused the Mashiter Creek rock dam that diverts

water to the cement intake structure to break. Adjacent to the new intake structure, a 50-ft. (15m) rockdam was ripped out. The hole in the dam allowed water to divert away from the intake and reopen the original creek bed. When the dam broke, a "tremendous pulse" of water, gravel and logs was sent down the creek. Damage was extensive and the Fisheries intake on the diversion structure was completely buried in gravel. Cost to repair the damage to the water intake was estimated at $15,000. Although a section of the diversion weir washed out and sediment was deposited, there was no apparent damage to the gates, screens or concrete of the diversion structure. It was rumoured that the dam had been designed to fail under such flooding conditions in order to reduce damage to the main intake. (*The Squamish Times*, November 14 and 27, 1990) As of November 15 in the Squamish-Pemberton area, the water levels were down. Internal drainage behind dykes caused problems and the Squamish water intake washed out. (Ministry of Environment).

By November 13, the Squamish highway was reopened but 6 km south of Whistler there were still delays. The Pemberton airport was flooded out. On the Cheakamus River, the rock riprap at the toe of the dyke washed out. Following the October 1984 flood, this site was repaired at a cost of $17,365. All forestry access roads in the Soo Timber Supply Area were closed due to the damage arising from the heavy rains. Early cost estimates for repairing forestry roads were over $300,000. (*The Squamish Times*, November 20, 1990).

A major debris slide at North Bend near Boston Bar destroyed the community water supply. In many areas, telephone service was interrupted. BC Tel advised they could not start restorations before water levels decreased considerably. In the Sumas area, where most telephone lines were underground, these failed due to the water. In Hope, telephones on Othello Road would be out until the road could be repaired. Near Chilliwack Lake, telephone service was not expected to be restored till November 22. At Hatzic Lake/Everglades telephones could not be restored till the water levels decreased.

Deroche Creek jumped its banks upstream of Morton Road and threatened a nearby residence. Hereford Creek's channel got infilled and changed its course through an adjacent field. On Silverhope Creek, the riprap repaired after the 1984 flood got eroded again.

On November 10, another large flood event occurred on the Coquihalla River, following the one in November 1989. The river jumped its channel at the km 996.0 crossing of the TMPL pipeline. The river rapidly developed a new channel along the existing pipeline right-of-way. The pipeline was exposed and damaged along most of its length between the two crossings at km 996.0 and 996.2. Using heavy equipment and large quantities of riprap, the river was pushed back into its original channel. Subsequent inspection revealed that the top of the pipeline had been exposed for a distance of over 125 m. The resulting small dents and gouges were significant enough to require the complete replacement of the damaged section (Rice et al. 1992). In the Silverhope Creek area, erosion was apparent at the Edward property. The upstream end of the Riviera Motel appeared to have failed. Erosion occurred at the west abutment of the old railway bridge. At the creek's mouth scattered logs and debris were deposited. Kawkawa Lake Road washed out at Othello. The Kawkawa bridge abutment washed out, stranding residents. Debris and logs accumulated above and in the tunnel. The lower 200 m suffered some erosion of crest fill. Holes were noted in the riprap. Opposite the Glenhalla Dyke erosion progressed threatening a house at its downstream end. Erosion was noted on the River Parade dyke above the railway toe. On Mallard Drive, the upstream end of a lawn eroded. Town riprap below R/W eroded badly. In the golf course reach, a large gravel bar noted and scattered debris at the river mouth (Memorandum P.J. Woods, November 15, 1990).

On November 9, the torrential rains caused flooding in the Victoria region. An overflowing creek closed parts of Sooke Road west of Colwood. Rising waters threatened several bridges along Highway 14 between Sooke-Jordan River. After Bilston Creek flooded its banks, traffic was detoured around Dewdney Flats. Sooke-bound traffic was diverted 1 km along Awsworth Road back onto Sooke Road. Traffic heading for Victoria was re-routed through Metchosin by way of Kangaroo Road. High water from Veitch Creek caused single-lane traffic on Sooke Road near the Kangaroo Road area. The resident of 4815 Sooke Road said the flooding was the worst he had seen in the three-and-a-half years he had lived there. He was pumping water from his basement every 15 minutes and found his car afloat. His flooded yard had a boat for sale that he thought of keeping now. Regional medical health officer Dr. Shaun Peck issued an advisory to Sooke and East Sooke residents to boil their drinking water. *6)

Other Victoria problem areas included sections of West Coast Road where crews were watching for potential mudslides. In November 1989 during similar weather, three slides took out sections northwest of Sooke. B.C. Parks Ministry closed the trails at Goldstream Park east of the Island Highway for November 10 and 11. Most flooded homes were the result of blocked sewer connections. The worst damage was at Crystal Pool where tree roots plugged a storm drain about 11 p.m. on November 8. Water started backing up into the lobby. Early on November 9, there was more than 1 m of water in the lower viewing area. The only other major problem in the city was at a motel on the Gorge where a shopping cart had been dumped in a drain outlet.

In the Sayward Valley, the Sayward and White rivers flooded, washing out bridges. In some places, floodwaters were 5 ft. (1.5 m) deep. Two-thirds of the Sayward Valley was under water. On November 12, at 6 a.m. the water level peaked. On November 10-11, floodwaters from the Salmon River ran through the yard and buildings of the Sayward elementary and junior secondary school. By November 13, the main road into Sayward remained closed. The village of Sayward, along the Salmon River suffered extensive flood damage. On November 12, helicopters were used to evacuate 50 people trapped by flooding on Vancouver Island. A total of 81 Sayward Valley residents were evacuated, 40 overland and 41 using four helicopters. At one point, 65 residents were stranded, while the water continued to rise by 1 ft. (30 cm) an hour. An additional 30 people were evacuated by boat or four-wheel drive vehicles. On November 8, Port Alberni broke a 20-year record for rainfall for that date. A total of 67.6 mm broke the one set in 1979 with 62.0 mm). On November 7, an additional 28.0 mm had fallen. Floodwaters came to within 2 in. (5 cm) of cresting the dyke at the bottom of the Hump. At another crucial point where the river flows close to the highway, 3 ft. (90 cm) of dyke were lost. At the section of road at Highway 4 and Stuart Road the usual drainage problems occurred. Highway 4 was flooded at Hector Road, with water backing up and flooding the flat area. Floodwaters threatened two bridges on the other side of Cathedral Grove and around Cameron Lake. Some bank erosion occurred on the wide shoulders. The river levels around the Papermill Dam were higher than residents had seen in a number of years. BC Hydro lost its feeder line to Bamfield twice, early on November 11 and again on the morning of November 12. Oversaturated soils caused trees to come down (*Alberni Valley Times*).

On the night November 9, the tiny Native Indian village of Owikeno hit by flooding was partly evacuated. Of the 42-member Oweekeno band, 14 women and children were taken by helicopter to Port Hardy from the remote village at the head of Rivers Inlet. Though the flooding had subsided and there was no immediate danger, Chief Frank Johnson expected to evacuate the remainder of the village later by a Canadian Coast Guard vessel.

Emergency releases from John Hart Dam contributed to flooding in Campbell River. At Campbell River, the Quinsam River spilled its banks on November 13, flooding at least three properties along Quinsam Road. The river threatened to change course to a route through the small mobile home park. Crops were lost and septic fields washed out. The floodwaters also caused major bank erosion. The previous bad flood in the area had occurred in the mid-1970s. Rising floodwaters necessitated evacuation at Gold River.

The large, active debris flow channel in the Tsitika Valley on Vancouver Island delivered debris, in a series of pulses, onto the road the quantity of the debris was such that, following regrading of the road, the running surface was observed to be 2.5 m higher than before the storm. The channel was nearly 2.5 km long from source area to depositional fan, and dropped some 1,000 m in elevation to the valley floor (Fannin et al. 1992).

According to the Western Canada Wilderness Committee, one of the washouts resulted from MacMillan-Bloedel not building a proper culvert over a creek. Following the heavy rainfall, a debris dam formed causing the road to wash out. A 40-ft. (12 m) section, in places 15 ft. (4.5 m) deep, spilled into the Tsitika River. Dan Hogan, research hydrologist with the Ministry of Forests, said the discharge into the river appeared to be a 1:50 year event. As for the two washouts, he noted that they began on lands that were already the sites of old landslides. The road sections that did wash out contributed to the debris flows but formed only a minor part of the overall washouts (*The Vancouver Sun*, November 10, 1990).

The floods virtually wiped out chum salmon in southern British Columbia and Washington. According to federal fisheries biologist Wayne Saito, the floodwaters had a devastation effect on chum in

the lower Fraser Valley, state of Washington and Vancouver Island. Unlike pink and sockeye salmon, which spawn above Hope, coastal floods seriously effected chum salmon. The Chilliwack, Pitt and Vedder river systems were particularly hard hit. Chum salmon spawning in the Fraser and Harrison rivers were not affected because flood effects were not as extreme as in the other river systems. In November, a large amount of sand and gravel was deposited in streams adjacent to Pixie Creek. Culverts were inadequate and caused washouts and subsequent damage to fish habitat (*The Daily News*, May 14, 1993). *7)

In November, a rockslide occurred on the north side of the Britannia Creek valley over part of the old Mt. Sheer townsite.

McMullen (1990) lists the watercourses impacted during the November 9-10 flood event in the Lower Mainland, complete with detailed damage information for: Bear Creek; Belcharton Creek; Carratt Creek; Cascade Creek; Chawathan (Chawuthen?) Creek; Cheakamus River; Cheekye River; Chilliwack River; Coquihalla River; Coquitlam River; Crabapple Creek; Dale Creek; Davis Creek; Deroche Creek; Fitzsimmons Creek; Frosst Creek; Hatzic Island/Prairie; Her(e)ford Creek; Karen Creek; Lagace Creek; Lake Errock (Erroch Lake?); Lorenzetta Creek; McNab Creek; Mamquam Creek (River?); Mashiter Creek; Miller Creek; Munroe Creek; Murray Creek; Nineteen Mile Creek; Norrish Creek; North Alouette River; Pattison Creek; Pemberton Creek; Pye Creek; Ryan River; Siddle Creek; Silverhope Creek; Squamish River; Stawamus River; Sumallo River; Sumas River (area); Sylvester Brook; Twenty-one Mile Creek; Unnamed stream (district of Kent); Vedder River and Whistler Creek.

For the Lower Mainland area, the total cost of channel restoration, log clearing and repair work was estimated at $9 million. Required enhancement works were estimated at $2.2 million and additional works were predicted to cost $450,000. For the Vancouver Island and southern Interior areas, very preliminary cost allocations of $2 million and $500,000, respectively, were included for budgeting purposes (McMullen 1990). For the Vancouver Island Region, the estimated cost of channel restoration, log clearing and repair work was estimated at $350,000. Requirement enhancement work would cost $1.2 million. Other works, including emergency response to flooding and erosion totalled approximately $414.000.

Enhancement and restoration costs for O.I.C. 1819 (November 1990 flood) for Oyster River, Cascade Creek, Chawathan (Chawuthen?) Creek, Cheakamus River, Cheekye River, Sheldon Road, Chilliwack River (Campground and Mt. Thurston Camp); River Parade Dyke; Coquihalla River, Cultus Lake Deroche Creek I.R. #11; Albion Dyke; Frosst Creek; Dale Creek; Lagace Creek; Lorenzetta Creek; Lost Creek; North Alouette River; Pattison Creek; Ryan River; Squamish River (upstream of Judd Slough and Pillchuck Creek); Sumallo River; Unnamed creek at Rockwell Drive; Vedder River and Tulameen River totalled $2,826,260 ($750,531 enhancement and $2,075,729 restoration).

Affected areas as of November 15: Coalmont: the Tulameen River had dropped but contamination of water wells prevented the return to their homes of 38 evacuees; Hope: though the Coquihalla River dykes prevented flooding, some repairs were required, erosion and debris accumulations occurred; Kent: local high water table problems were experienced; Lake Errock (Erroch Lake?)/Ruby Creek/7th Day Adventist Camp: local flooding and debris torrents were reported; Hatzic Lake: recreational property and some farms were flooded, landsliding was reported on Pattison Creek infilling the creek and threatening two homes; Norrish Creek: a major water supply washed out; Silverhope Creek: erosion problems reported; Chilliwack River Valley: many reaches of erosion washed out the road; three houses were lost and one remained hanging on the edge of the bank; Yarrow: The Vedder River dykes prevented flooding but internal drainage caused basement floodings; temporary repairs were being made to the washed out railway structure, Sumas Prairie West: overflows from the Nooksack River ended on November 13. It was reported that over dyke failures contributed to overland flows, which escaped into the Sumas River. The floodwaters started to recede on November 12; Lindell Beach: emergency work was required to prevent an avulsion of Frosst Creek through the community, erosion and sediment was a concern; Squamish-Pemberton area: water levels were down, internal drainage behind dykes caused problems, and the Squamish water intake washed out; Coquitlam: flooded basement were reported; Sayward: water levels receded since November 12 and some evacuees returned to their homes. Bridges washed out; Campbell River: flooding occurred in the Campbellton area due to emergency releases from John Hart dam. (Ministry of Environment).

---

*1) An official with PEP estimated the damages could reach $10 million, while government officials expected at least $15 million in property damage claims. Althrough the Provincial Emergency Program (PEP) the British Columbia government compensated homeowners, businesses and farmers for up to $100,000 in damages that were not covered by other insurance arrangements. On November 20, the provincial government announced the approval of $20 million in emergency assistance for flood losses of November 1990 from funds available under the Flood Relief Act and PEP (*The Province*, November 21, 1990). In December, the provincial government came up with an additional $22.5 million in flood relief bringing the total provincial contribution to $42.5 million (*Times Colonist*, December 22, 1990).

*2) The affected areas have an extensive history of periodic winter rainfall problems and flooding events. Previous ones occurred in November 1989, 1984 and 1981. The 1989 event affected a similar area centered on Chilliwack with a total of $6 million expended under the Provincial Emergency Program as relief and restoration of eligible damages. During 1990, Water Management staff was directly involved in the restoration of stream channels, debris cleanup and repair of flood mitigation works totalling $1.2 million. Some Chilliwack Valley residents blamed the flooding on logging practices and on the environment ministry for not doing enough preventative work due to federal fisheries restrictions. Federal Fisheries apparently refused to allow the clearing of logjams or deepening of river channels because of salmon runs. An editorial in *The Chilliwack Progress* questioned where the Canadian Armed Forces were when they were needed and how funding had been found for new dyking along the Soowahlie Reserve, "yet politicians balked when similar work was requested to protect Chilliwack River homes." Federal Fisheries would have to loosen up protective restrictions to avoid further flooding, which also damaged salmon habitat. Since the previous year's flooding, river valley residents had been lobbying for protective river work and a river management study. Communities along the river, concerned about the loss of property, roads and infrastructure caused by the eroding banks, held public meetings early in 1991 demanding that the federal and provincial governments to remedy the situation. Environment minister John Reynolds and Chilliwack MLA John Jansen promised action. Almost a year later, just before the next even more devastating flood, the answer was that full funding for a river management study was not available. Following the November 1990 flood, Federal Fisheries advised that they would likely "stand aside" to allow riverbed work to save homes and property. Meanwhile, Jansen indicated that full funding for a river management study just might be found now (*The Chilliwack Progress*, December 5, 1990). Dykes built after the 1990 flood are credited of preventing more flooding in 1995 (*The Chilliwack Progress*, December 1, 1995). Under a jointly funded Memorandum of Understanding, SEP's Development Division tackled the slides at Slesse Creek and Ranger run, while the provincial Ministry of Environment handled the one at Slesse Park. At Slesse Creek and Ranger Run, the main channel was diverted away from the actively eroding high banks. The emergency work on both slides was completed in under a month, in March 1991. In July 1991, more work was done at the Slesse Creek to form a small pool at the bottom of the slide.

*3) Historically, the course of the Chilliwack River has changed many times. According to Jim Bowman, archivist with the Chilliwack Archives, there is geological evidence and evidence from Sto:lo legends that in prehistoric times the Chilliwack River went up the channel of Elk Creek at the east side of Little Mountain. Around 1808 at the time of the first European contact with local Native Indians, the Chilliwack River ran right up what is now Chilliwack Creek, emptying into the Fraser River at the foot of Wellington Avenue. It ran also ran along Luckakuck Creek, Atchelitz Creek and Vedder Creek. At one time, the Sumas Prairie area was under water for most of the year. The entire area was a lake that stretched from Vedder Mountain to Sumas Mountain. It remained that until the early 1920s, when several drainage canals were constructed (*The Chilliwack Progress*, December 5, 1990). See also *2) of November 16-24, 1990 event.

*4) Some 500 lakeside residents claimed that the flooding crisis of November 9 at Hatzic Lake was worsened by the lake's pumping and dyking systems. They requested the provincial and federal governments to pay for dredging the lake, increasing the size of the CPR culvert from the lake, increase pumping capacity and water problem solutions for their reoccurring flood problems. The residents

maintained that the flooding, which had been a problem for about 20 years, was man-made because of problematic dykes and pumps (*The Vancouver Sun*, November 20, 1989). Early December, a $200,000 comprehensive damage control study for the Hatzic drainage area was announced. Included in the study would be Lagace Creek, as well as pumping requirements at the outlet of Hatzic Slough (*Abbotsford News*, November 28, 1990; *News Record Weekend*, December 8, 1990).

*5) The Nooksack River, which drains much of Mount Baker, has a history of flooding. The last major flood was in 1935 and again in 1953. In 1989 and 1990 it happened two years in a row. In 1989, the river went over its banks three times. Abbotsford Mayor George Ferguson was keeping tally of the flood damages caused on November for a possible court case. He wanted to make an issue out of the costs in support by the Whatcom County communities of Sumas, Everson, and Nooksack to pressure their senior governments for a permanent solution to flooding (*Abbotsford Times*, December 19, 1990). According to Abbotsford Mayor George Ferguson, the cost of a larger dyke near Everson, Wash. would be close to $1 million, but the cost of the November 10-11 flooding in Whatcom County was expected to be well over $10 million. Flooding on November 9, 1989 had cost Whatcom County $8 million in damage.
Representatives of Nooksack upstream communities of Deming and Glacier, Wash. suggested that clear-cut logging in their regions had caused soil and gravel erosion and contributed to the frequent Nooksack flooding (*Abbotsford Times*, December 5, 1990). In recent years, Sumas Prairie had become increasingly flood-prone from the Nooksack River, which flows east west through Whatcom County, just south of the border. Canadian officials expressed frustration over an unwillingness in the U.S. to fix the flooding problem. While clear-cut logging had been blamed, most officials pointed to two other factors. Several years earlier, Washington's department of natural resources raised the royalties on gravel which private companies used to dredge from the riverbed. Consequently, gravel bars developed that displace much of the river's capacity. Additional dyking was required near the town of Everson, Wash., where the floodwaters spilled over on November 12. In the mid-1970s, nearly 200,000 $yd.^3$ (152,920 m^3) were removed annually by several companies. By 1980 after the royalty jumped, only one company was taking 17,000 $yd.^3$ (13,000 m^3) annually. By 1990, the massive sandbars had trees growing on them and the state's ecology department claimed these "islands" were essential fish habitat and could not be removed. Additional dyking of the Nooksack River at Everson could be done for about $200,000 but the river would need "outflow" capacity downstream to protect downstream areas from flooding. The U.S. responded only with a promise of an U.S. Army Corps of Engineers study of the problem, which would take years (*Abbotsford Times*, November 29; January 23, 1991). A March 1989 U.S. Army Corps study determined it was not worth dredging the Nooksack River to fix siltation problems, or to build dykes in the Everson area to contain flooding (*The News*, November 14, 1990). Spending $100,000 to upgrade the dyke near Everson on the Nooksack could stop flooding into Canada. Building dykes might cause more harm to the lower end of the river near Ferndale and Bellingham. The residents downriver would be hit harder by floodwaters because the water kept in the river channel would reach them (*The News*, November 14, 1990; *The Province*, November 14, 1990). In November 1989, Sumas also flooded though not nearly to the same extent. According to Sumas Mayor Bob Mitchell, the federal government had refused to deal with the Nooksack (*Abbotsford Times*, November 14, 1990).

*6) These two communities which were getting their drinking water from Charters Creek, which was swollen and dirty from the heavy rains. Other parts of Greater Victoria were getting their water from Sooke Lake.

*7) In 1993, Fletcher Challenge Canada Ltd. pleaded guilty in provincial court to logging causing destruction of fish habitat. In restitution, the company had to contribute $135,000 to the cost of rehabilitation of salmon stocks near its Port Renfrew logging operations (*The Daily News*, May 14, 1993).

November 16-24, 1990
(Rain-on-snow).

Discharge (m^3/s): Max. daily: November 23: Capil.: 630E; Kok.: 202; Nan. C.: 951; max. instant.: November 23: Capil.: 376; Chem.: 265.
Source: *Alberni Valley Times*, November 15 and 26, 1990; *Times Colonist*, November 21, 26; December 28, 1990; *The Squamish Times*, November 27, 1990; *Chilliwack Times*, November 27, 1990; *The Chilliwack Progress*, November 28, 1990; *Abbotsford Times*, November 21 and 28, 1990; *The Vancouver Sun*, December 1, 1990; *The Globe and Mail*, December 6, 1990; *Goldstream Gazette*, December 12, 1990; *PEP Talk*. Vol. 2, No. 1, Spring 1991; VanDine 1992; B.C. Ministry of Forests 1990b; Fannin and Wilkinson 1995.
Details: Between November 21-24, for the second time in November an active Pacific frontal system passed over southwestern British Columbia, bringing heavy rains. The front first approached the coast on November 21 and had a strong southwesterly flow of moist subtropical air associated with it. Though not as continuous or as heavy as during the November 8-12 storm, heavy rains fell in the Victoria area with lesser amounts further east. Precipitation amounts were quite variable across southwestern British Columbia. On November 23, Hope recorded a maximum one-day total of 116.1 mm and a total of 247.8 mm over the four days. On November 22, Squamish recorded a one-day maximum of 123.8 mm and a total of 275.4 mm over four days. Port Alice recorded 176.0 mm on November 22. Two-day totals in excess of 200 mm were reported at both Port Alice and Gold River. Precipitation in other regions varied from 20-70 mm for one-day totals to 40-130 mm for the four-day period. Return periods for this storm were quite variable. One-day amounts had return periods of five years or less except for Hope and Port Alice with 15 years. The maximum return period value was 25 years at Princeton for a three-day total. Although the bulk of the heaviest precipitation occurred on November 23, some localities received substantial precipitation after November 24. The November rains, which accounted for two separate flood events in Victoria and up-island, made it the soggiest November at the Victoria airport. *1)

Reports of flooding came from many of the same areas affected earlier in November. Flooding occurred on the west coast of Vancouver Island, Greater Victoria, northern sections of Vancouver island, around Squamish and in the eastern half of the Fraser Valley. The Coquitlam Lake reservoir was overfilled, requiring the complete opening of the floodgates. This caused very high water levels in the Coquitlam River. Some flooding occurred in the Princeton and Merritt areas. Cooler temperatures in that area caused more of the precipitation to fall as snow making the runoff to be less severe.

On November 16, slides and high water closed Highway 99 at the Tunnel Point slide site, Function Junction and near Paradise Valley. At the old slide site north of Lions Bay, mud came down, closing the highway at 12:02 p.m. The highway opened to single-lane traffic only at 4:45 p.m. At Function Junction, the highway closed between 4 p.m.- 9 p.m. A washout at Paradise Valley, 23 km north of Squamish closed the highway from 3:45 p.m.- 9 p.m. In Brackendale, basements flooded again.

North of Pemberton, a mudslide covered about 150 m of BC Rail track. Crews hoped to have it cleared by late on November 25 instead of November 28 as earlier predicted. On November 16 from 10:30 a.m.-2 p.m., flooding and avalanches closed the Duffey Lake Road A smaller slide about 50 km north of Pemberton was also expected to be cleared at the same time.

On November 17, high water on the Green River south of Pemberton washed out one tower on a major powerline between the mainland and Vancouver Island and buckled another one, bringing down about 550 m of the 500-Kv transmission line. Repairs were expected to cost more than $500,000. The downed line also affected customers on the Sechelt peninsula and Powell River. BC Hydro hoped to have the line back in service on November 18. Repairs at the confluence of Rutherford Creek and Green River were just being completed when the second storm struck. On November 17 between 8 a.m.-noon, the water rose 4-5 ft. (1.2-1.5 m) (*The Squamish Times*, November 27, 1990).

According to the Hope weather station, between November 18-21 almost 200 mm of rain was dumped on the Fraser Valley. The constant rainfall caused the Chilliwack River to again flood its banks, not nearly to the same degree as two weeks earlier. Residents along Chilliwack Lake Road suffered additional property damage. The area worst hit by flooding was Ryder Creek, where residents were still cleaning up from the last storm and flooding. Ryder Creek properties along the river were flooded with 2-3 ft. (60-90 cm) of water. *2) On November 19 at 9 p.m., a red alert flood warning was issued but was withdrawn four

hours later once the river crested and began to recede. Even as the flooding subsided, the riverbank continued to erode. The flooding did not reach the magnitude of two weeks earlier. By early afternoon on November 20, the rain turned to snow, allowing the river level to come down. The unseasonably warm weather of the previous two days had caused snow at higher elevations to melt.

On the evening of November 21, the Chilliwack River rose "dramatically," threatening to overflow the Wilson Road dyke. By November 22, weather conditions eased and river levels began to decrease. More than two weeks after the Chilliwack River flooded, the walkway under the CNR tracks near Charles Street was still impassable. It was feared that schoolchildren might get hurt as they carried bikes over the railway tracks to get to school. The small pump the district, which was responsible for the maintenance of the tunnel/underpass, used to remove the water from the tunnel had failed.

On November 23, heavy rainfall on northern Vancouver Island caused again floods in Sayward and other communities. In Parksville, the Englishman River flooded Parry's Trailer Park. The high water forced the evacuation of part of the trailer park. About 30 people were moved to a local hotel. Although the flooding was less severe, the list expanded to include Port Alice, Duncan and Nanaimo.

Despite warnings it would be hit hard, the Abbotsford-Sumas region received only minor flooding. As of November 20, all roads were open and the last of the damaged water mains, on South Parallel Road, had been repaired and disinfected. By November 21, in all rural areas of Abbotsford a "boil water order" remained in effect until further notice. The district sustained an estimated $400,000-500,000 flood damage, including repairs of roads and water mains, cleanup and overtime and double time during the weekend of the flood.

The Sayward area was affected by melting snow in combination with record rainfall. Melting snow during the rainstorm may have increased the flow of water at the flood peak but to a small degree. *3) The storm was classified as a 1:20-year event. The town of Sayward was flooded for a second time in a month. A psychologist from Victoria came up to Sayward to help residents cope with the personal stress caused by the disaster. *4) According to the *Times Colonist*, the floodwaters at Sayward were higher than during the Remembrance Day weekend flooding earlier in November. In Sayward, about 40 residents were forced from their homes. They returned home on November 25. Flooded roads temporarily cut off about 90 people. But despite a couple of bridge washouts in the Sayward area, there now were detours around all the flooded areas.

Combined with snowmelt it produced a 1:50-year flood event in the Salmon and Tsitika rivers. It caused considerable streambank erosion and high siltation in all rivers in the area. On November 23, a large slide occurred at 49 km on the Tsitika Main Line road. The slide, which occurred in a forested area, covered 1 ha. Numerous smaller landslides occurred in unlogged, forested portions of the watershed, mainly along steep streambanks. Also several minor road slumps occurred during both November storms. According to Forests Minister Claude Richmond, it was not associated with any logging or road building activities.

The Greater Victoria area was also hit by flooding. On the night of November 23, about 50 people were evacuated from the hard-hit area across from the Mayfair Shopping Centre. The residents flooded out by 1 m of water. It was thought a backed up city drain caused the flood damage done to their homes. Hugh Robertson's property and basement at 2605 Forbes Street flooded. It was the first time since the 28 years Robertson had lived there, that the yard flooded. Bowker Creek flooded the bridge and properties in the Haultain Street area. A portion of Lochside Drive near Doumac Avenue had been ripped after water tore through the Doumac Ravine. Late on November 24, Doumac Avenue had their water turned back on. On Cook Street, the Fairhill apartments were flooded.

On November 23, Langford recorded 77.5 mm of rain. According to Colwood's municipal engineer Gary Smirfitt, the cost for flood damage repair following the November 23 downpour could amount to $15,000. This would include repair to a city hall parking lot access, new emergency drainage work at Triangle Mountain and staff costs to deal with the flooding.

Goldstream River jumped its banks on November 23, flooding the path beside it and the parking lot. The strength of the river carried logs almost 1 m in diameter onto the parking lot. The fast-moving water also ripped out many of the recently laid salmon eggs from the gravel riverbed and beached at least 200

adult salmon onto the banks, parking lot and into the bushes. Clean up of the damage included logjams in the river. The riverside trail and picnic area were closed.

On November 23, due to the heavy rain Port Alberni was cut off for over eight hours. Highway 4 was closed for over eight hours when the high winds started bringing down trees in Cathedral Grove and waves were washing up unto the highway at Cameron Lake. Though Cameron River threatened to flood its banks, the reinforcements erected during the most recent storm held. A boat moored by Pearce Log Recoveries broke loose, floated up the inlet, got stuck between logs and sunk. At the foot of the docks, a boathouse collapsed with a boat inside.

On November 23, near Great Central Lake, a mud and debris slide into Dorothy Creek killed a logger. The victim was working at a logging operation for Pat Carson Bulldozing (PCB) when a wall of mud and debris came thundering down without warning. The slide was believed to have been caused by heavy rain and wind battering the area at the time. According to PCB president Donald Hayes, his crews have worked in rough weather countless times but you can never tell when the ground is about to give way. *5)

Storms in November and December triggered 35 landslides in the three Greater Vancouver water supply watersheds (Capilano, Coquitlam and Seymour) including the Jamieson Creek landslide in the Seymour watershed with an estimated volume of 5,000 m^3 (Fannin and Wilkinson 1995).

Overnight November 24-25, the Nooksack River again overflowed its banks. Areas of Huntington were under water for a second time in November, as was the city of Sumas, Wash. The District of Abbotsford lost a section of Second Avenue, where it turns into Boundary Road and had been patched as a result of the major flooding on November 10. A shoulder on the downstream side of the roadway was also scoured away. Huntington properties, including Ainsworth Lumber and Verdonk's farm were flooded again.

---

*1) The 270.6 mm of rain recorded broke the previous November record of 267 mm set in 1955. It was still nowhere near the all-time rainiest month, January 1953, when 358.9 mm of rain fell (*Times Colonist*, January 3, 1991). The rains brought precipitation totals for November at Hope and Squamish to over 800 mm. At Hope, this far surpassed the previous November record of 596.1 mm, only set one year earlier. It also established a new record precipitation for any month.

*2) In the Ryder Creek area, the Chilliwack River was continuing to evolve with the river course having changed "significantly." (*Times*, November 27, 1990).

*3) Research indicates that the biggest effect of clear-cutting is not on peak flood flows but on increased sediment in rivers (*Alberni Valley Times*).

*4) The town of Sayward is built on a natural floodplain. At the time, about 15% of the watershed had been clear-cut (*Alberni Valley Times*). Sayward residents worried about a hard-to-reach logjam on the Salmon River near the Menzies logging claim southwest of the town. It caused some concern that the jam would move closer to the town and to divert floodwaters towards the community (*Times Colonist*, December 28, 1990).

*5) This fatal event caused Workers Compensation Board to consider establishing limiting-rainfall criteria above which logging activities would be suspended.

December 2-8, 1990

(Rain-on-snow and storm surge/tidal flooding).

Discharge (m^3/s): Max. daily: December 4: Chem.: 401; Cowich.: 371; Kok.: N/A; 951; L. Qual.: 83.4; Shaw.: N/A; Sproat: N/A; max. instant.: December 4: Cowich.: 326; Kok.: 117; Nan. C.: 649; Shaw.: 24.8; Sproat: 210.

Source: *The Vancouver Sun*, December 4, 1990. *Nanaimo Daily Free Press*, December 4 and 5, 1990; *The Globe and Mail*, December 6, 1990; *Times Colonist*, December 5 and 11, 1990; January 3, 1991; *Alberni Valley Times*, January 10, 1991; *PEP Talk*. Vol. 2, No. 1, Spring 1991.
Details: Rains from another sub-tropical storm caused a third major flooding event on eastern Vancouver Island in a month. *1) On the night of December 2, 39 people were evacuated from their island homes. About 90 residents were stranded in Sayward after the Salmon River on December 3 overflowed its banks again. Floodwaters covered roads with 1 m of water. In the Sayward Valley, fourteen families were evacuated. Damage was not as extensive as in the previous two floods. One Sayward Valley resident said they had 3.5 ft. (1.05 m) of water in their basement during the first flood, 3 ft. (90 cm) during the second one, and this time only 8 in. (20 cm).

For most of December 3, flooding and mudslides isolated seven other North Vancouver Island communities. Late on December 2, Port Hardy, Port McNeill, Port Alice, Alert Bay, Sointula, Coal Harbour and Holberg were left cut off when gravel and water blocked the Island Highway. Flooding also closed several small roads and the Island Highway at Woss Camp. It took highway maintenance crews all day on December 3 to clear a path through "tons of rubble and debris" that blocked a 100-m section of road near the turnoff leading to Zeballos. A 25-m section of the highway near the same spot was also flooded. By late afternoon on December 3, one lane of the Island Highway was reopened. Another washout and a damaged bridge cut the road to Zeballos. High waters washed out the only road to Port Alice. Near the Port Alice pulp mill, two major slides destroyed the town's golf course.

Floodwaters wiped out a rail line resulting in the layoff of 375 Canadian Pacific (?) Forest Products Ltd. employees. According to Canfor operations superintendent at Woss Camp, Dave Summers, everybody was laid off for at least a week. The washout destroyed a rail culvert. "You had that major snowfall, 2 or 3 in. (50-75 mm) of rain and then the snow melt. Nothing could handle it," Summers said.

Near Campbell River, some 30 families were evacuated. Further floods occurred in several of the same communities, as well as Cowichan Bay, Lantzville and Qualicum Beach. In Qualicum, a mudslide damaged a home. In Chemainus, minor flooding occurred after the Chemainus River flooded the Trans-Canada Highway near Mount Sticker. Chemainus also lost power for about an hour. In and around Duncan and Cowichan Bay, a few roads closed to be reopened on the afternoon of December 3.

On December 2, Nanaimo reported the first measurable snow of the season. Several cm of snow were followed later in the day by rain. On December 2, Nanaimo recorded 42.1 mm of precipitation and on December 3, 58.8 mm of rain. On December 4, high tides lashed by strong winds caused severe flooding in the Cedar area, for the third time in a month. On the morning of December 4, the Nanaimo River flooded Cedar Road and other areas near the river. Aikenhead Road was completely closed. A residence on Raines Road was completely surrounded by floodwaters. The combination of rain and an unusual high tide caused road between the Cedar bridge and the waste landfill to flood. In Parksville, the Englishman River flooded Parry's Trailer Park, forcing all 25 residents to move out. Like at the end of November, the campground flooded again. *2) On the morning of December 5, another 16.2-ft. (4.9 m) tide was expected.

After a Westwind Drive family lost another 8 m of their backyard into Mill Stream, Environment Ministry officials issued an evacuation order to leave their home. During the previous month, already about 21 m of their backyard had slid into Mill Stream.

In early December, heavy rain combined with high tides caused severe flooding of homes along Lugrin Creek. Ed Wellings experienced severe flooding in the basement of his home on Alexander. For many years, flooding had been an issue for local residents in the area but the problem had worsened since the dyke was built along River Road. They noted that though were flooded before, the water would drain with the tide. "Now it sits there until the weather improves and it dries up," said Wellings. "They have created an inland lake here; there is nowhere for the water to go now." *3) Wellings claimed that the old culvert on Beaver Creek Road never had been replaced and that the creek was not being cleaned out. The bed was supposed to be cleaned out. "There is no clear passage for the water to get into Kitsucksus creek." On Josephine, the channel was not straightened, the banks were not built up and the brush was not kept cleaned out. When the water get high, it cuts right over the bank and into the field behind his house, Wellings said. He also claimed that the city welded shut a sewer drain at the corner of Heath and Alexander.

City Engineer Ken Watson disagreed that the dyking had made the flooding worse. “Before the area flooded several times a year, whenever there was a high tide.” Watson noted this was the first flooding in seven years. He agreed that the water did stay longer but noted that the area flooded less frequently now. “The dykes are to keep water from flooding in from the river and Kitsucksus and Lugrin creeks,” Watson said that Wellings problem was caused by heavy rainfall. (*Alberni Valley Times*, January 10, 1991).

According to Moe Sihota, MLA (NDP, Esquimalt-Port Renfrew), water and erosion problems on Westwind Drive had started at least six years earlier but the Capital Regional District (CRD) and the Ministry of Highways had refused to accept responsibility. *4)

Among those stranded were 10 hikers in Strathcona Provincial Park cut off by a bridge washout at the Westmin mine in the Thelwood area, about 60 km southwest of Campbell River. Westmin employees rebuilt the bridge with logs and rescued the hikers on the night of December 3.

---

*1) For some locations the year 1990 would eventually become the rainiest one on record. Victoria, for example, recorded a total of 1,138.4 mm, 265 mm above the norm and nearly 30% wetter than normal. This record wiped out the previous high of 1,099.8 mm that stood for 42 years (*Times Colonist*, January 3, 1991).

*2) It also flooded five years earlier (1985) but at that time floodwaters were not as high. The last big flood here had been in 1974 (*Nanaimo Daily Free Press*, December 5, 1990).

*3) On one side of the flood plain, the dyke keeps the Somass River from flooding at high tides. It also keeps water from flowing back into the Somass River. Flap gates on the riverside close when the river is high, so water does not drain from the field. On the other side, work done by the city on Lugrin Creek does not effectively take the water into Kitsucksus Creek, Wellings claimed. According to City Clerk George Wiley, the work performed on Lugrin Creek was not done with the aim of completely eliminating flooding, Watson observed that the design worked on the statistical averaging of storm intensity, duration and frequency for a 1:25-year period (*The Alberni Valley Times*, January 10, 1991).

*4) CRD and Highways had approved this subdivision on the banks of Mill Stream about 18 years earlier (*Times Colonist*, December 11, 1990).

1991

Source: Evans and Savigny 1994; Evans, unpublished data.

Details: In 1991, a debris avalanche from the south side of Goat Ridge covered part of the abandoned site of the former mining village of Mount Sheer. Had the village still been occupied, many houses would have been destroyed and substantial casualties could have resulted (Evans and Savigny 1994; Evans, unpublished data).

January 1991

Source: VanDine 1992.

Details: In January, at Tofino Creek a 15,000-25,000-m^3 rockfall occurred. It destroyed 500 m of forestry road. An excavator operator narrowly escaped death (VanDine 1992).

Early February 1991

(Icejam/flooding)

Source: *Alberni Valley Times*, February 4, 5 and 6, 1991; *British Columbia Report*, February 25, 1991; *PEP Talk*. Vol. 2, No. 1, Spring 1991.

Details: In early February, unseasonably warm weather caused a rapid break-up of ice on the Nicola and Coldwater rivers. Prolonged cold weather had caused thicker than normal ice build-up on the Coldwater River. Then in five warm days, 5-10 degrees above freezing, it began melting. At the river’s headwaters in Kingsvale, 25 km south of Merritt, the ice broke into large chunks that headed downstream, pulling in more on their way. The ice jammed between Merritt-Colletville, impeding the river’s flow and causing flooding at

Merritt, Canford, Kingvale and the 14-Mile Reserve area. Some 100 residents were flooded out and 10 dwellings were damaged or dislodged, causing up to $1 million damage. The huge ice floes caused heavy damage in Merritt. Several metres of riprapping were wiped out, leaving Merritt and Sunshine Valley vulnerable to future flooding. Roads were washed out, minor bridges damaged and gas lines shifted. The ice pushed a hole in one house, pushed mobile homes off their pads and turned others on their sides. At Spring Island Trailer Court, water as deep as 6 ft. (1.8 m) forced residents atop roofs. It spanned an area of 25 city blocks, flowing through and over the 6-ft. (1.8 m) dykes. City crews immediately began repairing dykes and managed to bulldoze ice that threatened to take out the wooden Main Street bridge. The chunks of ice swept into the Nicola River piled up again 20 km west at Sunshine Valley. Evacuees had to spend at least two weeks in motels. Cabinet allotted $1 million via the Provincial Emergency Program to compensate residents and the city.

Between the morning of January 31-February 5, Port Alberni recorded 258 mm of rain. Early on February 1, a plugged drain caused the area in front of Wood Elementary School to flood. The almost non-stop rain caused flooding elsewhere. The city received many flood-related calls. According to City Works Manager Jim Levin, "It's just the volume of water… The drains aren't taking it." Buildings in the lower area of the (City works?) yard were under water.

Early on February 4, downed trees, flooding and erosion caused partial closure of Highway 4 East. Around the "hump" and around Cameron Lake, it was restricted to single-lane traffic. A mudslide was reported on the railway tracks. A soil-saturated tree toppled on a Grandview house. On February 6, at least two houses at the end of Alexander Street, an area with an habitual flooding problem, were still flooded. Winds broke loose and subsequently flipped over a floatplane tied to a dock at Sproat Lake.

August 7-9, 1991

Source: *The Alberni Valley Times*, August 8, 1991; *PEP Talk*. Vol. 2, No. 3, Fall, 1991; Ministry of Environment files.

Details: A surprise storm hit the Ucluelet-Tofino area. High winds knocked out power and 100 mm of rain flooded the only highway out of the Pacific Rim National Park area. According to weatherman George Sasaki, during the previous two days the area had received more rainfall than during all of June and July. Between the afternoon of August 7-the morning of August 8, some 60.8 mm was recorded. It broke the record of 37 mm, set in August 1961. Precipitation at Ucluelet, Nootka Island, Port Hardy and Campbell River was 102, 107, 46 and 28 mm of rain, respectively.

On August 7 at 10 p.m., the log dump bridge 14 km from Ucluelet-Tofino junction washed out. The road was reopened at 8:30 a.m. on August 8 to one-lane pilot controlled traffic as repairs were being made. As highway officials were not sure how long the bridge could be kept open, there were fears the Pacific Rim Highway might have to be closed. Hundreds of people were stranded and 18 visitors were left without accommodation. Parts of the West Coast Trail were washed out.

On August 9, flooding occurred on the Lillooet River, Green River and Pemberton Creek. The flooding was caused by rain and melting of a late snowpack melt, with temperatures in the 75-85 ^{o} F range (23.9-29.4 ^{o} C). Adjacent to the Pemberton airport, the Lillooet River rose to within 0.3 m of the crown of the road, which corresponds to the 1:200 year level. The high waters in the Lillooet River backed up the Green River. The Forest Service yards to the east of the airport flooded. Trailer units on the site were inundated to a depth of 15 cm. Though the newly constructed bridge on the Green River remained free of debris and logs, the old bridge with its many bents would undoubtedly have become clogged. Water levels of the Green River were high enough to overflow the bridge's access road. The existing earth berm of the right bank of the creek was breached at three locations. Early on August 9, water was flowing at the foundations of the house under construction and near the barn on the Wuschke property. As a result of the berm breaching, some minor erosion occurred along the footings of Wuschke's new house.

August 17-18, 1991

Source: *The Vancouver Sun*, August 21, 1991; *PEP Talk*. Vol. 3 No. 1 Spring 1992.

Details: Heavy rain over the weekend caused mudslides, cutting rail and road links to Lillooet. According to BC Rail spokesman Barrie Wall, four slides covered a total of about 250 m of track, rendering the line impassable. The first slide occurred on August 17 on the Duffey Lake Road. It covered a 50-m stretch of the rail line about 7 km south of Lillooet in a 5-m pile of mud and rubble. Two cars, loaded with timber, of a southbound freight train were derailed by a second mudslide as the train sat waiting for the first slide to be cleared. About 200 BC Rail passengers were bussed north and south around the slides on August 17 and 18. The rail line was reopened in the early afternoon on August 18.

On August 17, Highway 12 between Lillooet-Lytton was closed because of mudslides. On August 21, the Ministry of Transportation and Highways reported the Duffey Lake Road to be in "muddy and extremely rough conditions."

The rainfall caused BC Hydro to spill the most water over the top of the Carpenter Lake dam into the Bridge River near Lillooet since 1972. According to BC Hydro spokesman Peter McMullan, the power company was spilling 210 m^3 of water per second into the river.

Floods caused heavy damage in Britannia Beach, a town of just 300 year-round residents. Tons of gravel and debris buried cars and submerged homes.

August 27-31, 1991

(Dam burst/flooding).

Source: *The Squamish Chief*, April 16, 1991; *Coquitlam Port Moody Port Coquitlam Now*, September 1, 1991; *The Squamish Times*, September 3, 10, 17 and 24, 1991; February 4, 1992; *The Citizen*, September 5, 12 and 26; October 3, 1991; Ministry of Environment files; Ward and Skermer 1992 (pp. 355-363); Bland 1992 (p.1 and 5); Evans, unpublished data.

Details: August was an unusually wet month in southwestern British Columbia. During the last week of the month, a low-pressure area stalled for a long period off the west coast. This caused weather patterns similar to those usually expected in the late fall. Winds associated with the front carried moist air into the western Cordillera and caused heavy precipitation between August 27-31. Temperatures during the storm event remained relatively high, unlike temperature conditions in the late fall. Freezing levels were at an elevation greater than the tops of the higher peaks of Fitzsimmons Creek basin. Consequently the whole basin received just rain, rather than rain at lower elevations and snow at higher elevations.

The torrential rains caused devastating flooding in the Howe Sound communities of Britannia Beach and Cheekye. Dozens of people evacuated from their houses after rivers burst their banks and flooded at least 50 homes. At Britannia (Beach), gravel build up in Britannia Creek caused the creek to overflow its banks, temporarily cutting off Highway 99 and depositing considerable amounts of sand and gravel in and around homes and businesses on Copper Beach Estates. Around 10 p.m. on August 29, Britannia Creek, carrying thousands of tons of gravel and debris flooded the lower townsite with 5 ft. (1.5 m) of water. The evacuation of about 30 residences on the north and south sides had just started half an hour earlier. Heavy flooding during the night of August 29 and all day August 30 stretched 800 m in width along the highway from the Britannia Creek bridge to the 99er Restaurant. The BC Rail line acted as a dyke and prevented the floodwaters from escaping into Howe Sound. According to some eyewitness accounts, BC Rail made the disaster worse by shoring up rail lines along the Britannia foreshore thus preventing the flood waters to drain. As BC Rail gradually completed its operations, floodwaters visibly rose 1-2 ft. (30-60 cm) along the 400-m wide flooded area. Floodwaters eventually flowed out over the bridge and into Howe Sound through the 2-m hole washed out of the rail embankment.

The water and gravel of the August 1991 flood in Britannia Creek caused an avulsion and flooding across the fan. At the time of the flooding, the creek channel had already been partially infilled by the previous 1989-dam breach flood. About 11,000 m^3 of bed material were deposited in the creek, and about 20,000 m^3 on the fan. *1) An unknown amount of material was swept into Howe Sound (Bland 1992).

Poor maintenance of old Jane Basin mining roads resulted in debris slides that added to an already loaded Britannia Creek. John Crook, Squamish Forest District media relations officer, said that some of the slides originated from the old mining roads and carried down debris to Britannia Creek. He noted that most of the recent slide activity had taken place on the south side of the creek.

Peter Jordan, geomorphologist with the Vancouver Forest Region, said that at least six fresh debris slides and debris flows had been observed along the old mining road that switchbacks into Jane Basin. Some of these slides originated from the road itself, others originated further upslope. According to Jordan, the reason that there was no much flood damage was because of the amount of gravel in the creek, which made the creek jump its banks. The source of the high quantity of gravel in the creek was identified as originating from the previous year's floods, by the gravel in the creek as a result of Copper Beach Estates blowing the Park Lake Dam the previous year and from the most recent fresh debris. (*The Squamish Times*, September 10, 1991).

After an emergency meeting of Britannia Beach residents, Copper Beach Estates' 12 trailers were moved to a new site in a trailer park high above the creek. Though Copper Beach Estates would absorb the cost of moving the trailers, Ralph Fulber, president of the Britannia Beach Community Association, said Copper Beach Estates had been negligent in allowing the trailers on the floodplain along the north shore of the creek to begin with. "At least four trailers were moved into the area after the Thurber Report [1983] was presented, labelling the north shore of the creek as a high risk area to flooding." (*The Squamish Times*, September 24, 1991).

Early estimates of damage inflicted over the three days starting the night of August 29 amounted to $4 million. Britannia Beach alone suffered damages between $500,000-1 million. According to the area Regional Director Dan Cumming, "the last one (flood) about three years ago was bad but this is infinitely worse." Ministry of Highways authorities said that the avulsion was caused by a logjam which had formed on the west side of a footbridge, backing up the water until the creek broke through its bank 700 m upstream. By the morning of August 31, floodwaters had subsided leaving the community under several inches of water. When the last of the water finally retreated, much of the lower Britannia Beach lay under several feet of hard-packed sand, gravel and rocks that appeared to be 5 ft. (1.5 m) deep at points.

Extremely heavy rainfall between August 27-31 resulted in flooding or near-flooding situations in the Squamish area. On August 30, Squamish recorded its greatest one-day rainfall with 103 mm. In Squamish, high flows in the Squamish, Cheakamus, Cheekye, Mamquam and Stawamus rivers and in Culliton and Mashiter creeks caused limited flooding and considerable damage to rock riprap bank protection, roads and the water intake of Mashiter Creek. The dyke and revetment on the right bank of Stawamus River in Valleycliffe suffered damage to bank protection at several locations. Damage also occurred at Mamquam River opposite the golf course and at the Squamish River at Judd Slough, Culliton Creek, Cheakamus River, Fitzsimmons Creek, Miller Creek and Ryan River.

On August 31, the Mashiter Creek dam was taken out after a debris jam formed in the Mashiter Creek water intake. On August 30, rocks and debris had filled the dam solid and rendered it inoperable. An estimated 20,000-50,000 tons of debris clogged the Mashiter. The overall damage seemed worse than previous year's. *2) Squamish-based engineer Frank Baumann first expressed geotechnical concerns about Mashiter Creek in a letter to the Ministry of Municipal Affairs in December 1987: "Mashiter Creek drains a basin that has been heavily logged. Its upper reaches are underlain by unstable volcanic debris from Mount Garibaldi that has produced numerous mud flows in the past and is likely to produce more slides in the future." In a submission to council just over two months before this event, Baumann stated, "The unstable soils together with the clear-cut logging and poor road building of the past, mean that the Mashiter watershed is much more susceptible to landslides than the Stawamus River basin." On the morning of August 30, the original creek bed was riprapped but it was not until 5 p.m. that day that the creek was redirected.

The widespread flooding forced the evacuation of many Upper Cheakamus residents. The First Nations community of Cheekye was completely flooded in several feet of water. Starting on August 29 at 10 p.m., waters quickly rose and flooded an area encompassing 15 homes. Residents were evacuated by helicopter. The First Nation graveyard was also washed out. Floodwaters washed away the majority of the grave markers. Sandbagging was unsuccessful, as the water was moving too quickly. At one point, the Cheekye River was monitored travelling at 28 km/h. The community has no proper dyking system. On one side the dyke was not high enough and the water just ran over it. *3)

On August 30-31, the Stevenson property (Block L. Dist. Lot 6958) in the Cheakamus River valley (Paradise Valley) was flooded with approximately 0.5 m of water. The floodwaters overtopped the bank just upstream of the house and water entered the yard from overland flows.

On August 27, a retaining wall collapsed at the Westwood Heights subdivision, releasing a flood of mud onto Pipeline Road. *4) The walls buttress the rear yards of a string of properties fronting the 1300 block of Kenney Street. The mudslide compromised the retaining wall of at least two adjacent properties. It was caused by sanitary and storm sewers being in the wrong place (i.e. below the slope near Pipeline Road and not up near Kenney Street).

On August 29-30, a flood event of unprecedented timing and size occurred on Fitzsimmons Creek near Whistler. *5) Gravel deposits and log debris infilled the creek in the lower reaches of the creek within the townsite. Existing bank protection was damaged or destroyed. In the steep upper reaches of the creek, considerable log debris had accumulated and a large slide was reported. The peak instantaneous flood was estimated at 120 m^3/s, and the daily average maximum flood at 100 m^3/s. This instantaneous flood magnitude was about twice the channel full capacity of Fitzsimmons Creek. The most spectacular changes to the channel bed and floodplain occurred in the canyon reach. During the tail end of the flood, the creek eroded its own deposits, and within eight days the bed level had eroded to an elevation that was 4.5 m lower than the elevation in June 1991. Concerns existed about the stability of a logjam that existed about 100 m upstream of the Blackcomb Mountain pump station intake. The logjam was completely carried away and/or smothered by new bed material and debris. At the pump station immediately downstream of this reach, the creek bed had risen about 2.5 m during the flood. Within eight days of the flood, it fell to the same level that existed before the flood. Significant amounts of damage were done to bridges and other facilities near the creek channel. About $4 million have been spent since the event on remedial measures, including removal of sand, gravel, boulders and organic debris brought down by the unusually high flows.

According to fire chief and co-ordinator of the Whistler Emergency Program Tony Evans, the damage in Whistler was substantial. The biggest problem was to get things back to normal before the winter would strike. Fitzsimmons Creek needed rechanneling and the banks would have to be fortified. The bridges would have to be repaired and the water had to get back to White Gold. By September 3, the bridge to the KOA had been repaired for emergency access to White Gold as the flood had demolished the White Gold bridge. Fitzsimmons Creek Park was completely washed out and the Blackcomb Skier bridge had to be repaired.

White Gold residents expressed their concern about a proposed dyke along Fitzsimmons Creek and wanted to explore other alternatives before proceeding with the dyke. They suggested dredging deeper and increasing the amount of riprap along the creek side. The proposed dyke would be 4-6 m in width and approximately 1-2 m in height, extending from the south boundary of White Gold (at Park) to the north boundary of White Gold. (at the KOA property). Dave Waldron, engineer with the municipality, said the dyke would be lower than the one presented to council in December 1989. It would be lower than originally planned since the Nancy Greene Bridge, which acted as a bottleneck during the flood, would be removed or replaced with a higher structure and the creekbed would be lowered. Waldron also said the design flood would be less than the Ministry of Environment's 200-year flood standard of 400 m^3/s, which was currently under review. Director of Public Works John Wilson said the dyke offered a significant increase in protection at a minimal cost. White Gold residents claimed the proposed dyke would destroy the integrity of the creek and diminish the natural beauty of their neighbourhood. Others said the dyke would become a throughway for cyclists and walkers. Preliminary estimates indicated the dyke would cost $470,000 with PEP contributing $370,000 and the municipality $100,000. The dyke would be constructed from gravel removed from the creek (*The Citizen*, September 26, 1991).

The Pemberton Valley reported 60 mm of rain in 24 hours. In Pemberton, significant flooding of agricultural land occurred when the dyke on Ryan River was overtopped. In addition, damage was caused to bank protection and dykes on the Lillooet and Ryan rivers and Miller Creek. Lillooet River flow rates reached 1,260 m3/s causing damage to the Pemberton airport and croplands in the floodplain area. On August 29, Miller Creek spilled its banks. Paul Froese of Agriculture Canada estimated that at least 50 % of the valley's potato crop was lost. Many farmers lost two to three years worth of future potato seed. *6)

Between 75-100 calls for aid were received on the first day after PEP opened a claim centre for the Squamish-Whistler area. It would take months to repair the estimated $4 million of damage in the Sea-to-Sky transportation corridor. Train operations were expected to be back in service around September 7.

A group of people attending a big funeral off the Skookumchuck Reserve was evacuated. Emergency response personnel located over 200 people stranded by floodwaters northeast of Pemberton on Lillooet Lake. On August 31-September 1, 40 of those stranded were evacuated to Pemberton. Food and supplies were flown to residents who decided not to evacuate their homes. Residents of the upper Cheakamus Valley circulated a petition calling for an independent inquiry into BC Hydro's operation of the Daisy Lake dam. The residents downstream from Daisy Lake dam contended that BC Hydro had been negligent in their operation of the dam during the storm. They claimed that BC Hydro's actions caused the resulting flood damage to be more excessive than necessary. Helmut Scherer, Upper Cheakamus resident for over 12 years, said "In 1980, we had a severe flood because they didn't release the water in time and then they released too much." Scherer claimed that BC Hydro kept as much water in the dam as possible. Then they released too much water at once, which the river down below could not handle. (*The Squamish Times*, February 4, 1992) "This time, Daisy Lake was full and there was no water released ahead of time. With weather warnings they should have released some water. There would still have been flooding if the dam was operated right but it would not have been as severe." Scherer said the problem dated back to 1982 when BC Hydro decided to eliminate the job of dam keeper at Daisy Lake Dam. Instead the dam was controlled electronically from Burnaby. "We told (BC) Hydro then that we would start a class-action suit if flooding happened again."

Bill McNeney, a production manager for BC Hydro, said that the spill levels at the Daisy Lake dam were governed by a consulting report that was conducted in 1982. According to a report by Northwest Hydraulic Consultants, the critical bank-full conditions for the Cheakamus River are located at the entrance to a stretch of the river known as Midnight Way. The report concluded that bank-full conditions would result from a discharge amounting to 450 m^3/s. This ratio is reduced to 225 m^3/s when water from tributaries joining the Cheakamus River downstream from the dam are factored into the equation. According to McNeney, the most recent bout of flooding was due to unusually high water levels in the creeks feeding into the river downstream from Daisy Lake dam. "This particular storm had some unique characteristics in that Rubble Creek was full to overflow, and that's never since I've been here [16 years]. In Culliton Creek they almost lost the bridge because the water was threatening to wash away the bridge on Highway 99. The contributors to the river downstream from the spillway in this storm were extremely high flows. McNeney contended that the plan adopted by BC Hydro to manipulate the water levels in the Cheakamus River worked fine in its current form. "In November of 1990 it worked right to the letter and the plan hasn't changed."

The washouts and damage caused by the heavy rains to bridges in the Squamish Forest District resulted in cutting off approximately 75% of the district logging roads. Damage to forestry logging roads could reach as high as $2 million. By September 26, the majority of the damage caused to Forest Service logging roads on August 30 was repaired. Remaining closed while under repair, included Indian River, Chance Creek, Meager Creek, west side of Lillooet Lake (from Billygoat Creek south to Fire Creek) and Upper Lillooet (access to Salal Creek only).

Flood damage to Meager Creek Hot Springs resulted in that area's closure for the remainder of the year. The M-Creek access road was also closed due to flood damage.

---

*1) A very approximate estimate of the natural bed material movement was 120,000 m^3. It was considered prudent to make allowance for 100,000 m^3 of storage volume in any development scheme for the fan at Britannia Beach (Bland 1992).

*2) The Mashiter Creek dam had earlier been the centre of controversy because of accusation about flawed engineering and disagreement over its cost effectiveness. In November 1990, only three days after its completion, the dam collapsed in a series of disasters that had plagued the $1.6 million project intending to supply Squamish with an additional water source (*Squamish Times*).

*3) Graham Rawlings, an engineer and principal consultant with Thurber and Golder, estimated there were 5 million tonnes of debris distributed across 200 ha. Since early July, a study was underway on the Cheekye River fan and its surrounding area. The findings of this Cheekye River Terrain Hazard and Land Use Study would determine the geological hazards present there and what kind of development could take place on the land in the future. The $290,000-300,000 study, expected to be completed by February 1992, would evaluate the area for potential landslides, flooding and debris flows that might affect future development (*The Squamish Times*, September 17, 1991).
The findings of the current study would replace the information provided in three studies done since 1974. As many people "doubted" the Crippen Reports of 1974 and 1981, this resulted in another study in 1990, the Morgan Report, which used only available data from the two earlier reports by Crippen. (*The Squamish Times*, September 17, 1991). A Ministry of Environment study dating slide material determined that portions of the Cheekye fan are still active. According to consulting geologist Frank Baumann, carbon dating collected from wood debris indicated that the slide happened 1,100 years ago. The study also suggests that the active area is elongated east-west and is situated well away from the Cheekye-Brackendale population centres (*The Squamish Chief*, April 16, 1991).

*4) The area, formerly a gravelpit located next to the Coquitlam SPCA was historically plagued by flooding and washouts (*Coquitlam Port Moody Port Coquitlam Now*).

*5) The infrastructure development, including bridges, roads and buildings, have all been built on the alluvial fan reach of Fitzsimmons Creek (Ward and Skermer 1992).

*6) For some valley growers the potato crop amounted to 90% of their annual income. Agriculture Canada had chosen the valley because of its location and low insect populations. In 1979, four greenhouses were built in Pemberton and local farmers began producing their own cuttings. By 1991, growers in the Pemberton Valley annually harvested about 500 ac. (200 ha), producing 4,000-5,000 tons of potatoes with an estimated value of $1 million. The bulk of the Pemberton valley potato crop was sold as seed potatoes to British Columbia, Manitoba, Alberta. Washington, Montana and California (*The Citizen*, September 5 and 12, 1991).

September 3, 1991
Source: *The Squamish Times*, September 10, 1991; Smith 1994; Bunce et al. 1997 (p. 345).
Details: On September 3, a rockfall on the Squamish Highway near Porteau Cove Provincial Park claimed the life of a 43-year old Squamish man. The 12-in. (30 cm) diameter falling rock fell through the windshield of his vehicle. The accident happened 3.5 km north of the Just fatality on January 16, 1982. *1)
---
*1) The Just case had set a legal precedent when Just was awarded compensation by the B.C. Supreme Court for losses resulting from a rock fall in the Argillite Cut. Subsequently, Lewis (Smith 1994) was awarded compensation for the death of her husband (Bunce et al. 1997). Since 1993, the Ministry of Highways and Transportation has adopted the Rockfall Hazard Rating System.

November 12, 1991
Source: *The Vancouver Sun*, November 13, 1991.
Details: On November 12, the Lower Mainland recorded 17.5 mm of rain in a 24-hour period ending 4:00 p.m. The rainfall caused some road washouts, resulting in the temporary closure of the Bailey bridge between Coquitlam-Port Coquitlam. According to BC Hydro spokesman Peter McMullan, the storm caused some power blackouts in the Lynn Valley area of North Vancouver. Between 300-400 customers were left without electricity for several hours.

January 22-February 2, 1992
Source: *The Squamish Times*, January 28; February 4, 1992; Ministry of Transportation and Highways, Rockfall notification summary; Ministry of Environment files.
Details: On January 26 at 3:45 a.m., 150 m^3 of rock came down onto Highway 99 (at 34.3 km) near Britannia Creek. The rockslide 1 km south of Murrin Lake blocked two lanes of Highway 99. No vehicles were involved. Later that morning, highways crews were able to open one lane of traffic Two boulders, "comparable in size to tandem dump trucks," were drilled and blasted. Long lines of ski traffic were held back until the road opened to two-lane traffic at 10:15 p.m.

Early on the morning of January 28, flooding occurred near the point where the Cheekye River flows into the Cheakamus. Debris left over from the massive flooding in August 1991 contributed to the minor flooding of the Cheakamus. The force of the river spread it out and water was spread over the sides. According to Squamish public works assistant superintendent Mike Darbyshire, damage could have been more widespread were it not for the high grade of the Paradise Valley Road, which held back much of the rising water. "The build up on the road acted like a dam and caused the water to flow into the right area, away from the houses and the highway. The damage was minimal compared to what would have happened if the road was lower." The water bypassed Squamish Nation band's nearby subdivision and followed an old riverbed. As a safety precaution the subdivision was evacuated for one night.

On January 30, a flooding Englishman River caused the evacuation of the residents of Parry's Trailer Park on Martindale Road, Parksville. *1)

---

*1) The trailer court had suffered the effects of flooding on several occasions during the previous two years, primarily during the November-December rainy season. PEP had assisted most of the permanent residents to evacuate their homes. The evacuations, which include meals, accommodation and transportation, and repairs over the two-year period amounted to more than $30,000, excluding volunteer loss of wages (Ministry of Environment files).

May 11, 1992
Source: *The Daily Townsman*, May 12 and 13, 1992; Dawson et al. 1994.
Details: On May 11 at 7 a.m., a flowslide at Westar's Greenhills Coal Mine dump near Elkford killed one person. The truck and its driver were swept away by the waste dump flowslide in the Fording River Valley (Dawson et al. 1994). After almost two days of continuous search the victims body and his vehicle were recovered under 4 m of rock. Over 100 workers and sniffer dogs took part in the search. The slide in the Cougar Five area of the mine poured approximately 150,000 m^3 of waste rock across a mine haul road.

June 9, 1992
(Controlled dam burst).
Source: *The Squamish Times*, March 31, 1992; June 16, 1992.
Details: On June 9 at 10:30 a.m., Tanac Development Canada Ltd. successfully dismantled the Furry Creek dam, 2.2 km upstream from Highway 99. *1) The structure was demolished by a blast from 74 charges, which removed 50 m of the dam's length, 8 m in a test blast and 10 m of vertical.

The Ministry of Environment's dam division had considered the structure susceptible to failure since it was catalogued 24 years prior. But an agreement with Anaconda Exploration of Canada Ltd., previous owners of the site, stipulated that the dam could remain because there was no development downstream. After Tanac purchased the property from Copper Beach Estates Ltd. and began the next phase of its multiple-purpose development, the dam was slated for demolition

The structure was holding back an estimated 20,000-30,000 m^3 of sand, gravel and wood debris, 8,000-10,000 of which was released in a 200-m surge when the dam was demolished. According to Michael Egan of Tanac, the material behind the dam was much finer than expected and there was very little tree stumps and wood debris. Depending on the amount of rainfall and the number of storms that will flush the material, it would probably take one to three years to make its way downstream.

To act as a trench, through which the material was to flow, Tanac had removed 5,000 m^3 of gravel from the front of the Squamish highway bridge. The company would later dredge the trench until all the material has worked its way out of the creek.

---

*1) Built in 1916 for the Britannia copper mine, the Furry Creek dam was the largest one in British Columbia at the time of construction. The 51-m (?) high and 100-m long structure once supplied water through 48-in. (1.2 m) diameter wooden pipes to a power station at Britannia (*The Squamish Times*, June 16, 1992).

September 16, 1992

Source: *Summerland Review*, September 24; October 1, 1992.

Details: On September 16, a mudslide occurred in Summerland in the Okanagan Valley. *1) A property owner on North Lakeshore Drive sustained some $200,000 damage. The slide wiped out landscaping, a garage, three boats and two cars.

---

*1) In 1970, a slide in the same area destroyed two homes, killed one man and hospitalised his wife. Another slide in 1982 did not cause property damage. Following the slide, Golder Associates Ltd. again did a terrain inspection. According to the report, four "adverse conditions caused the slide: heavy irrigation and leakage from irrigation lines in the orchards behind the slope; seepage entered the slide area in one area 4.5 m below the top of the cliff; soil underneath part of the cliff that fell became saturated with water. The extra weight at the top of the cliff added pressure on the slope. The farmer on top of the cliff had a part drip, part above ground irrigation system. Municipal clerk George Redlich stated that Council might well consider stricter monitoring of problem zones such as the Crescent Beach cliffs.

To lessen the chance of future slides, the report suggested the municipality to follow five points: that soil and ground water conditions be investigated; that seepage be monitored; that irrigation systems be inspected for leakage, that water metering and/or water restriction valves be installed, and that cliff movements be measured by instruments on top of the cliff. A slope to the south of the slide, posing a particular risk to traffic on North Lakeshore Road should be removed. Dykes, or berms, on either side of the road should help catch any future slide material. The report stated that all these suggestions were preliminary, "based on site inspections only."

According to the residents of North Lake shore Drive, the three-and-a-half page engineering report left more questions unanswered than answered. Previous reports by Golder Associates Ltd. in 1976, 1979, and 1984 regarding the area suggested similar action to make the cliffs safer. But the municipality had not acted upon the suggestions. Soon after, the construction of a berm, 1.5 m in from the asphalt commenced. It would stand 4.5 m high, 18 m wide at the bottom and 4.5 m wide at the top (*Summerland Review*, September 24; October 1, 1992).

October 23-24, 1992

Source: Ministry of Environment files.

Details: On October 23-24, flooding occurred in Pemberton after Ryan Creek breached a dyke. Fitzsimmons Creek in Whistler and the Squamish River were also reported to be in danger of flooding. In Pemberton, the airport and the golf course flooded from the Green River side. During high water, a washout on the Meager Creek Road stranded 14 vehicles with 20 people.

On October 23, residents at the Tantalus Acres subdivision, north of Brackendale near the Squamish River experienced flooding problems. Water was flowing along the Squamish Valley Road and onto the road to the subdivision. The water, 6 in.-1 ft. (15-30 cm) deep, collected in some low-lying areas including front and backyards. Subdivision residents noted they had been experiencing flooding more frequently in the past few years. They attributed the cause to an increase in riverbed elevation in the Squamish River. Apparently at high water in the Squamish River, water backs up a creek channel that crosses Squamish Valley Road, leading along a hill side and back under the road to the east and south to a wide low area, from

where it flows down the road to Tantalus. Some of the houses in the subdivision appeared low enough to suffer flooding at such times of high water.

December 22, 1992
(Non-fatal avalanche).
Source: Jamieson and Geldsetzer 1996 (pp.175-176).
Details: On December 22, an avalanche in the Kootenay Pass on the Salmo to Creston highway hit a moving vehicle. A storm that started on December 18 had caused several highway closures for avalanche control. On the morning of December 22, avalaunchers on Towers 1, 2, 3 and 5 were used. Shots from Tower 2 caused four avalanches to deposit 2-4 m of snow onto the highway. After the highway reopened, a natural avalanche from avalanche path "21.5" hit a westbound car broadside. The car was pushed to the edge of the road, 300 m above the bottom of a creek. The car was damaged and a passenger sustained minor cuts to the face. The highway was closed. Analysis of events suggest that not all the unstable snow in path "21.5" had released during avalanche control that morning.

April 9, 1993
Source: *Revelstoke Times Review*, April 13 and 16, 1993.
Details: Late on April 9, a rockslide caused by natural erosion occurred at Three Valley Pass blocking both lanes of the Trans-Canada Highway. Depth of the debris, which covered a 60-m stretch of highway, ranged from 2-5 m. Some of the rocks were about "half the size of a rail coal car." Some small rocks smashed through the windows of a hotel. The slide caused about $400 damage to windows and a door of the nearby Three Valley Gap Motel, which had been closed for the winter. Motel owner Gordon Bell said, "We've had rocks come down before but this is the worst slide we've had." According to Highways District supervisor Dean Handley, "overall there was not a lot of material on the highway. There have been some slides at Three Valley but nothing of this magnitude."

Westbound traffic was re-routed via Highway 23 south with people waiting up to four hours for the Shelter Bay ferries. On April 11, the Highways Ministry opened another detour via the CPR right-of-way. On April 13, this detour was closed indefinitely after it became too muddy for traffic. As the Shelter Bay ferry detour caused 12-hour delays for Greyhound buses, the company ended up rerouting their buses along the Creston and Jasper routes. After reopening to two-lane traffic a construction zone limited speed of 50 km/h remained in force for several months while work crews built a new lane to replace the one covered by the 60-m long berm built to contain any future rock falls in the slide area.

May 28-31, 1993
Source: *Creston Valley Advance*, May 31, 1993; Evans, unpublished data.
Details: At the end of May, the village of Ymir narrowly missed being flooded by the Salmo River. The river rose up to the ties of the Burlington Northern railway, threatening to undermine the approach to the Wild Horse Creek bridge. The highways department used a stockpile of surplus rock from improvements made on Wild Horse Creek Road to erect a dyke. The work, which commenced late on May 28, continued through May 29.

On May 31, a gigantic coal mine waste slide occurred at Sparwood (Evans, unpublished data).

June 4, 1993
Source: *Royal City Record/New Westminster Now*, June 8 and 13, 1993.
Details: On the afternoon of June 4, a spread (fill failure) in the southwest corner of New Westminster's Queensborough district caused some $300,000 damage to properties. The water pressure beneath Queensborough burst through the soil. *1) The roadway spilt open, sinkholes up to 8 ft. (2.4 m) deep formed and a torrent of water poured through cracks in the 6-m high berm of fill which surrounds that section of the development site. The force of the water burst an adjacent water main, repositioned an underground gas pipeline and forced a small mountain of dirt skyward into Nick Hrabar's backyard. When the water forced tonnes of sand through the ground, approximately 200 m of the 12-in. (30 cm) diameter steel cased BC Gas

natural gas line, running 5 ft. (1.5 m) underneath Slater Street was damaged. Utility poles remained upright but moved as much as 10 ft. (3 m) forward towards Hrabar's house. On June 8, the intersection of Dawe and Salter streets remained closed.

---

*1According to local residents, the area was a "bog which had been squeezed like a huge sponge." Though the soil beneath Queensborough is bog, the geotechnical consultants said preloading would allow construction on the site. For several months prior to the failure, the Queensborough residents had been warning about the dangers of Queensborough Development Inc.'s preloading of 80 lots running parallel to Salter Street. Hrabar, whose house was now unsuitable for living, and nine neighbours questioned City Council why their warnings had been ignored and what the city was planning to do to recompense Hrabar. A preliminary report of an independent engineering firm hired by the city suggested on area of the site might have been filled too rapidly. The too-rapid rate of preloading had led to the fill failure. According to Vic Sagorski, project manager for Vector Engineering, the co-ordinating company, the cause was "a pocket of especially weak soil on that site." But the City called it a "fill failure." A shift in the road grade around Christmas 1992 was written off as frost heave. The road grade in fact did change as shown by the pink BC Hydro stakes put six or seven months earlier.

According to Dawe Street resident Bob Liprot, the managers of the site were "bordering on criminal negligence." Despite a stop-work order from the city, on June 8 the company was still working on the site. Also a site of that size and danger had not even been fenced off. The high berms of sand were constantly shearing off. Lorne Elliott, resident of the area for 50 years, explained that there are vertical and horizontal avenues in the peat below the surface and that water can go any which way. He said that filling can block groundwater streams and trap the water. Contrary to some studies, the peat was not centred in the island but rather along tow old river channels which cross the island, Elliot said. Residents also wanted a 24-hour guard on the property that would remain as is for six to eight months as the preload settled. Queensborough ratepayers called for an inquiry.

July 1994

(Glacial outburst flood).

Source: Evans, unpublished data.

Details: In July, a glacial outburst flood occurred at Farrow Creek.

August 3, 1994

Source: *The Golden Star*, August 10, 1994.

Details: On August 3 at 6:30 a.m., a flash rainstorm caused a debris flow at Mount Stephen, near Field. The mudslide into the Kicking Horse River caused the river to back up and cut the Trans-Canada Highway. The flood coursed down the side of the highway, eroding the gravel bed and carrying off chunks of asphalt. It left more than 400 people stranded. About 350 people were cut off in a campsite and the Field Elementary School sheltered about 50 others. Terry Willis, Yoho Public Safety Co-ordinator described the slide as "it was like a waterfall of rocks and mud coming off the snowsheds." A party of wardens hiking on Mount Stephen first sighted the slide.

On the night of August 4, one lane of the Trans-Canada Highway was reopened, while two-lane traffic was restored by August 6.

November 18-19, 1994

(Fatal avalanche).

Source: *The Vancouver Sun*, November 21, 1994; Jamieson and Geldsetzer 1996 (pp. 94-95).

Details: Overnight November 18-19, Vancouver recorded 31.2 mm of rain in a 24-hour period. Whistler recorded 31.4 cm of snow.

On November 19, an avalanche in the Hemlock Valley Ski Area (70 km east of North Vancouver and 22 km north of Chilliwack) killed a 33-year old ski-patroller.

Late December 1994
Source: *The Vancouver Sun*, December 27, 1994; *Hiballer Magazine*, 45 (4):19.
Details: On December 26, heavy rain caused a rockslide at Turpin Creek, about 8 km north of Horseshoe Bay. The slide, which occurred at 7:45 a.m., covered three lanes of a four-lane section and extended for a distance of about 8 m.

Heavy rains over the Christmas period caused a landslide, which removed the main span over the Canadian Forest Products' East Fork rail trestle. One new tower and the glulam girders and supporting towers were swept away, leaving the rail tracks and ties hanging above a 40-metre long gap. New 38-metre steel span girders and three new steel towers were put into place. The rails were removed, using explosive charges, while the new girders were assembled adjacent to the site and the new main towers were craned into position (*Highballer Magazine*).

January 20, 1995
Source: *Nelson Daily News*, January 23 and 24, 1995; *British Columbia Report*, February 6, 1995; Evans, unpublished data.
Details: On January 20 at 7:30 a.m., a 49-car CPR freight train on the Cranbrook to Nelson line struck a massive 3-m high rockslide east of Nelson, killing an engineer and a trainman both from Cranbrook. Their locomotive plunged off a 38-m cliff into Kootenay Lake and came to a rest on a rock shelf 50 ft. (15 m) below the water surface. The two lead locomotives were completely submerged. A third engine and two open cars carrying zinc sulphide were partially suspended. Later that day, RCMP divers recovered the two bodies, trapped in the lead locomotive 18 m under water. The track reopened on January 22 at 2:30 p.m.

Freeze-thaw conditions caused the rockfall in a remote area along the South Arm of Kootenay Lake, 4 km south of Procter (Evans, unpublished data). *1)

---

*1) Two trains pass through the area from Cranbrook to Nelson daily. According to CPR spokesman Steve Morris, slide-warning devices were not necessarily the answer. "That particular area is not prone to slides. Slide fences are only put in slide areas, like Frank (slide)." (*Nelson Daily News*, January 24, 1995).

March 1995
Source: Evans, unpublished data.
Details: In March, a slide at Aberdeen, Kamloops affected 42 homes.

June 5-7, 1995
(Spring runoff/flooding).
Source: *The Daily News*, June 7, 8 and 9, July 19, 1995; *Fernie Free Press*, June 14, 21, and 28, 1995; Ministry of Environment files; City of Fernie, June 6-7, 1995 Flood Overview; CBC newscast, June 27, 1995.
Details: Early June, heavy rains quickly melting a late spring snowpack caused flooding and washing out of roads and bridges in the Elk Valley. A combination of late spring, a high snowpack and recent hot weather created flooding conditions. Between June 5-7, more than 60 mm of rain fell in the Elk Valley. A number of creeks and rivers in the area overflowed their banks. Accelerated snowpack melt, prompting the evacuation of some residents of the east Kootenay cities of Fernie and Sparwood. Flooding caused serious streambank erosion on public and private lands and extensive damage to highways, roads, bridges, pipelines and other structures. On June 6 and 7, Fernie experienced serious flooding from Elk River and Coal Creek. According to RCMP reports, about 750 people were evacuated from Fernie's Airport subdivision.

According to the Ministry of Environment's gauge along Elk River, the river's flow rate rose from 260 m^3/s at noon on June 6 to the peak of 682 m^3/s at 8:40 a.m. on June 7. *1) According to another source, the flow rate of the Elk River at its peak was 790 m^3/s, 170 m^3/s more than was measured during the previous high in 1974 (*Fernie Free Press*). While the Elk Valley received about 60 mm of rain on the day of the flooding, in the mountains probably higher rainfall occurred, causing the river level to jump dramatically. Damage in the Elk Valley was estimated to be over $7 million (CBC newscast, June 27, 1995).

*2) Mudslides and flash floods paralysed transportation and industry. The Crowsnest Highway washed out 10 km east of Sparwood and the CPR line was damaged in two locations.

Overnight June 6-7, about 100 families were forced from their homes in Fernie. Coal Creek turned into a raging torrent and burst through a dyke. Two days of driving rain caused the creek, which runs through the southern part of Fernie, to flood. On June 6 shortly after 8 p.m., a protective dyke gave way and the creek began flowing freely through the streets and into basements. Other dykes in the area were reported destroyed and the flood either washed out or destroyed access to several bridges, including the main CPR line. By 8:30, part of the Park Avenue bridge had collapsed into the creek and the railway bridge 300 ft. (90 m) up the creek was heavily damaged. In West Fernie, residents sandbagged their properties to keep the water out. Floodwaters caused severe damage to private residences, roads, bridges, water, sewer and natural gas service in the Moutainview subdivision. It was Fernie's worst flooding in almost 50 years. *3) Had the Cokato Road bridge over Coal creek failed, the evacuation of the subdivision would have been extremely difficult because the bridge was the only remaining quick access link from the city.

During the June flood event, water escaped the main Coal Creek channel and entered Brewery Creek. In addition, local storm water increased the flow of Brewery Creek. At the time, the creek was directed through a culvert in the CPR embankment, then through an open channel behind Elk View Crescent, and in turn entered the Coal Creek at a flood box. During the flood event, the flood box closed due to high water in Coal Creek and water flooded out onto the properties behind the dyke.

A Fernie man was missing and presumed dead. His overturned vehicle was found at a road washout 34 km up the Bull River (Forest?) Service Road. The vehicle was spotted by BC Forest Service staff who were doing a helicopter check of roads damaged by high water. Forest Service officials warned motorists to stay off logging roads until the ministry and local forest companies inspected them. Cranbrook Greyhound Bus manager Tom Keiver expected the Crowsnest Highway to be closed to bus transportation at least until June 9.

Summary of events of June 6-7 flooding at Fernie: Floodwaters threatened the golf course. The banks of the gymkhana grounds were heavily eroded. Sandbags reinforced the bank and re-directed the breaching flows. Floodwaters approached the GNR 17th Street intersection. (The dyke terminates at GNR). After a large logjam lodged against the bridge abutments, water was diverted towards the east bank. Above the riprapped portion north of the bridge minor erosion occurred. Northlands flooded, the highway dyke allowing water to percolate to 16th Street, 10th and 11th avenues. The floodgates unable to open caused the storm water system to back up. Extensive sandbagging averted damage. The storm system floodgates caused the catch basins to back up for two blocks. Floodwaters were trapped behind the setback dyke in Annex pond. The outflow breached the dyke at the intersection. To prevent erosion, it was sandbagged. Ground water levels flowed through low-lying areas. Sandbags diverted water along the toe of the dyke to the storm water system. The Fairy Creek water supply water main was exposed as the raging creek eroded the riprap toe of the creek edge. West Fernie Bridge floodwater began to flow between the two upper abutments. Sandbagging to 1 m contained and diverted the flows back to the main river channel. The river flowed over the walking trails under the bridge. Sandbags diverted the flows away from the Quattrin Apartments' parking lot. Sandbags kept away water from breaching to within inches of crest of the Dyke between West Fernie Bridge-8th Avenue. The river crested the West Fernie dykes and flowed into the subdivision. Floodwaters caused extensive damage to houses. Sandbags diverted major flows around properties. Suspended gravel from Coal Creek was deposited on the large island in Elk River. The flow was redirected towards the bank at Mountain View. Park Drive Bridge washed out on both accesses. The existing flow channel was unable to handle the volume of water. Coal Creek undermined the footing of the CPR trestle and dislodged and twisted the track. The area behind the abutment and the Coal Creek Trail washed out. The 150-mm concrete-encased City of Fernie water main crossing beneath Coal Creek broke due to the undermining by suspended gravels back washing effect created by the weir. Coal Creek overflowed the bank at the Hydro right-of-way, flowing through Brewery Spring across Cokato Road, outflowing beneath the track, through the culvert and drainage tunnel to Elkview Crescent. Coal Creek unravelled the main dyke above the bridge and flowed down Mt. Minton. It eroded the toe of the slope at the end of Park Lane. The saturated slope on lubricated clay layer released to the creek waterline. Though the property line was still

intact, it had only limited support. Due to the high river level the floodgates were unable to open. Coal Creek water could not escape from within the dyke. The storm sewer system backed up at the catch basins. Elk River flowed into Mountain View Park with levels exceeding the rock dyking at the road edge. Major sedimentation and wood debris were deposited throughout the entire park. Storm sewer water trapped behind the dyke flowed into the drainage ditch and accumulated at low-lying areas. As the storm water back flow gates were inoperable due to the high water, the flows followed the dyke. The Mountain View Park access asphalt was cut to allow the water to bypass back to the river. The Elk River eroded the soil bank downstream from the previously placed riprap. The river eroded private property and threatened the highway. Coal Creek submerged the sanitary sewer pumping station site. The water level came within 1 in. (2.5 cm) of entering the door at the east entrance. The increased flows of infiltration caused the large pumps to kick in. Coal Creek asphalt slipped into the creek as the toe of the slope eroded to shale bedrock. Due to logjams the creek changed course downstream. CFI River Road Ext. Bridge washed downstream of the log footings on the north side, completely washing away. High water flows and a logjam forced Castle Mountain Bridge to wash out both approaches to Coal Creek Road. The toe of the slope eroded extensively. Previously placed riprap saved the road by directing perpendicular flows back towards the original channel. The Park Avenue bridge, which lost both approaches, had only its cement structure sitting high and dry in the middle of the creek. It was determined sound enough for use.

Early on June 15 the bridge reopened to traffic. A higher one would eventually replace the structure. The cost for the bridge was estimated at $190,000. For several hundred metres upstream and downstream, a temporary dyke was constructed of river-run and quarried rock. A total realignment and redesign of the dyke had to be conducted. The cost for all flood-connected work was estimated at $1 million.

In Sparwood, Michel Creek washed out a 4-km section of Highway 3 east of the Michel Hotel. A section of Highway 43 just north of town was under water. Early on June 7, about 90 families were evacuated from the Mountain View trailer park after Mayor Toto Miller declared a local state of emergency. The area around the trailer park was completely flooded and a protective dyke came within 1 ft. (30 cm) of breaking. Eventually a number of logjams broke, allowing water to escape and lowering the risk of flooding. After floodwaters severed the BC Gas natural gas line, Michel Hotel residents were also evacuated. On June 7, the Sparwood Heights area was without power for about eight hours.

Repairs to Highway 3 were expected to be completed by the end of August. Eight km of the Crowsnest Pass Highway was left impassable after massive flood hit the area on June 6. Rainy weather in July delayed the work and set it back by a week and a half. The soil was super saturated and crews were unable to apply surfacing material until the base was dry. During the reconstruction traffic moved through the area by two lane continuous convoys. Crews were working 12-hour shifts, six days a week to rebuild the highway. Over 300,000 m^3 of rock and gravel were used to rebuild the highway. The ministry had 20 dump tucks at its disposal with each truck carrying 7 m^3 per trip.

Following the flooding, coal traffic moving in and out of the Elk Valley suffered extremely. Since midnight on June 7, CPR had construction crews working on the two breaks on the Fording River line. The Fording coalmine shut down as crews attempted to right powerpoles that were knocked over and restore electricity to the site. The road into the mine was closed and rail traffic into the mine was halted. More than 25 locations on the CPR mainline were affected by high waters, including damage to three bridges. Shortly before midnight on June 11, the Coal Creek bridge was repaired. Two loaded coal cars (trains?) stranded since the night of June 6, immediately headed west to Vancouver. Cars (trains?) heading east to Calgary were still re-routed north through Golden. It was expected to take at least four weeks before the line east of Michel Creek would be repaired. Between Byron Creek-Coal Mountain, at least 12 locations still needed to be repaired. Twenty pieces of rail equipment and personnel totalling 100 were dedicated to repairing the line. At key locations, repair work was carried out 24 hours a day. Fears of losing the Fording River Road after the river washed over its banks prompted the mine to send 125 workers home. CPR expected service in the Elk Valley to be entirely back on track in less than four weeks. Permanent repairs might take up to eight weeks. The Byron Creek spur was expected to be back in service in two weeks. After the three Fording coalmines had their rail service resumed, operations continued to be hampered by a shutdown of gas service. Damage to the BC Gas line occurred following the flooding of Michel Creek. The bill for repairing flood-

damaged gas pipelines in the Elk valley could exceed $2 million. The natural gas pipelines supplying Alberta gas to southeastern British Columbia would have to undergo a “massive rebuild.” Emergency repairs only already cost about $250,000. By June 18, full gas service was restored to four of the five area coalmines. Coal Mountain, the fifth mine, was expected to have gas service restored around June 22 after 600-700 ft. (180-210 m) of broken line was replaced. BC Gas constructed a new 460-m long 8-in. (20 cm) pipeline from the Michel Hotel around a washed out area of Michel Creek. Earlier, a 2-in. (5 cm) bypass was placed in the same general area. Later in the year, a broken 4-in. (10 cm) line would be repaired.

At 2:30 a.m. on June 7, a truck with two occupants drove into a rushing river. The vehicle was swept downstream until it became caught in a berm around a telephone pole. One occupant was able to escape the vehicle but the other was swept away by the current that finally returned him to the edge of the highway. A BC Hydro crew found him at 6 a.m. near the Michel Hotel suffering minor cuts, bruises and mild hypothermia.

Larry Patterson, Cranbrook district highways manager, estimated the cost to repair Highway 3 at about $5 million. Corbin Road was salvageable but 7 km of the highway had to be totally rebuilt. The ministry hoped to have Highway 3 open to two-way traffic between Sparwood-Crowsnest Pass within two weeks. On June 12 at 6 a.m., the highway had reopened to regular scheduled convoy traffic allowing vehicles through on an hourly basis while repair work continued. On Highway 43, north of Sparwood, Michel Creek bridge and shoulder erosion on the Fording River to Fording Mine Road was being repaired. On Highway 3, Michel Mouth bridge abutments had eroded and shoulder erosion and plugged culverts had to be repaired. At Michel Old Town bridge, the rupture of the gas line had destroyed part of the highway. Extensive reconstruction of 2 km of Coal Creek road, where the creek left its bed and ran down the road, was required. On Cokato Road, culvert washouts and a road washout had to be repaired. On June 12, Coal Mountain mine road crews and highways ministry workers were able to link up on Corbin Road. On June 13, the first vehicle traffic went through on the road, allowing mine crew-changes and fuel and other supplies to reach the mine site.

Crestbrook Forest Industries estimated damage to bridges, their approaches and to roads in the Elk Valley to $3.1 million. The Elk River also flooded rural properties unprotected by dykes. By the afternoon on June 7, Jim Fitzen’s farm about 15 km south of Fernie just off Highway 3 flooded. Floodwaters were up to the windowsills of Fitzen’s house. The Elk River was eroding away prime topsoil, carrying away his tools, tractors and other equipment, adding up to more than $200,000 uninsured loss. A few km from Fitzen’s property towards Fernie, Jim Rawson lost most of his barn and two 1950s-vintage cars and most of his 40 ac. (16 ha) were under water. Near Hosmer bridge, Don Caldwell’s entire farm became a river. Elk River was flowing within 50 ft. (15 m) from his house instead of the usual 100 yd. (90 m). Fitzen, like Elkford-area farm owner Warren Seifrit was frustrated with the Ministry of Environment because of its refusal to allow landowners to do work along riverbanks to protect their property.

Though Elkford suffered some runoff problems around its sewer lagoons due to a logjam, no residences were flooded and the lagoons escaped damage. A section of the Elk River along the golf course started to backwash and flow towards Highway 43. But work crews were able to build up the area and stop the flow. Flooding damaged some roads north of Elkford and some flooding occurred in the Round Prairie area. Mudslides that felled a number of trees hit the Todd Hunter area. Flooding in the Sparwood area left EK Radio’s Sparwood 1,000-W transmitter 2 ft. (60 cm) under water.

The high water came at the worst possible time for the fish stocks. Fish eggs buried in the gravel beds of the tributaries of the two rivers were washed out by the high water. Bedload movement and suspended sediment likely killed one- and two-year-old juvenile fish that had not yet graduated to the main river. As a result of the flooding, the environment ministry closed the catch-and-keep fishery in the Elk and Flathead rivers for three years. The floodwaters likely wiped out up to three years of fish population regeneration. The ban extended to cut-throat trout, bull trout (Dolly Varden), brook trout, rainbow trout and mountain whitefish (locally known as grayling).

---

*1) During previous floods, the river peaked at 466 m^3/s in 1986 and 620 m^3/s in 1974. There was no gauge at Fernie during the 1948 flood when the Hosmer bridge washed out. But according to a water management branch official, that year's flood peak was likely higher than the 1974 peak by about 20%.

*2) Elk Valley residents hit by flooding might be eligible for relief funds after the provincial government approved funding for the area. The program paid up to 80 % of a total claim for eligible items up to $100,000 after a $1,000 deductible.

*3) The Elk River, into which Coal Creek flows, flooded in some areas in 1974 and 1986. The worst flooding occurred in 1948 when several subdivisions were under water (*The Daily News*, June 7, 1995).

July 15, 1995
Source: *The Williams Lake Tribune*, July 18, 25 and 27, 1995.
Details: On July 15 at 7:30 a.m., a slide came down on the Green Acres Trailer Park in Williams Lake. Ten families were evacuated after a section of the west escarpment caved in. A crack had been observed in the backyard of one of the properties before the bank began to crumble. Angela French, one of the residents, described the slide. "I heard a terrible rumble and crash." Within seconds, a shed disappeared over the edge and fragments of a wooden fence hung to twisted wire dangling over the cliff. The landslide carried an estimated 8 m of backyard 100 m down a canyon. By the afternoon of July 15, less than 5 m of yard divided the French home from the gaping canyon.

Green Acres was private property owned by Garrett Land Management in Kelowna. In a letter to Green Acres Trailer Park residents Wayne Thiessen, city clerk-administrator, waved the city of "responsibility for the safety of persons above the top of the entire escarpment..." Four families, residents of pad numbers 15-18, were not allowed to re-occupy their homes and their mobile homes had to be relocated. Seventy residents of 60 homes were later declared at risk. Mayor Walt Cubb declared a local emergency. The Provincial Emergency Program funded the relocation of seven mobile homes. Three more homes had been added to the original four to be relocated.

October 9, 1995
Source: *The Globe and Mail*, November 23, 1995.
Details: On October 9, torrential rains caused a slide with an estimated volume of 40,000 m^3 in the Capilano reservoir watershed. The glaciolacustrine sediments caused a green cloudiness in the drinking water. The contamination of Greater Vancouver's drinking water gained national attention (*The Globe and Mail*, November 23, 1995). Following this event the Greater Vancouver Regional District shut down the Capilano reservoir and drew its water from the Seymour and Coquitlam reservoirs. According to a member of the regional water committee Doug Evans, slides around the Capilano reservoir are more likely because part of the surrounding valley seems to be shifting.

October 13-17, 1995
Source: *The Squamish Chief*, October 17, 1995; *Alberni Valley Times*, October 19, 1995.
Details: On October 13, heavy rain caused increased the level of sedimentation in Squamish municipal drinking water, which turned noticeable, discoloured. As well, some pine needles, moss and mucky material came through some resident's taps. The turbidity did not increase enough to require a boil water advisory. *1) At the Stawamus River water intake settling pond, which serves most of Squamish other than Garibaldi Highlands, water is allowed to settle for several hours before it enters the municipal water system. This eliminates most large organic and heavier material. However, some turbidity, clays and silts in the water, will remain suspended indefinitely. A filtration system in a water treatment plant is necessary to eliminate the finer particles. *2)

On October 16, heavy rains caused debris flows at Barkley Sound. More than a dozen families and seven outdoorsmen were trapped. The Barkley Main had to be cleared to give residents of Salmon Beach access to Ucluelet. The road from Toquart Bay to Highway 4 was not expected to be cleared until October

21. Overnight October 16-17, heavy rain fell in the Port Alberni area. Ministry of Forests engineer Doug Ericson estimated some 8 in. (203.2 mm) fell in 12 hours. On October 17, some 50 people vacationing at the Forest Service recreation site at Toquart Bay and the Salmon Beach Estates and residents on the Macoah Reserve were cut off from any road access. A dozen mudslides near Maggie Lake blocked roads and bridges. One slide started at the top of an old growth timber area and picked up logging debris from logged areas on its way down. *3) Between 7,000-10,000 m^3 of wood alone ended up in Maggie Lake. The Department of Fisheries hatchery and egg incubation boxes and fish weirs in Maggie River were threatened. If the logboom that held back all that wood would have broken, that wood could have washed into the river.

---

*1) The previous year during heavy rains and subsequent increased water turbidity, there were several temporary boil water advisories in Squamish (*The Squamish Chief*, October 17, 1995).

*2) At an older system like the Stawamus, chlorination is adjusted manually and is not increased as turbidity increases to avoid the risk of over-chlorinating (*The Squamish Chief*, October 17, 1995).

*3) According to Ericson, there is evidence that some big slides occurred here in the past 25-30 years but none recently (*Alberni Valley Times*, October 19, 1995).

October-November 1995

Source: *The Globe and Mail*, November 23, 1995; *The Vancouver Sun*, December 4, 1995.

Details: In October and November, heavy rain caused many landslides on Vancouver Island. One point on Vancouver Island, reported 442 mm of rain in 24 hours. Sources in the Ministry of Environment confirmed that since mid-October at least 90 significant landslides occurred across Vancouver's working forests, almost exclusively on publicly owned land. This figure was almost certainly conservative. According to Ministry of Environment, in the Port Hardy region alone, 18 slides were reported. But on cross checking with Ministry of Forests data, the actual number turned out to be 33. An environment official noted there presumably more than 90 slides occurred. *1)

Near Port Alberni, one major slide seriously affected fish habitat highly rated for recreational and commercial value because of the salmon and steelhead under way when the slide occurred. The Klanawa River, which runs through logged areas, is important for its runs of winter steelhead, Coho and Chinook salmon, and sea-run cutthroat trout. In October, it was blocked by a major landslide; followed by two more in the heavy rains in November. The slide at Klanawa River took out a main logging road when it swept down into the main channel.

---

*1) Of the slides so far reported, between 95-98% were believed to have originated along logging roads or on logged slopes. Some of the slides came from old, pre-1988, logging roads that were inadequately constructed. But some, a ministry of environment specialist confirmed, originated in areas logged as recently as 1991 (Stephen Hume In: *The Vancouver Sun*, December 4, 1995). See also the October 21, 1996 landslide event in the Toquart Bay area.

November 12, 1995

Source: *The Vancouver Sun*, November 13 and 18, 1995; February 25, 1999; *The Province*, November 19, 1995.

Details: On November 12, a debris flow with an estimated volume of 10,000 m^3 occurred in the Orchid Creek basin in the upper Seymour watershed. Following the October 9 slide into the Capilano reservoir, Vancouver's drinking water from the Seymour reservoir was cloudy as well. On November 14, the water's turbidity was 9.4 ppm compared to the 1994 average of 0.84 ppm (*The Province*, November 19, 1995). Stabilisation of the Capilano slopes would cost some $250,000. A proposed new filtration system might cost upwards of $1 billion (*The Vancouver Sun*, November 13 and 18, 1995).

In November, a major storm triggered a “train-load-sized” debris flow on MacKay Creek. The steep creek on Vancouver’s North Shore immediately below Grouse Mountain ski area caused serious flooding damage to houses located almost up to the foot of the hillside. *1)

---

*1) To assess the risk of future debris flows impacting the development, the District of North Vancouver immediately engaged river engineers Kerr Wood Leidal Associates and geotechnical engineers EBA Engineering Consultants. Advice was sought from experts in Austria, where similar problems have been faced for many years. Emergency protection works were put in place before Christmas. Early in 1996, a state-of-the-art debris basin was designed to provide permanent safeguards to the residents below. The debris basin was built in 1996-97 at a cost of nearly $2 million (*The Vancouver Sun*, February 25, 1999). During the winter of 1998-99, a similar but smaller debris flow on MacKay Creek would occur. The constructed basin arrested the debris before it could do damage downstream (*The Vancouver Sun*, February 25, 1999).

November 28-30, 1995

(Rain-on-snow).

Source: *The Chilliwack Progress*, November 29 and December 1, 1995; Jakob et al. 1997; Evans, unpublished data; Ministry of Environment files.

Details: On November 28, a storm system moved through the Lower mainland in a series of waves dumping varied amounts of rain in different areas. Freezing levels were at 2,500-3,000 m. The storm system that threatened the flooding of the Chilliwack River on November 29 moved too fast and held too little rain to cause extensive flooding in Chilliwack. Dyking built after the 1990 flooding was also credited with saving residents from more flooding this year. *1)

By early on November 29, Chilliwack had recorded 51 mm of rain in 24 hours. Of the expected 50 mm for the next 24 hours only 20.4 mm fell. In the Chilliwack area, some residents in Yarrow moved livestock to higher ground. Chilliwack Lake residents were cut off when the Chilliwack Lake Road was closed east of the Tamihi Bridge due to flooding. The Chilliwack River crested on November 29 at 3 p.m. reaching 8 ft. (2.4 m) at the Tamihi Bridge, about 1 ft. (30 cm) below the 1990 flood level. Mount Thurston prison camp located east of the bridge, lost about 200 yd. (180 m) of a dyke built after the 1990 flood. A “river” nearly 2 ft. (60 cm) deep flowed through the prison site after a gravel bar let go or a logjam changed the direction of the river to hit the dyke almost head on. *2)

The Vedder Bridge was closed to traffic because of flood danger after the Vedder River topped its banks. Early on November 29, residents of the Vedder Campground were getting ready to evacuate. About 10 people, most of them with smaller trailers had already left. The river level had stayed constant overnight but rose 1 ft. (30 cm) and 16 in. (40 cm) in the early morning. The flood also tore away about 100 m of the new Rotary Trail at the end of Lickman Road west of CFB Chilliwack. On November 28, a debris flow occurred at Pierce Creek in the Chilliwack Valley. Jakob et al. (1997) estimate the velocity of the Pierce Creek debris flow at 8.6-9.5 m/s (Evans, unpublished data).

As the Nooksack River threatened to flood its banks, Abbotsford farmers moved livestock to higher ground.

By November 29, Agassiz had recorded 50 mm and Hope 62 mm of rain, most of which had fallen during the previous 12-16 hours. In Hope, which recorded 96 mm of rain by late November 28, about 50 residents along nearby Silver Creek were evacuated for a few hours. Fifty homes in the Glenhalla subdivision near the Coquihalla River were also briefly evacuated. Highway 3 was closed 42 km east of Hope due to erosion.

A mudslide 33 km west of Boston Bar derailed eight empty cars of a 100-car coal train. No injuries were reported.

During November flooding occurred on the Coquihalla Highway. The river approach to Brooks Ridge eroded the armouring of the channel upstream of the blocked culvert on the ephemeral stream under the Coquihalla Highway approximately 400 m downstream of Mine creek. The majority of sediment that blocked the culvert came from the area between the highway culvert and the wildlife fence. (Brodie Bridge

erosion protection-Erosion of Coquihalla Highway right-of-way 4 km downstream of Mine Creek, referred to as “Dead Fir Corner”).

---

*1) Early in the winter, the risk of flooding of the Chilliwack River is less than later in the season as rainfall turns into snow. When in spring snow packs in the nearby mountains melt to fast, spring “freshets” can cause major flooding.

*2) Abbotsford MLA John van Dongen called for more flood protection for Chilliwack River Valley residents.

November 29-early December 1995

Source: *The Similkameen Spotlight*, December 6, 1995; Ministry of Environment files.

Details: On November 29, the Tulameen River flooded its banks near Princeton, Coalmont and Tulameen. At 3:30 p.m., the Tulameen River started to trickle over the dyke into the Allison Court area. By 6 p.m., the dyke was no longer visible and the river flowed between the buildings. Floodwaters caused damage to houses at Allison Court. The Allison Flats were hit hard in all areas along the river. At the worst of the flooding, a large portion of Allison Flats playground was under water. In the Silvercrest apartments area of downtown Princeton, lower areas were flooded right up to Lime Street. At the sewerage lift station near the bridge, crews worked frantically sandbagging the dyke. On the road between the wooden bridge and the arena, the roadbed and one lane fell into the river. This was one of a number of sites where the road was ruined by the November 29 flood. Some sandbars in the Similkameen River 10 km east of Princeton were in some places higher than the riverbanks.

After the flooding, a considerable amount of work was carried out on the flood protection works. The work consisted mainly of raising and armouring the dykes upstream of the one-lane bridge on the Tulameen River.

Mid-January 1996

Source: British Columbia Environmental Report, Spring 1996 (p. 15).

Details: In mid-January, heavy rains triggered over 400 landslides on the west coast of Vancouver Island. Clayoquot Sound was heavily impacted by 172 slides. Of these only 19% occurred in unlogged old growth forests. The majority of the slides occurred on young growth forests, where fragile roots are not as able to hold the soil as the root structure in old growth forests. Many of the slides originated at decommissioned roads that were contoured to fit the original slope. A Forest Service evaluation of the problem determined that 55% of the slides were related to clear-cutting and 25% to road building activities. (British Columbia Environmental Report).

January 16, 1996

(Non-fatal avalanche).

Source: Jamieson and Geldsetzer 1996 (p.180).

Details: On January 16, a size 3 avalanche came off the snowfield on Snowpatch Spire in Bugaboo Provincial Park. It had a fracture line 1-1.5 m deep and dropped 350 m onto the moraines of Crescent Glacier, initiating a size 3.5 avalanche. A large rock uphill from the Conrad Kain Hut acted as a wedge, splitting the avalanche into two parts, with the larger left arm giving the hut a glancing blow. *1)

---

*1) The Conrad Kain Hut, which serves climbers in the area during all but the winter months, has a history of being hit by avalanches. The location of the hut protects it all but the largest avalanches. Therefore, the only recommendation was to strengthen and winterise the back wall as a remedial measure. (Jamieson and Geldsetzer 1996).

March 12, 1996

(Dam burst/flooding).
Source: *Penticton Herald*, March 12, 13 and 15, 1996; Ministry of Environment, Lands and Parks File 76915-09).
Details: By March 12, heavy snowfalls had boosted lake levels in Okanagan Lake to higher than normal. Snowfall in the Okanagan and Similkameen valleys had been 36-44% higher than normal. According to Bryan Symond of the provincial water management branch, the lake outlets such as at Okanagan River at Penticton were being kept much higher to control the lake levels.

Early on March 12, a torrent was released into Gillies Creek tributary to Skaha Lake. The torrent had jumped the banks of Gillies Creek upstream of Smythe Road. The creek had left the channel at SL18, heading down a private road, gathering road materials, rocks, debris and gaining in volume. It washed into the channel at the Schnupp's property, wiping out intakes, jumping the channel banks again at 170 Smythe Road and flowed down through the intersection of Eastside Road and down Lakeside Court. Local residents estimated that the torrent lasted approximately one hour, carrying a great load of water, mud and debris. This event caused the deposit of mud and debris onto Lakeside Court and other properties in the Penticton area.

At about 5:30 a.m., dozens of houses along Lakeside Road were inundated. One of the residents said, "I heard a sound like thunder and looked outside, and there was a lake covering the entire cul-de-sac…and there were boulders rolling down the street." The water and silt mixture poured rapidly into Lakeside Road, turning the roadway into a 50-ft. (15 m) wide river flowing north towards the city.

Much of the floodwaters diverted into Lakeside Court, Derenzy Place and into yards on the lakeshore side of the road. At Derenzy Place, basements flooded and one house had a log smashed through a window. Fences were ripped out, yards buried in muck, gardens disappeared and basements and low-lying homes were flooded. A homeowner bordering Gillies Creek had water 1.5 m (45 cm) high in the house. One room was flooded and filled with mud. Outside, 65 rosebushes, an ornamental wall and a fence were ripped out. Other neighbours had retaining walls along the beach torn out and most surrounding yards were covered in mud.

Initially it was believed that a debris blockage in the creek at higher elevation had caused the flash flood. The high snow levels combined with effects of logging and the aftermath of the Garnet Fire would have created the right conditions for the flood. The Forest Service flew the entire watershed by helicopter but no cause was evident until an abandoned dam above SL18 was discovered. It had apparently burst and released an estimated 3,500-5,000 m^3 of water down a tributary to Gillies Creek. Judging by the vegetation on the remaining part of the 10-ft. (3 m) structure, the dam was estimated to be 40 years old. The provincial water management branch had no record of this dam.

April 1, 1996
Source: *Merritt Herald*, April 3, 1996; Evans, unpublished data.
Details: On April 1, a slide at the Tulameen River damaged one home. March precipitation in the area was slightly below the 20-year average. During the last week of March, temperatures in the evenings cooled down to approximately 7 ^{o} C then warmed up as high as 9 ^{o} C.

April 23, 1996
(Spring runoff?).
Source: *Nelson Daily News*, April 25 and 30, 1996.
Details: On April 23 at about 9 p.m., a rock and mudslide at Passmore's Slocan Park, half way between Nelson-Castlegar, engulfed a three-storey wooden house on Slocan Valley West Road. The huge slide pushed the home about 10 m downward and destroyed it. The two occupants jumped out of a window from the still moving home. Because the first floor was crushed and buried in the mud, they did not have to jump down too far. Two cars were also crushed. About 700-1,000 m up a creek, a small slide had landed into a gulley and the built up came subsequently down in a torrent.

The slide, caused by recent heavy rain combined with spring runoff, left about 30 residents cut off from Highway 6. The creek had washed out the only road into the community of 20-30 homes. A privately

owned footbridge was the only access. The Department of Highways hoped to have the road open late on April 25. According to Nelson RCMP, some residents were temporarily evacuated.

Two environmental groups claimed the slide was caused by clearcutting in the area. Though the mudslide did not start at a clearcut, the heavy runoff may have contributed said Valhalla Society director Colleen McCrory. “There are huge clearcuts along the top of the ridge with a snowpack of one metre still melting.”

A team of Valhalla Society and Silva Forest Foundation foresters surveyed the area above the slide and called for an independent hydrological investigation. Herb Hammond of Silva said that clearcutting drastically reduces the capacity of the forest floor to act as a sponge. Roy Lindgren of the Ministry of Transportation and Dwayne Boyer of the Water Management Branch, who checked the area by helicopter on the morning after the April 23 mudslide, stated that it was “entirely a natural occurrence.” (*Nelson Daily News*, April 30, 1996).

May 18-24, 1996

Source: *The Squamish Chief*, May 21 and 28; June 4 and 18, 1996; Ministry of Transportation and Highways, Rockfall notification summary; Ministry of Transportation and Highways rockfall records; Squamish RCMP File # 96-4598.

Details: On May 18, three large rocks for a total of 30 m^3 came down onto Highway 99, 500 m south of the Garibaldi salt shed. The largest rock measured 20 m^3. On the evening of May 18, a smaller slide was reported to have occurred on the highway south of Whistler. On May 19, MoTH reported 40 m^3 of rocks that came down onto Highway 99, 500 m south of the Garibaldi salt shed. Ten rocks measured approximately 10 m^3 each. On May 19 at 8:25 a.m., 15,000 m^3 of rock came down onto Highway 99 (at 28.0 km) at Godfrey’s Lookout in the Cheakamus Canyon. It covered an estimated 100 m of the road and was about 15 m high in places with rocks “as big as houses.” At noon, there were still bits of debris coming down. After predicting the road would be closed for at least 24 hours, one lane was opened to alternating traffic late that night. The slide just south of the Garibaldi salt shed covered all three lanes, leaving motorists in Squamish and Whistler stranded. There were no injuries reported from the slide.

The highway closed for part of the week. When the highway reopened, it was open limited hours only with single-lane alternating traffic. On May 21, as clearing work was carried out, more rubble fell from above. On the morning of May 22, another slide closed the highway for the rest of the day and most of the next day. There was further rockfall activity on the evening of May 23 and the morning of May 24. Using passenger cars from the Royal Hudson sightseeing train BC Rail transported people between Vancouver-Whistler on May 24.

Cleanup and stabilisation work would take more than two weeks. By early June, crews had worked for 18 days straight. One member of the rock-scaling crew sustained minor injuries. By June 4, about 45,000 m^3 of rock had been removed from the cliff face, while an additional 10,000 m^3 still would be sheared off. Commuters and weekend travellers would experience further delays well into August. A design for re-aligning the highway around the slide area would create a new right-of-way closer to the bank of the near-by Cheakamus River. *1)

The reason for the slide was not established but it had been raining heavily at the time. Where the slide occurred, the remaining rock was a smooth, browny plane, indicating an old discontinuity and weakness in the rock. As well, rainwater was probably also a factor. The first smaller slides of the series of them came from lower on the slope and likely undermined rock, resulting in a bigger slide.

Jim Hegan, acting area manager for the Ministry of Transportation and Highways (MoTH) said that the area that slid was an area of “slip planes” and was isolated from the rest of the slope. According to Bruce Hayden, MoTH geotechnical engineer, the metavolcanic in the rocks in the area resulted in a random jointing and fracturing pattern with some shear zones and very definite faults or joints. *2) Electronic monitoring equipment was placed on the slope above the highway and the slide area was monitored and evaluated. But there is not much that could be done be done to prevent a major slide because “whenever you push mountains up, they have to come down,” Baumann said (*The Squamish Chief*, May 28, 1996).

On May 24, six “fist-sized” rocks came down onto the northbound lane of Highway 99 at Windy Point 20 km north of Horseshoe Bay. One car was hit. (Squamish RCMP File # 96-4598)

---

*1) The diversion plan was a simpler solution rather than attempting to shear off any further overhanging rock. Instead an entirely new three-lane road surface to the west of the slide site was build. As the road would be closer to the environmentally sensitive Cheakamus River, a set of rock walls had to be constructed to protect the river’s flow. Along one portion of the river, an 80-m long, 5-m high retaining wall was constructed. The new section of highway would be completely adjacent to the original one. It would tie in at the hydro tower at the south end of the site and the pullout at the north end. The design would also try to straighten out the entire salt shed to canyon passing section, reducing the existing three curves to two (*The Squamish Chief*, June 18, 1996).

*2) According to Frank Baumann, a Squamish geological engineer, small rockslides in Europe have on several occasions foreshadowed a major slide. “These slides are a suspicious sign of what could be more deep-seated and widespread instability.” Baumann said that the area where the slides are occurring is an area of unusual faulting as just south of the salt sheds a major fault is visible that is cutting through the area (*The Squamish Chief*, May 28, 1996).

Late May-early June 1996

(Spring run-off/flooding and rain-on-snow).

Source: *Lakes District News*, May 29, 1996; *Kamloops This Week*, May 31; June 2, 5, 7 and 9, 1996; *The Vancouver Sun*, June 2, 1997; Ministry of Environment files; Memo, June 4, 1996 Kari Hendriksen.

Details: At the end of May following a prolonged period of below normal temperatures, coupled with higher than normal snowpacks in many British Columbia river basins had the potential to high run-offs and possible flooding over the next weeks. The most recent snow surveys showed snowpacks above normal in much of the interior. Since this survey, some areas received additional snow accumulations, most unusual at this time of the year. Particular areas of concern were the Thompson, Columbia and Kootenay River basins.

On May 25-26, flooding in the north Okanagan resulted in damages approaching $3 million. The flooding in the north Okanagan and Kamloops areas was largely due to rain falling on saturated soil and rain-on-snow. Little of the reported run-off could be attributed to the above average high-elevation snowmelt. May was much colder and wetter than usual. Between May 1-30, Kamloops recorded 49.2 mm of precipitation. *1)

The first properties to be affected by flooding in Kamloops included Royal Avenue, Cambridge Street and Front Street. On May 31, Mount Tod Road washed out just before Whitecroft. Flooding occurred in the Sun Peaks area. Dredging McGillivray Creek would be required to solve the problem. (*Kamloops This Week*, May 31, 1996).

On June 5, the Thompson River at Kamloops reached a level 342.5 m. *2) By June 9, the South Thompson River was rising and expected to peak within two to three weeks with a higher than average level. The North Thompson River dropped at Blue River and McLure ferry.

In June, the Village of Chase experienced flooding from Chase Creek. The preliminary damage assessment and remedial cost estimates totalled $132,275. In June, many of the basements of low-lying homes near Okanagan Lake flooded.

---

*1) The average precipitation for May was 28.2 mm. The wettest month ever recorded in Kamloops was in 1902 with 63.8 mm. (*Kamloops This Week*, May 31, 1996)

*2) The “mean” annual flood level was estimated at just above 343 m. The floods of 1948 and 1972 surpassed this by approximately 2 m. (*Kamloops This Week*, June 5, 1996).

September 11, 1996

Source: *Nelson Daily News*, September 12, 1996.

Details: On September 11 around 10:30 a.m., a coal waste dump flow slide at Coal Mountain near Sparwood killed two loggers working near the base of the gigantic waste rock dump or spoil. The victims were in a party of five or six men in a log loading area. The slide struck virtually without warning and engulfed "two or three" vehicles with tons of loose rock. Rocks the "size of a garage," took out part of the landing and the logging machinery Late on September 11, a buried truck was recovered. Early on September 12, one body was recovered.

Fall 1996
Source: Aztec Geoscience Inc. Terrain failure report and slide rehabilitation report for 5 km West Callaghan Main File PFW610, October 28, 1996.
Details: In the fall of 1996, a debris flow occurred at 2.9 km below the West Callaghan Mainline, Calahan Creek (Chilliwack Forest District). The approximately 75 m long x 10-20 m wide slide is thought to have resulted from ponding water above moderately steep sideslopes in an area of thick, highly compacted tills.

The slide occurred during road construction in an area where the new road was built up along the inside edge of an older road. A culvert installed at a small creek crossing the site resulted water crossing the new road and discharging on an inslope pold road base. The water continued downgrade on the outside of the new road, ponding on the old road above and old culvert. A sudden failure occurred in the slope break area on the lower side of the old road, resulting in two adjacent head scarps, and a short runout length of thick sediment and debris down to Callaghan Creek

October 14, 1996
Source: *The Vancouver Sun*, October 15, 1996; *The Province*, October 21, 1999.
Details: On October 14, Greater Vancouver was struck by heavy rain and winds, which cancelled four ferry sailings and delayed Thanksgiving dinner for thousands. Some 46 mm of rain fell in just 15 hours. The Thanksgiving storm caused power failures in Maple Ridge and Pitt Meadows. In Tsawwassen at 56th Street, an overhead power cable snapped at 9:15. A life wire was left twisting in the wind. Each time the end of the cable scraped a puddle on the pavement, a powerful electrical explosion occurred. BC Hydro crews were able to restore most of the outages within an hour or two.

The strong winds between 10 a.m.-2 p.m., forced the cancellation of regular services of two V-class ferries, which cannot properly dock in winds over 39 knots (72 km/h). Some 1,300 passengers for each ship were stranded on one of the busiest days of the year.

The cities of Vancouver and Surrey each reported about 50 cases of flooded intersections, with water draining into basements. In the 24 hours ending at noon on October 14, more than 50 mm of rain had fallen on Stanley Park. *1)

---

*1) The 24-hour record for rainfall was 61 mm set on October 29, 1975. Normal rainfall for October was 115.3 mm. By the afternoon of October 14, Vancouver had already received 75 mm, compared to an average to this point of about 43 mm (*The Vancouver Sun*, October 15, 1996).

October 21, 1996
Source: *The Alberni Valley Times*, October 28, 1996.
Details: On October 21, five landslides occurred on the Maggie Lake Forest Road in the Toquart Bay area about 35 km east of Ucluelet. The slides blocked the water intake for the Macoah village, located at the outer edge of Toquart Bay. More than 200 m of road were affected and several structures, culverts and bridges, were damaged.

According to a Forest Service press release, the landslides, similar to slides in 1995, were caused by intense localised rainfall on steep slopes that were harvested prior to Forest Practices Code standards.

December 28-29, 1996
(Extreme snowstorm and rain-on-snow).

Source: *The Vancouver Sun*, January 7, 1997; July 3, 1999; *the Windmill*, January 7, 1997; *The Vancouver Sun*, November 28, 2006; *Times Colonist*, December 17, 2006; *Campbell River Mirror*, January 17, 2007; Provincial Emergency Program 1997.
Details: During the last week of December severe winter weather hit most of the southern third of British Columbia. On December 28-29, it produced a 75-year record snowfall. The most severely affected areas were the upper Fraser Valley (Abbotsford area and east) and the southern portion of Vancouver Island. The storm dumped up to 4 ft. (1.2 m) on many parts of British Columbia and Washington State in less than 20 hours. Chilliwack recorded 66.8 cm of snow.

The "Blizzard of 1996" dumped a record two-day snowfall of 124 cm (48.8 in.) that "smothered" Greater Victoria's transportation links. Not since the great snow of 1916 had a winter storm so affected the residents of southern Vancouver Island. Though the storm involved much more snow, according to old-timers, the 1916 storm had been "much worse" than the now-called "blizzard of '96." Statistically, this type of event has happened only twice in 90 years and possibly only twice since non-native settlement took place. For many Greater Victoria residents, snow emergency preparedness is nothing more than having the patience to wait for a thaw. Some residents do not even own a snow shovel. The heavy snowfall caused $20 million in damage. On December 29, BC Ferries cancelled sailings because crews could not get to work (*Times Colonist*, December 17, 2006).

Victoria set a single-day snowfall record of 67.5 cm on top of the snow already on the ground. Over the next 24 hours, winds would build drifts from the fresh powdery snow. Then rain would add weight to the metre-deep (or deeper) snow, collapsing or damaging greenhouses, marinas and buildings. As more rain fell, some areas experienced flooding and landslides.

In the Greater Vancouver area, transit shut down completely for one day. Residential side streets were snowbound for days. But the storm's effects there were less than in the southern Vancouver Island and upper Fraser Valley areas. On December 31, government offices in many storm-affected areas closed, as employees were unable to get to work or would impede snow clearance activities by going to work. The total cost of cleanup by municipalities was estimated at $1 million.

The storm caused numerous road closures. In the lower Fraser Valley, the Trans-Canada Highway had impassable sections, effectively closing it, isolating communities and stranding motorists. All highways and secondary roads in the upper Fraser Valley east of Abbotsford remained closed for several days. Boston Bar was totally cut off. After running out of foodstuffs, the community had to be re-supplied by helicopter. In a major search and rescue operation, over 250 stranded motorists were located and taken to safety.

It was the most significant and intense life-saving operation carried out in British Columbia in many years. During the operation that lasted more than 24 hours, there were no fatalities or major injuries. Emergency shelter and food were supplied to more than 3,000 stranded travellers and persons rendered homeless by storm damage or storm-related conditions such as extended power outages or snowmelt flooding. Reception centres were set up for travellers stranded in Merritt, Princeton, Kamloops and Kelowna. The Merritt reception centre also received people whose power was lost.

As a result of heavy snowfall some roofs and sundecks collapsed and some structural damage occurred to a few large buildings. Roofs caved in at James Bay Thrifty Foods, Panorama Leisure Centre, and Glen Meadows curling club. At the Capital City Yacht Club in Sidney, the snow damaged boathouses, docks and watercraft; 31 boats sunk, more than 30 were damaged and 62 berths lost. At the Victoria International Airport, Viking Air lost $6-8 million worth of hangar space when the large structure collapsed under the weight of the snow.

The storm caused widespread damage to greenhouses of the region's flower, tree seedling and vegetable growing sector. Many of the greenhouse operators were faced with the task of replacing broken glass, in some cases as many as 200-300 panes. The snow levelled greenhouses of the Saanich Peninsula operation of G.A. Vantreight & Sons, Canada's largest producer of daffodils, causing $2.5 million worth of damage. Eurosa Gardens Ltd. at Brentwood lost 11,148 m^2 of greenhouse space, including 80,000 rose plants that would have produced 180,000 stems in time for Valentine's Day. Fraser Valley grower Rosedale Greenhouses were hardest hit with about 35,000 $ft.^2$ (3,220 m^2) of the 140,000 $ft.^2$ (12,880 m^2) of the

greenhouses having crumbled under the snow. Officials at United Flower Growers' calculated that the storm might cost the industry as much as $20 million between structural damage and crop losses.

Vancouver Island rose grower Hans Bulk and vegetable growers Ron Dowding and Don McMurray's greenhouses totally collapsed. Vegetable grower Svend Pedersen lost one of his greenhouses while flower grower Konrad Welle saw 75% of his greenhouses crumble or extensively damaged. A number of other operations were wiped out as well. Damage on Vancouver Island alone would likely reach $10 million. Greenhouse owners applied for up to $100,000 compensation under a disaster assistance program: 211 damage claims came from southern Vancouver Island and 41 from the north Island. Damage estimates from Vancouver Island's agriculture section totalled $21.4 million (*Times Colonist*, December 17, 2006).

The severe winter storm caused significant damage and hardship in British Columbia. Early on December 29, the Attorney General requested federal assistance for humanitarian purposes. In assistance to civil authorities, the Canadian Armed Forces were called out, being their first call out in British Columbia since the 1948 Fraser Valley flood. The federal government tasked the resources from CFB Chilliwack and Army "Militia."

Between December 28-January 1, 1997, military assistance was required. Though the operation was considered a success, it was also clear that the Armed Forces were not prepared to deal with a disaster such as an earthquake on Vancouver Island. The military, with the assistance of the fire department, had to break into its own Bay Street Armoury in Victoria to set up operational headquarters because no keys were available (*The Vancouver Sun*, July 3, 1999).

By December 30, all highways in the upper Fraser Valley remained closed and were not expected to reopen until the next day. In both rural and urban areas in the Fraser Valley and Vancouver Island, secondary roads remained closed. In various regions of the province, Greyhound buses were trapped. . In the Vancouver Greyhound station, 75 people were stranded. Stranded busloads were sheltered in Abbotsford, Chilliwack, Hope and Mission. Reception centres were set up in Abbotsford, Chilliwack, Mission, and Hope. Farmers and private citizens also provided accommodations

Freezing rain followed by rain caused additional flooding problems. Some roads washed out while landslides blocked others. Saltspring Island did not experience difficulties until heavy rain and rapid snowmelt damaged roads, buildings and started landslides.

At the end of December 1996, Yakh residents had to leave their homes when Moyie River overflowed its banks.

On January 1, a windstorm blew down hundreds of trees in MacMillan Park near Port Alberni, some of the Douglas fir trees up to 800 years old (*Campbell River Mirror*, January 17, 2007).

---

*1) By early March 1997, 576 claims had been received for Disaster Financial Assistance, totalling $10.3 million. 140 files had been closed and $163,000 had been paid out (PEP 1997). Since it was established in 1970, the federal Disaster Financial Assistance Arrangements program had paid out some $300 million in Canadian disaster relief. The program had been used 14 times in British Columbia since 1972, with the federal government contributing $23.4 million to cover 11 cases of flood-related damage (*The Vancouver Sun*, January 7, 1997). The British Columbia government used the snowstorm, the area's worst in 75 years, to reassess its ability to deal with disasters. Although nobody could have foreseen the extreme amount of snowfall, the community plans for earthquake response should have been capable of adapting to this particular situation. (*The Vancouver Sun*, July 3, 1999).

January 10-17, 1997

(Ice jam/flooding).

Source: Ministry of Environment files.

Details: On January 10, a number of minor flood-related incidents occurred in the Chilliwack River Valley. A debris flow caused an avulsion of a small creek, which for a time flowed down Lyardon Road. A shallow landslide occurred on the south valley wall opposite Bell Acres. It terminated below a Ministry of Forests road before reaching the river. The Slesse Park Clay Slide became active again. At least one minor slough flowed over the toe berm and into the Chilliwack River.

On January 12, a large snow avalanche blocked the Illecillewaet River 50 km above Revelstoke. The slide was reported to have been initiated by the highways ministry as an avalanche control measure. Water initially ponded to about 5 m against the 20-m high blockage and was rising about 0.6 m/day. By the morning of January 17, water levels subsided overnight about 0.15 m with a marked increase in downstream flows.

Around January 17, an ice jam on Bridge Creek near 100 Mile House created local flooding potentially affecting one home.

January 27-February 6, 1997

Source: *The Chilliwack Progress/* (*Weekender*), January 28 and 31, 1997; February 4, 1997; *The Vancouver Sun*, January 31, 1997; Ministry of Environment files.

Details: On January 27, at least two massive landslides came down into the Chilliwack River, pushing a 7-ft. (2.1 m) wave upstream and turning the lower river into a "murky, muddy mess." Peter MacPherson, who saw the first mudslide strike at about 7:20 a.m., described it as, "a loud rumbling, and the trees cracking and crunching." The whole side of the mountain started moving in slow motion. Once the massive slide had come to a rest, trees stuck out of the earth in bizarre formations. "It looked like half a pack of toothpicks mixed with mud," MacPherson said. The slide was about 200 ft. (60 m) wide. The water dropped 4.5 ft. (1.35 m) lower than normal for a short while until the river spilled over the mud barrier.

The second slide occurred at 12:30 p.m. beside the other one, about 0.5 mi. (800 m) upstream from the Slesse Park campground, burying the waterway under tons of soil. "It totally blocked the river," said Bob Stanton, assistant project manager at the Chilliwack salmon hatchery, who was an eyewitness to the second slide. "There was a big wall of water that shot down the river. Then it dried up downstream for about five to 10 minutes."

The slides, which completely blocked the river, threatened to devastate a run of chinook and chum salmon. Local fishing guide Fred Helmer estimated the river's fish resource to be worth $25,000 per fishing day based on a conservative estimate of 500 angler days at $50/day.

Frank Sobkowich, regional district director, said there were large cracks in the area behind the claybank, some running 300-400 m. In some places the ground had cracked, moved and slumped down about 50 ft. (15 m). "The whole hillside is constantly moving. It was not known whether the problem was caused by creeks or underground water percolating into the claybank.

According to a report by Dr. Oldridge Hungr, the massive clay block near Slesse Road weighs 3 million tons. It slowly but constantly moves due to ground water infiltration and freeze-thaw action. In his report to the Fraser Valley Regional District, Hungr wrote that while further movement will probably be slow, a massive slide of the whole block into the river is possible. He noted that steps like surface draining and earth shaping could reduce the groundwater effect on the clay bank, and a new channel could be dug on the south bank.

On January 28-29, the Vancouver area experienced a few hours of intense rainfall. On January 29, Chilliwack recorded 60.4 mm of rain. *1) In Vancouver, about 65 mm of rain fell in 24 hours, with the highest downpour late on January 28. In one hour, between 11 p.m.-midnight, White Rock recorded 10.2 mm. Other areas recorded similar amounts.

Flooding occurred near 33rd and Nanaimo. The flooding was partially blamed on sewer construction just half a block away. At the site of construction, water gushed from pipes and filled the road with 5 cm of water. Other areas affected by flooding included Joyce Street at Archimedes and Cherry Street, a low-lying area that was once industrial but is now densely residential. The north side of the Hastings Park racetrack on Bridgeway also flooded, as did the area near 8th and Balaclava.

Also hard-hit was the Coquitlam area, where five roads were closed due to flooding or washouts. City engineer Neil Nyberg estimated damage to roads at $25,000, mostly in rural areas. Nyberg expected costs from landslides of about $20,000 and cost of mitigating the overnight flooding problems at $7,000. Booth Creek recorded its highest-ever flows with water flowing over a new concrete bridge on Schoolhouse Street.

The rain event on January 29 caused three minor flood events in the Chilliwack Valley. A second debris flow occurred in the Bell Brook drainage. Debris flows crossed the Chilliwack Lake Road while three slugs of debris still hung up in the valley. A house located at the apex of the fan was having emergency protective work (rock wedge) constructed to split subsequent debris flows around the house. A second slide, which caused no threat to public safety, occurred at Slesse Creek. On Shaughnessy Road, a landslide covered the road a metre in debris. The slope lost about 70 m^3 of soil and was still extremely unstable on the afternoon of January 30. In North Vancouver, several minor slope failures occurred.

On January 31, Elk View Road, the main route to Ryder Lake, 0.25 mi. (400 m) from Bailey Road closed after a rockslide blocked the road around noon. Close to 20 truckloads of fill (debris) were taken from the site, including debris from excavations aimed at preventing further slides. Elk View Road reopened at 4 p.m.

On February 1, four large landslides occurred near Chilliwack, each time dumping large amounts of clay and silt into Chilliwack River's critical fish habitat downstream.

Around February 6, a further mudslide occurred in the Chilliwack Valley on an unnamed creek behind the Baker Trails Village mobile home park. In an area with an extensive history of debris flows, it was considered just a "nuisance" event. In White Rock, a slope failure occurred on a 45-m deep gully. Though tension cracks were observed within 2 m of the structure, a nearby residence suffered no structural damage. PEP commissioned a geotechnical study to determine status of failure.

On Bon Accord Creek, further slope failure occurred on a 50-m gully.

---

*1) This broke the previous record set on January 29, 1971 with 53.8 mm and pushed the total precipitation till January 29 to 307. 5 mm, well above the average 263.7 mm for the entire month of January. (*The Chilliwack Progress* (*Weekender*), January 31, 1997).

January-Spring 1997

Source: *The Golden Star*, May 29, 2002.

Details: In January, helicopter pilot Don McTighe first observed slumping on Heather Mountain. An unseasonably warm weather front with heavy rain caused water to percolate into the fracture near the top of the mountain. When the weather cooled quickly to –20 ^{o} C, the rockface froze and the pressure of trapped frozen water behind the face created the slope separation. *1)

While transporting heli-skiers in a nearby area, McTighe watched the cracks in the slope grow day by day. Blocks failed and slid. By spring, it grew into a massive debris flow that ended up as mud on the highway near the eastern boundary of Glacier National Park.

---

*1) Over the next two springs, the exposed surface was eroded and lubricated by the combination of rain and melting snow, creating a mountainside gash about 2 km long and half-a km wide, which continues to ooze each spring. (see: May 21, 2002 event). The failing rock is a talc-rich mica schist, strong when dry but easily disintegrating when it comes in contact with water. (*The Golden Star*, May 29, 2002).

March 17-26, 1997

(Tidal flooding and non-fatal avalanche).

Source: *The Vancouver Province*, March 20, 1997; *Times Colonist*, March 19 and 20, 1997; *The Hope Standard*, April 3, 1997; Evans, unpublished data; Ministry of Environment files.

Details: On March 18-19, record rains hit Vancouver Island and the Fraser Valley, causing extensive flooding. A southwest flow and a stalled frontal zone caused the mild and wet weather. In the Fraser Valley, Chilliwack was hardest hit with 120 mm. In the Lower Mainland 25 mm of rain on March 19 brought the month's total to over 200 mm. On March 19, Henderson Lake, about 40 km east of Ucluelet, recorded 440 mm of rain. In a 24-hour period from March 17-18, the Chemainus weather office recorded 86.2 mm of rain, breaking the previous 24-hour record for March of 79 mm. *1) Daily rain records at Comox and Port Alberni also fell.

Though the general flood warning for Vancouver Island was rescinded on March 19, provincial emergency program officials warned there still could be minor flooding in some homes. Though none of the major rivers peaked near flooding, a number of minor mudslides occurred on March 19 in White Rock, Coquitlam and the Fraser Valley.

On the morning of March 19, Port Renfrew was cut off for several hours after both the primary and secondary roads into the village were flooded. A mudslide 30-45 m long again cut the West Coast Road between Port Renfrew-Jordan River. It plowed over the road and into the water near Loss Creek bridge. The slide blocked about half the creek but instead of overflowing the banks, the water pushed the dirt aside. *2)

Days of record rainfalls, combined with high tides, brought flooding to the Cowichan Valley, Sooke, Parksville and Qualicum areas. There was speculation that runoff from the Vancouver Island Highway Project contributed to the flooding problems. A the high tide on March 19, 24 people of the 30 families in the lower section of Parry's Trailer Park on Martindale Road were evacuated. Englishman River swallowed one section of the motel campground and barbecue pit. Martindale Road floods are a regular occurrence. *3) A resident who had lived at Martindale Road for all of his 62 years, said that the trailer park, built on the Englishman River floodplain, should never have been allowed. "Just about every year we get a flood." According to the owner who had only recently bought the trailer park, old-timers had assured him there had not been a serious flood for 20 years.

The flooding stretched from Chemainus to Campbell River, with Nanoose, Parksville, Port Alberni and Qualicum hardest hit. The Chemainus River overflowed its banks at the intersection of Crofton and Chemainus roads, the regular rain trouble spot in the Crofton area. The worst flood damage on Vancouver Island occurred along the beachfront from Parksville to Courtenay, where several summer homes were swept off their foundations and collapsed.

On March 18, some residents in the Qualicum-Parksville area had to leave their homes. Near Qualicum Bay, one cottage washed away on March 18. A mudslide at Deep Bay, a fishing resort south of Courtenay damaged two houses and two mobile homes. A duplex collapsed from the mudslide. The slide brought down a section of bluff, cutting the connector road and depositing at least two trailer homes on the beach. In Qualicum, two other residences were damaged when a chasm opened. Nash Creek cut a new channel through a Qualicum Bay Bed and Breakfast, leaving a shed hanging over the side of the fissure. On the other side of the abyss, which was about 7 m deep and 18 m wide, a sundeck dangled precariously from a neighbour's home. The Qualicum Bay Resort had about 1 m of water in the basement, causing at least $10,000 damage. The creek also swallowed up much of a yard and a nearby family guest cottage.

On March 19 and 20, VIA Rail's Dayliner service was cut by a 3-m washout at Mile 37.95, just south of Duncan. Flooding also forced the closure of Sooke Potholes Provincial Park and the picnic area of Goldstream Provincial Park, including the trails to the visitors centre. Travel into the Carmanah/Walbran area was discouraged. RCMP urged motorists to proceed with extra caution in the Cathedral Grove, Cameron Lake, Martindale Road, Qualicum Bay, Horne Lake Road and Shaw Hill areas, where water crossed the road and in some cases, led to extensive flooding.

On the morning of March 18 in downtown Port Alberni, lower Third Avenue was closed after Dry Creek rose about 0.5 m. In Cedar, two Harley Davidson motorcycles worth more than $40,000 were under more than half a metre of water.

In the Chilliwack River valley, a brook burst its banks, sending debris crashing into an unoccupied house on Vedder Mountain Road. Early on March 19, a Chilliwack Lake Road home was evacuated after a mudslide hit the property. In Coquitlam, a landslide at the Allard gravel pit sent countless tonnes of silt into the Coquitlam River, as well as blocking the approach road. Slides also closed roads from Pemberton-Lillooet and from Yale to Boston Bar.

On March 19, the Trans-Canada Highway was closed at the Rogers Pass for avalanche control. In Rogers Pass and Kootenay Pass, avalanche control crews were shooting into peaks to trigger controlled avalanches. For the first time this winter, an extreme avalanche warning was issued for all of British Columbia. The first heavy rains had loosened the snowpacks. On March 19, a skier escaped injury after he was caught in an avalanche in Glacier National Park. In Kootenay Pass, 8-m high "piles of mud and slush" came down onto the highway. On March 19, Grouse Mountain was closed because of high winds.

On March 19 at 5 a.m., water was flowing 7 m deep over the 100-ft. (30 m) spillway of Jump Creek dam, which supplies Nanaimo's water. Flows peaked at 7. 3 m. On Bull River, a slide occurred 5 km upstream from the Aberfeldie Dam. According to BC Hydro, two slides were blocking the river and impounding water. Should it have been overtopped, it would have threatened the community of Bull River and the provincial fish hatchery at Bull River, both approximately 0.4 hours downstream of the dam.

On March 20, a mudslide came down at an angle, cutting off the flow of Bridal Falls. As the Bridal Falls stopped for the first time in modern history, there were fears a massive lake could form, building up and possibly rip over the side of the mountain. Once the water would break free, it could destroy Popkum homes below. As Bridal Falls faced evacuation, two Canadian Armed Forces Search and Rescue aircraft were sent up. One of these dropped flares while the crew of the other aircraft checked the area. As it turned out, the slope was just too steep to form a huge lake. Instead, the water just spread out along the mountain eating its way through the slide.

On March 26, a failure of a railway embankment caused a derailment at Conrad Siding, just south of Lytton in the Fraser Canyon (Evans, unpublished data).

---

*1) As of March 19, Vancouver had received 212.5 mm of rain, eclipsing a 23-year old record of 186.4 mm. Set in 1974. As well, on two days in March, the daily rainfall was more than 40 mm, close to the 49.3-mm record for the most rainfall in one day in March, set in 1974. In 60 years of weather recording where there was more than 40 mm in one day in March, two of which came in March 1997. It was the most rain ever recorded at Henderson Lake in a single day. On March 18, Victoria's old record for the month, set in 1972 with 144.8 m was broken. Early next day already more than 150 mm of rain had been recorded since the beginning of the month.

*2) There is a history of slides on this highway at Loss Creek. During heavy rains, road closures at Loss Creek are a well-known problem. According to Cpl. Hal Zech of the Sooke RCMP, the road gets blocked about twice a year. There is little highway crews can do because the road cuts deeply into the hillside as it winds from higher elevations to the low-lying bridge (*Times Colonist*, March 20, 1997).

*3) In 1990, the Martindale Road area was also hit by serious flooding (*Times Colonist*, March 19, 1997).

March 24, 1997
(Fatal avalanche).
Source: *The Vancouver Sun*, March 25, 1997.
Details: On March 24, a snow slide in the Selkirk Range north of Nakusp killed two heli-skiers. The victims were buried under about 4 m of snow.

March 26, 1997
(Fatal mudslide).
Source: *The Vancouver Sun*, March 27, 29 and 31, 1997.
Details: On March 26at 6:45 a.m., a 77 car eastbound CN Rail freight train plunged into a washout about 14 km south of Lytton killing an engineer and a conductor. The washout was created by runoff water eroding the track and triggering the mudslide into the Fraser River. The train's two locomotives and eight container cars plunged into the 50-m wide and 20 m washout. They were joined by six boxcars from a second 99-cartrain loaded with sulphur parked on a siding running parallel with the main line. A fire started when the two locomotives crashed down, igniting their fuel supply. *1) Toxic fumes from the wreck caused a concern as burning sulphur creates sulphur dioxide

The slide also caused stress cracks in the shoulder of the Trans-Canada Highway, located 38 m above the rail line. Highway traffic was reduced to one lane with alternating traffic. Nearby Siska Indian Reserve was evacuated but a few hours later the approximately 100 residents were told they could return.

---
*1) Normally about 40 trains move daily through this section. But since the accident CN Rail was running 10-15 trains on alternate tracks.

March 30, 1997
(Fatal avalanche).
Source: *The Vancouver Sun*, March 25, 1997.
Details: On March 30, a snow slide near Golden killed a Calgary man while snowmobiling in the Lange Creek area.

March-April 1997
(Spring run-off/flooding).
Source: *The Daily Courier*, April 15, 1997; Ministry of Environment, Lands and Parks File 35050-20.
Details: During March and April unusually, record-breaking wet weather occurred with a cool spring and rapid melting snow during early May. When heavy snow packs started melting during the early part of May, Yakh was threatened again with flooding. Nelson also suffered some flooding in March and again in April.

About the middle of April near Kelowna, nearby Robert Lake flooded a private road. On the afternoon of April 13, a 54-year old man drowned after he lost control of his bicycle while trying to ride across the flooded road. Some residents blamed the city that if it would have contributed $40,000 to a water control project, the accident would not have happened. The city responded that as the road had been private since the area was subdivided in 1912, it was up to the residents to pay for measures to control the annual flooding.

Early on April 14 in Kelowna, the unstable ground just below Lakeshore Road struck again, taking down several 60-ft. (18 m) trees between the Cedar Creek winery and Bertram Creek Park. The previous year the same area was the site of a slide that undercut Lakeshore Road asphalt. The slide, below the roadway, dragged the trees down the steep hillside and into Okanagan Lake. According to Kelowna Transportation manager Ron Westlake, it was a “drainage-related matter.”

Nearby resident Lee Gibson noted that a small plastic pipe running under the road draining just a few feet above the slide area, had been running “like a kitchen tap” for three weeks. She said that a highways department employee told her that the City should have plugged it weeks earlier. (The pipe was once used as a conduit for electrical wire and was now empty. Unintentionally it served to drain water from the ditch on the south side.

Two weeks previous, a slide buried a private road at the bottom of the hill.

April 19-21, 1997
Source: *The Province*, April 21, 1999; Ministry of Environment files.
Details: Between April 19-21, the Trail-Castlegar area experienced heavy precipitation. On April 19 and 20, Castlegar and Trail (Warfield) recorded 22.8 and 15.0; and 22.0 and 6.4 mm of rain, respectively. On April 20, Rossland recorded 26.0 mm of rain. More than 30 mm of rain and spring runoff caused flooding in Trail after the Trail and Gorge creeks spilled their banks. Gorge Creek, usually 4 ft. (1.2 m) wide, turned into a river. The severe flooding combined with gas leaks and power outages, forced the evacuation of about 150 people from their homes. Late on April 20, more were expected to be evacuated. One man drowned and rocks 2 ft. (60 cm) in diameter smashed into buildings and cars. Floodwaters flowed down Spokane Street through the commercial heart of Trail, tearing up the pavement at the intersection with Pine (Street?). Also a portion of Casino Road washed away. Residents hit by the flooding complained that the city should have cleaned up the debris before it clogged up the Gorge Creek culvert near their homes. About 200 residents pitched in to help Canadian Forces reservists stack sandbags. In Warfield, at the outskirts of Trail, the village bridge washed out and a gas line ruptured, prompting the evacuation of 15 families.

In Castlegar, Mary Creek overflowed, threatening a medical clinic and a day-care centre, washing out two sections of the CPR line and leaving much of the city without power. In one section, about 50 ft. (15 m) of rail line was taken out with holes 20-30 ft. (6-9 m) deep. Minor flooding was reported from Nelson.

Early-mid May 1997
(Spring runoff/flooding).
Source: *Times Colonist*, May 18, 1997; *The Province*, May 20, 1997; *The Vancouver Sun*, May 20 and 23, 1997; Ministry of Environment files; Memorandum May 29, 1997. Erosion problem Joe Rich Creek. File 35050-30/1997.
Details: On May 5, flooding occurred near Merritt. Mill Creek Road washed out, impacting six families. The culvert that replaced the bridge a year earlier was unable to handle the volume of water and became plugged. Stumble Creek overflowed its banks causing flooded fields and basements. Nicola River overflowed its banks. Guichon Creek suddenly rose and overflowed its banks, flooding a nearby residence.

On May 13, Cottontie Creek overflowed its banks 22 km south of Cranbrook, washing out a 20 x 8 ft. (6 x 2.4 m) section of Hidden Valley Road South and impacting a trailer. Near Falkland, fields flooded.

On May 13, a slide came down on Highway 6, 10 km east of Cherryville, blocking the highway.

On May 15 during a flood on the Similkameen River, 4,000 m^3 of riprap were lost along the toe of a 350-m section of dyke. Estimated cost to replace the lost riprap was $100,000.The cost to rebuild a 30-m section of dyke on the Tulameen River near Tulameen Village was estimated at $15,000.

On the morning of May 15, an erosion situation on Joe Rich Creek endangered two bridges on Schram Road. During this high flow period, the creek had cut into the left bank approximately 10 m. Since early morning it had eroded 1.5 m. The eroding bank was approximately 3 m high and appeared to consist of very erodable materials. The flow of the creek was estimated at 3 m^3/s. The Demiter family, residing downstream, complained about the creek channel running through their property being full of gravely material, overbank flow and were concerned having their basement flooded.

On the night of May 15 and on May 16, two mudslides damaged about a dozen homes near Chase. Flooding from a nearby creek led to the mudslide. On May 15, a debris torrent occurred on Hudson Creek, which enters Gillespie Bay on Shuswap Lake. The debris together with knocked down trees totally destroyed the creek channel. And debris flowed in several directions.

Around the middle of May, the provincial government opened a flood response centre in Penticton to co-ordinate response to potential flooding in the South Okanagan and Similkameen. About half a million sandbags, many shipped from Manitoba, were stockpiled in the Okanagan-Thompson areas (*The Vancouver Sun*, May 23, 1997).

On May 17 in Osoyoos, high water caused some basements and roads close to the lake to flood. A 14-person provincial fire suppression crew from Penticton helped sandbagging and keeping the water away from most homes and motels on the lakeshore.

Around May 18, cooler weather eased the threat of flooding at Merritt where the Nicola River only rose slightly overnight May 17-18. Joseph's (Joseph) Creek, which runs through Cranbrook, stabilised early on May 18. Though on May 18 the Kettle River in Grand Forks stopped rising, 20 homes in the area were still at risk.

The Kelly/Lepine dyke repair from Arab Run Road to Beachview Road-Rayleigh dyke at Kamloops would cost about $50,000. In May, along Osprey Lake Road nearby fields flooded. *1)

Around May 19, water levels in Osoyoos Lake were rising rapidly.

---

*1) In 1996, a mudslide on Osprey Road, 22 km east of Princeton had raised the creek level.

May 31-June 1, 1997
(Rain-on-snow).
Source: *Times Colonist*, June 2, 1997; *The Vancouver Sun*, June 3, 1997; *Bridge River-Lillooet News*, June 4, 1997; *The Daily Courier* (Kelowna), April 22, 1999; Evans, unpublished data. Ministry of Environment, Lands and Parks File 76800-20.
Details: Heavy rain on May 31-June 1 caused minor flooding across British Columbia and put several communities on flood alert. Ross Creek near Anglemont flooded forcing two families to temporarily leave their mobile homes.

On May 31, a freshet flood in Mission Creek resulted in the highest flows on record. Overnight June 1-2, Mission Creek spilled its banks, damaging a pub's beer and wine store and a dentist's office on Lakeshore Drive. The Creekside Pub had 5 in. (12.5 cm) of water on the floor and was put out of business for a day. In nearby Gallagher's canyon, a trailer park was evacuated. Repair cost of erosion of 1,500 m^3 of riprap along 200 m of the right bank at Hollywood Road South was estimated at $60,000 and another $35,000 for additional work. Cost to restore Mission Creek channel and dyke KLO Road to Lakeshore Road, Kelowna was $185,000 and same for Gerstmar Road, $125,000. Costs for Hollywood Road were $30,000 and $100,000 for Hollywood South. Okanagan Lake rose to 15 cm above its high level of the previous year. Flooding occurred in the Vernon area.

On May 31 and June 1, heavy rain and snow melt caused flooding on Russell Creek. The creek jumped its bank downstream of the Kitchener Imp. Dist. Intake. Water and debris flowed overland hitting the deflection berm causing erosion to the set back dyke. The high water also caused erosion to several sections of bank works on the outside bends of the creek

On May 31, a debris avalanche occurred at Gowan Creek. Heavy rain caused a large slide in a densely wooded area 95 km east of Pemberton, leaving one man missing. RCMP described it as about 3,000 m wide and "up into the clouds height." Around June 4, Pemberton RCMP called off the search.

On May 31-June 1, the culvert that housed two pumps, part of Lillooet's secondary water system, washed down Seton River. The washout, caused by high water levels in the Fraser River and rain in the Seton-Cahoosh headwaters, would cost $50,000 to repair.

On June 1, flooding occurred on Stagleap Creek, south of Nelson approximately 7 km east of the Nelway cut-off on Highway 3 junction with Highway 6. The creek created a new channel and one property owner lost some 300-400 trees and sustained heavy damage. The occupants of the residence evacuated and the highway was closed for a week. The heavy rains on May 31-June 1 washed out a section of Highway 3 between Salmo-Creston.

Late May-early June 1997

(Spring runoff/flooding).

Source: *The Vancouver Sun*, June 3, 4, and 5, 1997; *The Hope Standard*, June 5 and 12, 1997; *The Daily News* (Kamloops), June 7, 1997; *Lillooet News*, June 11, 1997; *Currents*, November 1999; Ministry of Environment files; File 35000.20; Letter Tony Heemskerk to Karen Williams, Administrator District of Sicamous. December 15, 1997.

Details: Despite snowpacks in southern British Columbia the highest recorded in more than 25 years, major flooding did not occur. Snow surveys conducted during the spring ranged from 40 to 100% above normal, including record levels in the middle and lower Fraser basin. In the Kootenays and the Similkameen basin they were 43% above normal; near record levels of 35% above normal in the Columbia basin and double the normal level in some areas of the South Coast and Vancouver Island.

Spring weather allowed the high snowpack to melt gradually away without causing any significant flood damages anywhere in the province. The cooler than normal temperatures resulted in higher than normal streamflows throughout the southern half of the province with some limited flooding in the Lower Mainland, Kamloops and Terrace areas (*Currents*, November 1999).

In 1997, a high snowpack caused flooding in Nicola, South Thompson, Okanagan, Kettle, lower Columbia, upper Columbia upstream of Golden, and Kootenays. This was caused by a prolonged warm spell in mid May while there was still a considerable amount of snow left at relatively low elevations. Saturated ground conditions resulted in the recession of flood levels being relatively slow. Thus, when substantial rains fell in many areas in June, lakes and rivers responded very quickly and returned to, and in some cases exceeded, the levels reached earlier. In preparation for floods in various places, the provincial government had spent some $12 million in flood prevention work across British Columbia. With about two weeks to go before this year's peak, the Shuswap lakes system had reached the previous year's peak levels. With peak levels still 2-3 weeks away, the Okanagan watershed was expected to reach 1990 levels.

In early June, residents of about 15 homes in Grand Forks reported basement flooding. The Kettle River was nearing its peak of two weeks earlier and still rising. On June 1, some 30 people were

sandbagging key spots along the river. Kootenay Lake was also rising rapidly. On May 31 and June 1, Mission Creek went over its banks.

On June 2, when the Fraser River at Mission rose above 6 m, the provincial government opened a flood response centre in Burnaby for the Lower Mainland. On June 3, floodwaters caused the evacuation of three families in Harrison Mills near Harrison Hot Springs while neighbours were bulldozing an emergency dyke around the two houses and two others. Harrison River dykes were too low to hold the river from overflowing. On June 3, crews were also building a dyke at Carey Point near Chilliwack to prevent floodwaters from damaging orchards and other farmland. Overnight June 3-4, water levels on the lower Fraser River at Mission increased slightly to 6.10 m from 6.05 m. On June 5, the Fraser River at Mission peaked at a 23-year high of 6.35 m. On June 9, it dropped below the caution mark of 6 m.

On June 3, floodwaters threatened about 20 lakeside homes near Vaseaux Lake, between Okanagan Falls-Oliver. Because snowpacks were higher than normal, during the winter the government began releasing water through dam floodgates. *1) But the river system could not handle all the runoff. On June 4, residents of at least two dozen Okanagan homes near the rising Shuswap River and Mara Lake were on standby to be evacuated. Around June 5, the Goat River washed out a private access road to one residence. The elderly resident was evacuated.

BC Hydro took action on a number of fronts to minimise the impacts of the spring freshet's rising waters. On June 5, they opened the taps increasing the flow of the Seton River from a minimal 900 cfs (25.5 m^3) to a maximum of 2,000 cfs (56.6 m^3). As of June 9, Seton Lake was only inches off full at 236.09 m but holding its own (Full pool is at 234.29 m). BC Hydro hoped to cope with the majority of the run-off through the Seton system in order to keep it from spilling into Bridge River. *2) The Downton and Carpenter reservoirs still had a little leeway as the inflows continued to rise. However, as in previous years, the bottleneck occurred at the Seton end, where the canal and generating station cannot handle the volumes of water sometimes presented. When Seton Lake is full pool and Seton River is running at full spate, a spill at Terzaghi Dam becomes the only option. Lajoie Dam at Downton was not generating at the time. With Downton's full pool mark at 749.81 m, it was at 726.19 m and rising. Carpenter Reservoir was a little fuller at 641.97 m of water. Full pool there, including the 2-m buffer zone written into operating orders some years earlier, sits at 651.08 m. If the buffer zone is adhered to, full pool was just over 7 m away. At this point, generating stations Bridge One and Two and Seton were operating. Lajoie was shut down to mitigate inflows into Carpenter Reservoir (*The Hope Standard*, June 12, 1997).

As BC Hydro was not running the turbines at Wahleach power station, the reservoir might have to be emptied into Jones and Lorenzetta creeks. Usually the spillway had a 10-ft. (3m) drop into the Fraser River but with the current high water levels the river was backing up into Laidlaw. Some 90 residents in Laidlaw were threatened with flood damage. It was hoped that the high river levels might flush out the massive build-up of gravel at the mouth of the Coquitlam River, improving the river's flow and lessening the chance of future flooding of the Coquitlam River. It was feared that the high river level might have undermined the dyking system of the sewage ponds.

BC Hydro continued to monitor the Jones Lake reservoir, which could have caused further flooding in the Laidlaw area. Had the reservoir reached full capacity, the overflow could have further aggravated the high levels of Jones and Lorenzetta creeks.

Early June the water levels of the North Thompson River peaked close to 1974 levels. Between McLure-Clearwater water levels were dropping. Between June 4-7, the North Thompson River had dropped 15 cm. Recent heavy rains caused a third peak around June 6-7. The concern now was not the height of the peaks but the duration of the high water along the riverbanks. Saturation could potentially result in major erosion. At risk were low-lying properties close to banks. Kamloops Lake was receding and the rise in South Thompson River slowed down considerably.

By June 5, a high number of flood-related problems were identified on the Lower Shuswap between Mabel-Mara Lake with 12 or more properties impacted, several of which might require evacuation. In Grindrod, homes flooded. At the south end of Mara Lake, problems were identified at Pat McBridge subdivision. Several farms flooded from Falls Creek to Enderby and Enderby to Mara Lake. The latest rises on Kalamalka Lake were thought to be mostly rain-driven. High waters impacted the Oliver Equestrian

Centre and an adjacent greenhouse. The water level on Kamloops Lake was now 1.5 ft. (45 cm) up on the emergency dyke. Attempts to re-establish the water line to the Lytton Indian Band had been unsuccessful due to high waters in Nikaia Creek.

On June 3, the Rotary Trails and four holes at the golf course were flooded and Wardle Street was completely under water. The areas of concern, Laidlaw, Landstrom Road, the Silver-Hope sewer ponds and Wardle Avenue were closely watched. Later water surrounded a brand-new home along Landstrom Road and floodwaters lapped at the trestle of the Fraser Hope bridge. Flooding occurred at Wardle and Seventh Avenue. Only one yard at the corner of Wardle and Seventh Avenue was completely flooded. In Laidlaw, floodwaters came right up to a house in the St. Elmo Road area. One home on the Shxw'ow'hamel Reserve was also threatened. Along Landstrom Road, just north of the Fraser bridge, floodwaters surrounded a new home but did not reach the interior. The District built a 3-ft. (90 cm) dirt dyke to keep the water off the road to prevent the flood from isolating residents in the area. On the morning of June 4, the Fraser River at Hope reached 9.41 m.

Early on June 5, the Fraser River at Mission (6.365 m) and Hope (9.595 m or 11,500 m^3/s). *3) On June 6, work continued on a 200-m section of a dyke on Nicomen Island. By June 7, the residents of seven homes in the Harrison Mills area between Hope-Mission had been evacuated.

In June, the Barriere River caused erosion damage to its north side bank between the Barriere Search and Rescue building and the bus garage compound downstream from the Barriere Town Bridge. The cost to repair the damage was estimated at $100,000. There was no previous erosion history at this site. Hundred metres of the 5-m high bank with a particularly incessant back eddy kept eroding, even at low flows. A lower erosion resistant layer of silt extending about 1 m above low water levels split the flow, which is confined to the right side of the channel by an ever expanding gravel-cobble bar on the left side of the channel.

The freshet of 1997 on Mission Creek resulted in the highest flows on record. It caused the following damage in Kelowna: deposition of 30,000 m^3 of gravel in the dyked channel, thereby reducing channel capacity and the erosion of dykes, requiring riprap. The total damage was estimated at $310,000. (Heemskerk).

---

*1) Vaseaux Lake, an arid area known for its migratory bird sanctuary and California bighorn sheep, is part of an Okanagan River system dammed decades earlier to provide irrigation water for orchards (*The Vancouver Sun*, June 3, 1997).

*2) Historically, the Seton River had handled as much as 8,000 cfs (233.1 m^3) when the need arose.

*3) On June 4, the Fraser at Hope was running at 11,000 cfs (311.5 m^3), compared to 13,000 cfs (368.1 m^3) in 1972 and 15,180 and 17,000 cfs (447.4 and 481.4 m^3) in 1948 and 1894, respectively. Unofficially, it was the fifth highest peak recorded in the Fraser River in 85 years. In descending order, 1948, 1972, 1950 and 1964 were greater.

Summer 1997

Source: Evans, unpublished data.

Details: During the summer, a rock avalanche came down Mount Munday in the Waddington Range.

July 11-13, 1997

(Dam burst/flooding).

Source: *The Vancouver Sun*, July 11, 1997; Ministry of Environment files; PEP Task No. 98-0662; Evans, unpublished data.

Details: Between July 11-13, heavy rainfall caused flooding throughout the Okanagan and central British Columbia. The extensive flooding experienced in British Columbia during July was due to a combination of heavy and extensive late fall 1996 rain, which saturated the ground over a large part of the province; a heavy

winter 1996-97 snowpack with resulting heavy snow melt and spring runoff; the heaviest spring and summer rainfall on record for a large part of the province. *1)

On July 11, excessive run-off on Simms Creek caused to partially wash out the Cambie to Solsqua Road and the bridge at km 2.1 at Simms Creek bridge. Scouring occurred behind ballast walls and two foundation piles were destroyed. The cost to restore Simms Creek to its original channel, replace riprap up and downstream from the bridge, replace bridge piles and repair other damage to the structure and backfill the ballast walls was estimated at $50,000. (PEP Task No. 98-0662).

On July 11-12, heavy rainfall caused severe erosion of Ashton Creek and some flooding of adjacent properties. The damage extended from the apex of the alluvial fan located approximately 1,150 m above the highway to a bridge washout located approximately 700 m below the highway. Throughout the area, deposition of material in the channel and erosion of the banks was widespread. A large volume of debris from the upper catchment was transported and deposited within the existing channel through the village of Ashton. The reduction in channel conveyance capacity resulted in the channel overflowing its banks and eroding the adjacent soils. Estimated repair cost was $150,870.

On July 11-12, Falls Creek jumped its channel for a distance of 300 m. As its new location posed a significant threat to the highway and three homes, it was returned to its old channel. The estimated repair cost was $15,000.

On July 11-12, the streambed of Kingfisher Creek destabilised and gravel berms/piles with an estimated repair cost of $30,000. The cost to repair damaged riprap in Ross Creek and streambed restoration was $10,000. The July 11-12 flood had left the channel obstructed with alluvial deposits that raised the bed. It would cost $12,000 to remove the piled dredgings from Brash Creek and $7,000 for repair of Ferry Creek near Cherryville.

During the freshet, the Slocan Park footbridge was damaged beyond repair. *2) The damaged bridge posed a threat for people attempting to cross it and to rafters, tubers and boaters.

On July 11, a debris flow occurred at Swansea Point, on the confluence of Hummingbird Creek and Mara Lake at Highway 97A. The debris flow resulted in damage to residences in the area and closure of the highway. Initial damages were placed at $1.8 million. The channel below Highway 97A filled with gravel between the highway and Mara Lake, a distance of approximately 600 m.

On July 12, channel avulsion caused major erosion on Creighton Creek. The instability of the channel posed a risk to a homeowner downstream. A debris flow at Mabel Lake-Enderby Road impacted four families, at least one of which required evacuation.

On July 11, a road washout at First Canyon 15 km north of Clearwater created a hole 50-60 m deep. The washout left approximately 260 people stranded, the majority of which in Wells Gray Provincial Park. Seventy-six people were flown out by helicopter. A temporary bridge 140 ft. (42 m) in length was placed across the canyon. By noon on July 17, the Clearwater Valley road access to Wells Gray Park reopened.

In Kelowna, Mission and Mill creeks flooded. On July 14, two golf courses adjacent to Mill Creek remained impacted.

<u>Summary water-related events Southern Interior flooding July 11-12</u>: (in alphabetical order) Almandbury (Almondberry?) Creek: road washout; Ashton Creek: two families evacuated, mobile home park and store flooded, debris flow and slumps into the creek; Avola: flooding reported in Clearwater area; Barriere: several roads experienced flooding; Blais Creek: rockslide; Blurton Creek at Mara: 12-unit mobile home park flooded; Brash Creek: City of Enderby: dam collapsed; Cherry Creek North Fork: house impacted, north fork road bank erosion and flooding; Cooke Creek: flow washed out Enderby Mabel Lake Road, debris torrent, washout and erosion; Crazy Creek: debris flow; Dees Lake: road washout; Duteau Creek: two homes evacuated due to flooding; Eagle Creek FSR: three washouts; Falls Creek road overtopped, properties damaged, channel relocated, campground flooded; damage to highway crossing; Goat River: McBride (north of SIR) hydro lines down, two houses lost. Highway closed; Homes Creek: overflowed Salsqua Road; Hudson Creek at Anglemont: debris flow, road closed, highway overtopped in three places; Humamilt Lake: slide 3 km north of the east end affecting Cellsta Creek; Hummingbird Creek: debris flow/landslide; Isic Creek: flooding; Kingfisher Creek: Enderby Mabel Lake Road washed out, land flooded, debris on bridge, bridge washout, culverts washed out; Loftus Creek: at Cott Creek, flooding of two houses; Malakwa:

Summerville-Husten (?); Mill Creek at Kelowna: road flooded; Mission Creek: Lakeshore Road threatened, bank erosion; Noisy Creek: erosion, road washout, campers stranded; North Thompson River: rapid rise in levels by 1.5 m; Postill Lake: road washout; Seymour River: slump, debris slide; Shuswap River: flooding damage, golf course under water at Cherryville; flooding and damage to Schappenzeller Ranch. Shuswap, Okanagan, Kalamal(ka?): rise in lake levels, Okanagan Lake exceeded previous flood levels setting a (information incomplete) On July 20, Okanagan Lake reached a new peak for the year.

---

*1) For the 10 months till July 1, Vancouver recorded a total of 1,701.6 mm of rain, making this the wettest 10-month period on record. Between July 1-10, Vancouver recorded 88 mm of rain in 10 days, more than double the average of 36 mm for the entire month of July (*The Vancouver Sun*, July 11, 1997).

*2) The structure had been built in the 1940s with no approval. Though the government donated the cables, the community had maintained the structure but nobody legally owned it.

July 21, 1997

Source: *The Daily Courier*, July 22, 23 and 24, 1997; *The Morning Star*, July 23 and 25, 1997; *The Kamloops Daily News*, July 22 and 23, 1997; Ministry of Environment files.

Details: On the evening of July 21, a violent storm passed through areas of Okanagan, Shuswap, central and northern British Columbia with hail, torrential rainfall and high winds. The storm, which stretched from the U.S. border north to Kamloops, flooded roads, capsized boats on Interior lakes and cut electrical power. In Kamloops, hail the size of marbles pelted the city in two storms that lasted only minutes. Some of the hail stones measured 25 mm across and rainfall across the city varied from 10-30 mm.

The storm resulted in two fatalities and significant damage to property, crops and infrastructure. Additional financial impacts from crop losses as a result of this event were estimated at around $60 million. Damage to the Okanagan apple industry varied between $10 million (total amount offered to the growers through the crop insurance program) and $100 million (according to B.C. Fruit Growers Association).

Hail, heavy rains and wind ripped over the Okanagan and Kamloops areas. Fruit crops were damaged and around Cranbrook lightning and thunder struck. An eight-year old girl died when a tree fell on her as she rode her bicycle in Wasa Provincial Park.

Doug Scott, operations manager of HMC Service Inc., said his company plowed 10 cm of hail in some areas on the Coquihalla Highway's Okanagan Connector west of Kelowna.

On the afternoon of July 21, 24.4 mm of rain fell in Vernon in a two-hour span. Several businesses flooded and many sidewalks were impassable. Flooding occurred at the corner of 32nd Street and 30th Avenue. On Highway 6, more than two months of work scheduled to be completed at the end of July washed out. The project expected to cost $60,000 included restoring fill along the edge of the highway, installing drainage pipe at the base of the fill and repaving the surface. On July 21, the construction of a 50-m section on Lumby's west boundary began.

In Vernon, the rain flooded some basements and swamped a mobile home park, forcing residents to flee. Some local roads and sewers were also damaged. Vernon Mayor Wayne McGrath said that he would seek provincial financial compensation.

Rushing waters from rain and hail washed debris through Kamloops streets clogging catch basins for storm sewers. Hardest hit were Westsyde and Sahali on hillsides where most debris came from. The city received more than 100 storm-related calls. About a dozen places experienced some flooding.

August 13, 1997

(Glacial outburst flood).

Source: Evans, unpublished data.

Details: On August 13, a moraine dam burst in the Nostetuko River Basin.

October 1997

Source: *Campbell River Courier-Islander*, February 3, 1998; December 22, 2004.

Details: In October, unprecedented high water levels hit the Quinsam River Hatchery hard. Pink salmon had spawned and Coho and Chinook salmon were entering the river system. Hatchery manager Dave Ewart suspected that pink salmon eggs washed out of the river. The high water levels forced hatchery workers to open a river fence meant to collect chinook brood stock, hurting the hatchery's chinook egg-take program. The river also damaged a roadway.

---

*1) In the winter of 1996, a BC Hydro spill from the John Hart Dam washed out the newly installed Second Island Spawning Channel. After an outcry from local politicians and conservationists, BC Hydro paid to rebuild the channel (*Campbell River Courier-Islander*, December 22, 2004).

January 12-14, 1998

(Rain-on-snow?).

Source: *Campbell River Courier-Islander*, January 15, 1998; Ministry of Environment file 3500-20/21-110.

Details: Overnight January 12-13, the Campbell River airport reported 17 cm of snow, followed by rapid snowmelt and 24 mm of rain by January 14 at 7 a.m. As snow at higher elevation did not melt, the precipitation did not cause any problems for BC Hydro's John Hart power station water reservoir system.

On January 14, a landslide occurred at the 783 Drew Road property at French Creek. The location is a steep bank on the left bank of French Creek about 1 km upstream of the Old Island Highway. The slide went into the channel of French Creek and threatened a house. It deposited material across the creek causing some redirection of flow. Staff from Environment and Lands recommended the home at the affected property (Lot 1, Plan 24427) not to be occupied until an assessment of stability of the site was completed. They also recommended the stability of the slope on neighbouring properties (lots 2, 3, 4, Plan 24427, and Lot 2, Plan 39538) also be assessed since there might be the potential for a similar slide.

January 23-26, 1998

(Rain-on-snow and tidal flooding).

Source: *Campbell River Courier-Islander*, January 27 and 29; February 3, 1998; February 16, 2007; Ministry of Environment file 1055-01.

Details: Between January 22-the morning of January 26, the Campbell River airport recorded 177.2 mm of rain. Just over 101 mm of that fell in the 24-hour period ending 7 p.m. on January 23. A flight services spokesman said, "I've been here 14 years and it's the most I've ever seen." With the snowline at an estimated 2,500 m, the rain melted much of the snowpack.

Throughout the fierce southeaster storm on January 24-25, at Cape Mudge lightstation winds consistently gusted between 25-38 knots (46-70 km/h). High winds and tide conditions led to the cancellation of at least one ferry sailing between Quadra Island-Campbell River.

High tides worsened the rainfall runoff problems. In some locations along the Island Highway, such as at the north end of Storrie's Beach, with water being pushed back by the high tide, the culverts were unable to handle the flow. On the evening of January 23, four culverts flooded over the Island Highway to a depth of 3-4 in. (7.5-10 cm). Some gravel on the shoulder washed away and some nearby basements were flooded.

On January 23, three slides came down in Campbell River. Plugged highway culverts caused water to back up and the bank above the Marina Inn/Time Out Pub to give way. A section of the Hilton property above, roughly 13 ft. (3.9 m) m deep gave way. *1) The mudslide slammed into the back of the inn flooding the hotel's beer and wine store. Four rooms, an office and at least one vehicle were damaged. Manager Kelly Brar noted that the pressure was so intense that the flow just knocked the door and frame right out of the wall of the hallway. Brar estimated the damage at $100,000-150,000.

Earlier in the day, vehicles were thrown about when a wall of mud and trees slid down the escarpment onto the end of Spruce street from a Tree Lane Road property above. The slide ripped up a fence, pushed a pickup truck several yards into a ditch and at Econo U-Store-It threw another car into a trailer. *2)

Another minor slide occurred just north of the Marina Inn on the bank above the Rockland Road project. Herb Forsyth, city Public Works director, said that the southeast wind's very intense storm driving rain against escarpments "will soak it up pretty good," and slides will happen when the material gets super saturated. "It slips away when it can't hang on any longer."

Rockfalls occurred on the road to Gold River along Upper Campbell Lake. On January 23 at 11:35 p.m., three Gold River residents were injured when their car when rounding a slight right hand curve drove into a rockslide 35 km west of Campbell River. A rockslide north of Roberts Lake closed the Island Highway for about an hour. Some minor washouts occurred on both the Gold River and Duncan Bay Road. On January 23, a section of Homewood Road flooded.

In January, Woods Creek once again flooded causing significant damage to a number of residences. See: flooding claims 3900 Block south Island Highway area, Campbell River.

The flooding combined with the October 1997 flood caused much damage at the Quinsam River hatchery. Hatchery manager Dave Ewart noted that "we've had high water before, but I've never seen it this bad." The heavy rains that swelled the river again on January 23-26 might have finished the job of decimating spawning beds and newly hatched fish. Though the floods did not do as much physical damage to the hatchery as the October 1997 floods, many banks had collapsed into the river, dumping mud and silt into the water. "Everywhere you look up the river, there's banks that have sloughed in and trees that have gone in and across," said Ewart.

According to fisheries staff, water levels in Campbell River approached the maximum level the new gravel spawning beds could withstand. On January 28, BC Hydro officials reported approximately 11,000 cfs (311.5 m^3/s) flowing through John Hart Dam's generators into the Campbell River. Around January 23-24, a major storm had dropped nearly 7 in. (175 mm) of rain on the region. *3)

---

*1) In March 1980, a section of Hilton's neighbour's property collapsed, slamming into and causing damage to what was then called the Island Inn Motel (*Campbell River Courier-Islander*, February 16, 2007).

*2) In the early 1970s, a similar slide occurred in the same area. (*Campbell River Courier-Islander,* January 27, 1998).

*3) During the summer of 1997, the Department of Fisheries and Oceans had installed the new spawning beds in a laborious effort involving 750 tons of gravel dropped by helicopter in three locations along the river. It was believed that the spawning beds could withstand about 12,000 cfs (339.8 m^3/s). As this would be the first winter since the installation of the beds, it was unknown how well they would stand up (*Campbell River Courier-Islander*, January 29, 1998).

November 24, 1998
Source: *Totem Times*, December 12, 2006.
Details: On November 24, Comox recorded 78.8mm of rain, setting a record for 24-hour rainfall, which still stood in November 2006.

January 15, 1999
Source: Ministry of Environment files.
Details: On January 15, a slide and road failure occurred on Highway 31, 1.3 km north of Davis Creek bridge (Nelson-Kootenays). The cost to reconstruct the shoulder was $35,000. On January 15, a slide and road failure occurred on Highway 31, 1 km north of Lost Ledge bridge. It was caused by water runoff. Total restoration cost was $36,000.

January 25, 1999
Source: Ministry of Environment files.
Details: On January 25, a road shoulder failed and slid at Argenta, Johnson's Landing. (Nelson-Kootenays). The cost to shift the road further into the slope was $15,000.

Spring 1999
(Snowmelt damage).
Source: Ministry of Environment files.
Details: Over the spring, a sinkhole gradually developed on Highway 3,750 m east of the Mosquito Creek culvert, at km 33.4 between Yakh-Creston. The sinkhole only became visible in early summer with the collapse of the roof on the cavern. It was first observed in mid August. Restoration cost to fill the hole including drainage at the base of the fills to prevent reoccurrence was about $20,000.

Between March 10-May 30, heavy snowload and subsequent melt caused extensive damage to the wildlife fence along Highway 97C, Pennask Summit and Brenda Mine. Repair cost to replace fence fabric, repair washouts and posts undermined by runoff and replace hi-tensile wire was estimated at $100,000.

On March 8, snowmelt caused a 40-m long and 3-m wide failure of highway at Shutty Beach near Kaslo, about 100 m south of the intersection with Kaslo North Road-Jacon Road No. 3109. The section slid into Kootenay Lake. Cost to excavate the bank to re-establish the road providing sole access to a residential area, further into the slope was $3,000.

On March 15, snowmelt resulted in a shoulder failure along 25 m of Highway 6, at Fauquier Bluff, to the edge of the travelled lane. The remaining shoulder was unstable and unsafe for travel. The cost to re-establish the original highway cross section was $126,000.

On March 15, snowmelt triggered a section of Highway 31A into the Kaslo River running along the toe of the highway fill. The failure eliminated 25 m of shoulder. A crack extending to the centreline of the highway indicated a high potential for future slide events. Restoration cost was $80,000.

On March 15, snowmelt saturated fills and triggered a shoulder failure 3 km east of the intersection of North Goat Road and Highway 3, Creston. The failure was about 25 m long and 2 m from the edge of the shoulder, threatening private residences below the slide. Restoration included the diversion of water from the wet area upslope of the slide and to reconstruct the slope. Restoration cost was $71,000.

On March 15, snowmelt triggered a slide on South Reclamation Road to the slough into the irrigation ditch. The about 30-m long failure cut more than 2 m into the road. Cost to reconstruct the failed toe with rockfill was $26,000.

On March 22, spring melt triggered a soil slide onto the Salmo-Creston Highway 3, 5 km west of Summit Bridge. It came down from an overhanging rock and covered both lanes. The slide area was approximately 30 x 100 m and impeded the traffic flow on both sides. Daily cleanup of the slope creep was carried out. The slide was threatening to slip across both lanes in the event of heavy rains. The construction of a rock berm was the only cost effective way to prevent further disruption to traffic. Restoration cost was $125,000.

On March 25, a mudslide closed Highway 31, 3.8 km north of Orr Road. The debris included trees and powerlines. The area initiated in a clear-cut. Schroeder Creek changed channel and triggered the slide, which damaged the road asphalt. Restoration cost was $9,000.

On March 26, snowmelt triggered a debris torrent commencing on old mine roads onto Highway 6 and adjoining highway right-of-way 1.4 km north of avalanche gates Memphis Cape Hm. It plugged the culvert. After the slide came down, Slocan Forest Products completed drainage improvements upslope. Cleanup of debris on the highway cost was about $5,000.

On March 28, a 60-m length of slope slid onto Highway 3A (10 Mile Nelson-North shore), blocking one lane. Cost of restoring two-lane traffic and flattening the slope above the highway was about $9,000.

On March 28, snowmelt triggered a 30-m long section of Slocan West Road Slough road to fail and slide downhill. The road, which provided the only access to 3-4 homes, had the potential to cut these of if the roadway continued to fail. The cost to reconstruct the road to its original alignment was about $4,000.

On April 2, a landslide came down on Highway 1, 13.1 km west of Revelstoke (Clanwilliam Lake slide). Coming down on the north side of the valley, it dumped approximately 5,000-10,000 m^3 of rock, earth and trees into Clanwilliam Lake (also known as Summit Lake). Consequently, the lake backed up to over 1 m above normal low water levels. Debris from the slide landed in the outlet of the lake, which is the headwater of the Eagle River, causing the creation of a weir. Though the slide did not block the highway at

the time of the incident, it did block the CPR mainline for 24 hours. Erosion problems were caused along the highway. On the lake there was a large moving log mass as well as a large volume of timber at the mouth of the lake. Total restoration cost was $150,000.

On April 4, extreme snowpack and abnormal snow densities caused the Gazex shelter at Kootenay Pass camp to collapse. *1) Damage to the shelter included the ripping of the inner and outer shells, bucking of the floor and damaging the tanks and valves. The platform joists also broke. Restoration cost was $50,000.

On April 6, the emergence of sub-surface flow below the road rill material on Summit Lake FSR caused a fill slip initiating a slide to Highway 6. The cost for debris cleanup, to re-establish drainage and replace fill was $35,000.

On April 13, spring snowmelt saturated a sidehill causing a large landslide that covered Highway 12 and destroyed a concrete barrier and existing pavement. (Highway 12 Slide south). Cost to remove slide material, stabilise the slope, restore pavement and replace the culvert was $169,387.

---

*1) The Gazex system provides avalanche control to protect Highway 3 in the Kootenay Pass. Infrastructure was a building on a platform designed to contain tanks, valves and electronic components of the Gazex control system.

April 20-May 4, 1999

Source: *Campbell River Courier-Islander*, April 29, 1999; Ministry of Environment files.

Details: On April 20, snowmelt triggered a cut slope of silty soil to slide onto Sheep Creek Road and into an adjacent creek. As minor sloughing was ongoing, the road, which accesses one residence and logging and recreation areas, remained closed to traffic. One event pushed a truck into the creek. Every two weeks, the daily sloughing was being removed. The cost to reconstruct a gravel road over the failed material on the road and to flatten the cut slope and provide drainage to groundwater to minimise further sloughing was $15,000.

On April 20, snowmelt caused a debris torrent to come down and plug a culvert on Highway 6 at Broken Back Corner near Nakusp. The cost to excavate the material upslope of the highway embankment, unblock the culvert and re-establish the original creek flows was $6,000.

On April 20, snowmelt triggered a debris torrent and blocked a large-diameter culvert and threatened to wash out the Hot Springs Road at Kelly Creek near Nakusp. The cost to excavate material from the road surface and material from the culvert entrance to re-establish the creek flows through the roadway was $21,000.

On April 21, the eastern slope uphill of Highway 6 at Passmore, 14.3 km failed onto the highway. It filled the ditch and crept onto the shoulder up to the white line and continued to creep onto the highway. Restoration cost was $76,000.

On April 23, a cut slope slump occurred across the Goat River FSR at 19 km. About 2,000 m^3 were deposited on the road and into Goat River. Total restoration cost was $10,915 and an additional $20,000 ministry enhancement cost to prevent future slides into the Goat River. (Nelson Forest Region-Kootenay Lake District).

On April 24, a debris avalanche along Sitkum Creek FSR at 3.1 km entered Bourke Creek, causing turbidity in the Community watershed. The cost to install a temporary water line, water quality assessment, site stabilisation and hydro seeding amounted to $18,551. (Nelson Forest Region Kootenay Lake District).

On April 24, a shoulder of Highway 6 Lost Ledge Rock Bluffs/Highway 31 Lost Ledge failed into Kootenay Lake leaving only 3 m of road surface and guard rail hanging in mid air. Total restoration cost was $86,000. Fill slopes were not possible due to the very deep slope of bedrock down over 120 m to the lake. The proposed repair was to excavate the road shoulder and to construct either a gabion basket or geogrid retaining wall.

Late on April 25, tons of rock, soil, trees and other debris came down the Nomash Valley about 8.5 mi. (13.6 km) north of Zeballos. Melting snow may have been the cause of the landslide, increasing the core pressure within the fractured rock mass acting to trigger the failure. The slide happened in fractured carbonate bedrock several hundred metres upslope from any timber harvesting or road building activity. It

placed a large volume of soil in the upper reaches of the Nomash River, sending a bloom of silt out into the Zeballos River and Zeballos Inlet. Zeballos Mayor Cliff Pederson suspected there might be more slides because of the heavy snowpack but no populated areas were threatened. The slide came at a bad time for salmon enhancement efforts in the area as a week earlier 30,000-40,000 salmon fry had been released into the Zeballos River.

On April 25, a partially blocked culvert pipe on West Wilson FSR caused the stream to overflow onto the access road to West Wilson Lake campsite. The saturated fill caused a slide occurrence into Wilson Lake. Cost to drill and blast to excavate a new running surface and pull back of remaining perched material was $35,250. (Arrow/Nelson Forest District).

On April 26, an old log culvert collapsed at km 11 on Lang Lake FSR causing the road serving residents and public facility Cariboo Region's Lang Lake "goal 2" park to wash out. Cost to remove old culvert and replace it with a 2,400-mm x 21-m culvert was $31,000. On April 26 and July 12, at 13.5 km on same road a plugged culvert caused the road to wash out. The cost to remove plugged culvert and replace with a 12-m bridge was $51,000. On the same date, at 14 km on the same road an old log culvert failed, causing erosion of the road prism. The cost to remove the old log culvert and replace it with a 15-m bridge was $63,500. (100 Mile Forest Region).

On April 30 in the Lillooet area, heavy rain saturated the road and embankment at km 5 on Mission Mountain Road, causing the road to fail. Restoration cost was $71,000.

On May 1, a natural debris flow scoured out a large portion of the Kootenay Albert FSR at km 56. About 2,000-3,000 m^3 of material were deposited in the Albert River. Total restoration cost was $10,000.

On May 4, a freshet washed out the roadway of Tulameen River Road, 15 km west of Tulameen. Awaiting funding to repair the road, it was closed. The cost to rebuild the section of the road and to replace a culvert was estimated at $40,000.

May 14, 1999

Source: Ministry of Environment files.

Details: On May 14, high water table resulted in the failure of the shoulder of Highway 3. Church property below the highway was threatened, forcing the placement of slope monitors during Sunday services. (Little Joe's Church slide-Highway 3 and Canyon Lister Road intersection; Nelson-Kootenays district).

May 23-June 5, 1999

(Spring runoff/flooding and dam bursts/flooding).

Source: *Kamloops Daily News*, May 26, 1999; *The Penticton Herald*, May 26, 1999; *The Vancouver Sun*, May 27, 1999; *The Province*, May 27, 1999; *Times Colonist*, May 27, 1999; *The Penticton Herald*, June 3, 1999; Ministry of Environment files.

Details: As of March 1, the basin indexes in the Fraser River showed from 20-80% higher snow water equivalents than normal (i.e. 1961-1990 levels). Cumulative flow (volume of water), which passed Hope between April 1-July 13, was nearly identical to the volume that passed Hope in 1948 during the same period. But the 1999 melt pattern was different. As a result of the much cooler than normal spring and early summer, La Nina, the same ocean currents that helped create the higher than normal snowpacks, instead of breaking up in spring as usual, remained in place.

Robin McNeil, the head of the River Forecast Center summarised the spring runoff. "Based on record snowpacks measured during the March, April and May snow surveys in the Thompson basin and much of the Fraser basin, damaging floods were quite likely. Several warm days in April allowed an early runoff of some of the lower level snowpacks. This was followed by a generally cool May including a two-week period of continuous below normal temperatures. The heat of the May long weekend brought river levels up very rapidly. Had this occurred earlier and/or lasted longer, the effects on river levels would have been dramatic. Temperatures in the first two weeks in June were again well below normal, followed by a week of warm weather eventually caused the main peak flows in the rivers. Because this first sustained warm spell did not start until almost mid-June, the snowline had crept upwards and the snow-covered area was small enough that extreme peak flows did not materialise."

Hot weather over the May long weekend caused a quick rise of East Kootenay rivers and streams. Two small communities were threatened and some farmland and part of a provincial campground were flooded. Residents of Bull River were put on alert and Yakh was also at risk. The Moyie River flooded three campsites in the provincial campground near Yakh. Around May 24-25, Hawkins Creek broke loose, sending a torrent of logs, mud and debris into Moyie River, which also threatened the Yakh townsite. Meanwhile, an evacuation plan was in effect at Bull River because of rapidly rising waters behind the BC Hydro Aberfeldie Dam. *1) Between May 24-25, reservoir levels increased 30 cm and the water was expected to continue to rise rapidly because of the long delayed snowmelt.

On May 23, spring runoff intensity washed culverts and the roadway for about 600 m on Botanie Valley Road. Repair cost was estimated at $50,000. (Kamloops Region).

On May 24, high water and a debris flow caused the washout of two culverts and roadway on Dickie Creek Road No. 40, 5 km west of Lillooet. A very heavy build-up of gravel occurred. The cost to remove a temporary bridge, backfill erosion, restore the creek channel, riprap banks and to replace the structure to new design standard was $350,000.

On May 25, rapid snowmelt resulted in high water flows, causing the loss of the existing riverbank along Squamish Valley Road, about 9.1 km from the Cheakamus River bridge. The cost to restore the riverbank and road protection along the full 15-m length was $44,556. It involved a volume of about 720 m^3. The next event would have the potential to wash out the road at this point and isolate the local Indian Band.

On May 25, spring runoff washed out a culvert under Highway 1 (Gladwin washout). The cost to replace the culvert, backfill and resurface the roadway was $1,546.35. (Kamloops Region). On May 25, the high snowfall damaged the ungulate fence along Highway 5. The cost of fence repairs was estimated at $70,000 (Kamloops Region).

On May 25, Bolean Creek threatened a waterfront home and nearby workshop near Falkland. During the previous week, the usually sedate creek rose nearly 2 m. *2) The Salmon River spilled its banks in a number of areas in the valley. Numerous fields started to look like lakes. Some minor flooding was reported near Salmon Arm and Lytton. Meanwhile, with the soaring temperatures the North Thompson River was expected to rise rapidly over the next two days. In the South Thompson River, water levels were also rising, especially at Shuswap Lake.

On May 26, inadequate culvert sizing caused flooding and erosion of road fill at 10 km Lang Lake FSR restoration cost to remove the culvert and replace it with a 12-m bridge was $51,500.

Overnight May 27-28, heavy rainfall throughout southern British Columbia in previous 24 hours resulted in localised flooding. Areas affected included Keremeos, Cawston and Chopaka (Lower Similkameen) Reserve. On May 27-28, a flash flood occurred on McIntyre Creek, at Deer Lakes Estates, between Okanagan Falls-Oliver. No residences were affected but the dykes were severely damaged. A high-pressure natural gas line runs through affected area.

On May 27 near Osoyoos, Haynes Creek came down off the mountain through an orchard flowing towards a house, which apparently did not sustain any damage. Flows reduced through the day.

On May 27 at 6 a.m., a landslide occurred north of Broadwater Road. It closed the road and deposited materials into Lower Arrow Lake. On May 27, Broadwater Road near Castlegar remained closed to traffic. The Marina operator provided boat service to the 30 residents stranded on the other side. Park staff continued to check those stranded in Syringa Creek Provincial Park. On the afternoon of May 28, Broadwater Road reopened.

On May 28, rapid snowmelt caused high water flows and Brohm Creek to relocate closer to the highway. It resulted in the loss of the existing road embankment. The cost of rebuilding the embankment including the placement of about 216 m^3 of riprap was $15,372.

East of Sparwood, bridge approaches of Michelle Creek at 18 km on the road to Coal Mountain coal mine washed out. Corbin Road, halfway between Sparwood and the Alberta border closed. Mine employees were taken out by helicopter. Corbin Road was expected to reopen late on May 29. Work continued on bridge approaches, re-armouring of the channel and ditching to open plugged and blocked ditches.

Near the Chopaka Reserve, several creeks broke out above the road access. One house was threatened. Being Native Land, any restitution of channels would be federal government responsibility. On

May 28, Barcello Road near Cawston, 10 mi. (16 km) east of Keremeos was still closed and ten residences still cut off. Some orchards were flooded.

Andy Good Creek near Crowsnest broke its banks and flooded a B & B. The creek changed course flowing between the garage and the house. The dining room was flooded and the back yard gone.

In the Fernie area, Hosmer creek overflowed again, running down Victoria Road. On May 25, a tornado was reported in the Jaffray area. Worst hit was Rosen Lake West in Jaffray. Numerous trees were down, many falling on houses. Flooding occurred and septic systems were damaged. The storm caused power outages up to 30 hours. A creek jumped its banks upstream from a fairly large highway culvert. Water was running parallel to the creek overland through the Worthington property and house.

On May 30 near Yakh, Two Bit Creek overflowed after three highway culverts became plugged. A house and property were flooded and a driveway washed out.

On May 30, the toe of the slope of Green Mountain Road 10 km. West of Penticton, within Indian Reserve No. 1 was undermined, causing the road surface to fail. Restoration cost was $40,000.

On May 31 due to heavy rain, Silver Creek overflowed its banks near Trailer Court on Orangeberger Road. The dam of the Okanagan Indian Reserve No. 1 on Six Miles Creek, on band land and funded by INAC, 50 mi. (80 km) from Vernon failed. The bank of the creek quickly eroded, severely impacting a residence and threatening a second one.

Shorts Creek, running through the community of Finery, caused erosion of the riverbank about 30 ft. (9 m) along the channel and threatened the bridge. Near Barriere, Haggard Creek jumped its banks threatening a home, a situation occurring every year. The flooding Kettle River impacted one home. Near Fernie, Sand River and Maguire Creek near Grasmere flooded and impacted a few properties. Moyie River near Creston flooded several properties from Yakh to Kingsgate. Across the valley from Creston, Corn Creek undermined and dislodged the intake of the water pumping station, leaving four families without water since May 24. The Christina Lake level rose, flooding the basements of two homes.

As of June 1, snowpacks in the Similkameen Valley remained more than 60% above normal. East of Kelowna, the Mission Creek remained above the record level set 27 years earlier. Okanagan Lake remained well below full, leaving much storage room for excess runoff.

On June 1, rising water from snowmelt washed out the Skoi Lakes trail in Bowron Park. Snow load and winter storms had shifted the Isaac Lake shelter in Bowron Park, causing structural instability.

On June 1, a 200-m^3 cutbank slump occurred at 13.8 km on the Meadow Creek FSR. It diverted ditch water onto the road, causing an additional 50 m^3 of material to be deposited into the nearby creek. The cost to restore the road, which provides access to the Goat Range Provincial park, was $11,492.65/ $10,363.70 Ministry of Environment enhancement cost. (Kootenay Lake district).

On June 4, melt mobilised debris that plugged a culvert on a forestry road upslope from Highway 6 at Summit Lake campground, 14 km east of Nakusp. Subsequent embankment failures flowed down a creek onto Highway 6. Sufficient debris and silt were deposited onto the highway to force single-lane traffic for the weekend. Cost to cleanup the material on the road was $16,000.

On June 5, the tailing dam on Sheep Creek near Rossland breached when a culvert under the dam collapsed allowing tailings to enter the creek. On June 5, Ashton Creek near Enderby overflowed its banks impacting one home. On June 6, flooding was reported on the North Thompson River near Clearwater and Barriere, involving farmland and impacting one home.

---

*1) The Aberfeldie dam was built in 1953 and holds back a small reservoir extending 1.5 km up the Bull River. The community of Bull River with about 20 residents is located about 30 km southeast of Cranbrook.

*2) Falkland is usually one of the first communities hit by rising spring waters as Bolean Creek and Salmon River meet in the centre of town.

June 8, 1999

Source: *The Globe and Mail*, June 9, 1999. *Times Colonist*, June 9, 1999; *The Vancouver Province*, June 9, 10, 11 and 16, 1999; *The Vancouver Sun*, June 9, 10, 11 and 16, 1999; Ministry of Environment files..

Details: On June 8 in less than four hours before noon, White Rock recorded almost 70 mm of rain and 10 cm of hail. This was more than the 50 mm White Rock receives in a typical month of June. *1) Gary Meyers of Environment Canada considered it a 1:100-year storm. According to Mayor Hardy Staub, it was a 200-300 year event. Hail stones, as big as jellybeans, coated the ground as deep as 15 cm and caused flooded basements and mudslides undermined roads. Small tornadoes, or funnel clouds, generated by chill winds pulled waterspouts out of Boundary Bay.

At least 60 residents were evacuated, some through the water in buckets of city front-end loaders. Several schools, some having several cm of water in classrooms, were closed because of overflowing sewers or leaking ceilings. White Rock experienced flash flooding. ICBC insurance claims for about 50 vehicles amounted to approximately $300,000 damage. Hail plugged storm drains. About 40 homes with up to 200 residents were evacuated. Hardest hit were homes and businesses near Duprez Creek, along the Marine Drive business district and low-lying areas between Marine Drive and the railway embankment fronting the beach. Along Duprez creek, yards were ripped away and elevated walkways taken out. The city's storm sewers on Marine Drive were unable to handle the flood and manhole covers were "blown off by geysers." Karin Layton's house was flooded the third time in two years. "This is by far the worst and we have at least $30,000 in damage this time."

According to the White Rock Director of Operations, most systems were built to handle the flow of water from a severity that occurs once in five years. White Rock's was built for a storm that comes once in 10 years. "At the five-minute mark of [Tuesday's] event, we hit the 25-year mark. I would say we hit the 200 year storm at the 30-minute mark."

Classified "destroyed" were Buena Vista Avenue from Everall Street to Oxford street and Everall to Prospect Avenue. Along Buena Vista Avenue, where the pavement was lifted 15 cm, homes may have suffered possible structural damage. Buena Vista Avenue might have to be ripped up and rebuilt. On June 9, many businesses remained shut, as cleanup crews were busy carting away the 30-cm deep muck.

Also affected were the Bergstrom Street pump station, hit by lightning, and portions of other streets. Stone estimated the cost to restore the destroyed streets at $300,000. Wayne Baldwin, the city's chief administrative officer, later estimated the cost of fixing public works at between $1-2 million. Early work would focus on Buena Vista and the Duprez Creek storm intake. Anticipating big cleanup bills, White Rock suspended all capital projects.

On June 8, heavy rain resulted in runoff eroding the road base, flume and sub-surface, culvert sub-surface, drainage ditch and creek at Highway 99 and 32nd Avenue, Surrey. Restoration cost was $46,000.

On June 9, localised flooding caused erosion damage to Highway 31 in the Lardeau area between Howser-Trout Lake. The cost for re-gravelling and shoulder reconstruction was $2,000.

---

*1) White Rock's average rainfall for June was 48.8 mm. The June 8 storm unofficially set two short-term intensity records, washing away the previous six-hour rainfall record of 55.9 mm set in 1976 and the 12-hour record of 67.8 mm set in 1972.

June-July 1999

(Spring runoff/flooding).

Source: *Kamloops News*, June 17, 1999; *Vernon Morning Star*, June 23, 1999; *Hope Standard*, June 24, 1999; *100 Mile House Free Press*, July 7, 1999; *The Province*, June 21; July 8, 9 and 11, 1999; *The Province*, June 20; July 18, 1999; *Times Colonist*, June 21, 1999; July 9 and 10, 1999; *The Vancouver Sun*, July 9, 1999; *The Globe and Mail*, July 10, 1999; Ministry of Environment files 99-03-501, 99-03-502 and 99-05-501; PEP Flood Situation reports June 20, 21, 23, 24, 25, 27 and 28; July 10, 17 and 19, 1999.

Details: On June 10, diverted ditch water saturated the road embankment of Buchanan Lookout FSR at km 1.2, causing a landslide /slump in the roadway. The restoration cost was $2,014.50. (Kootenay District).

On June 15, the Intipam bridge abutments on Texas Creek road about 30 km south of Lillooet washed out, causing $5,000 damage. On June 16 and 17, high water and a debris flow over the Texas Creek Road caused erosion and culvert damage at Spray Creek, McFee and Cat Creek. The costs to replace the culverts, riprap and road surfaces was $17,000, $7,800 and $2,000, respectively. On June 16, high water

levels in Hell Creek near Lillooet eroded upstream of a culvert and filled in the culvert, causing $2,500 restoration cost.

On June 17, the Attorney General announced a $3 million flood fund for communities in British Columbia for long-term flood protection work. The fund was a continuation of an assistance program a year earlier. Then the government gave $3 million for 52 projects in 37 communities, including Kamloops that got $164,000. According to Don Funk, Kamloops' design and drainage engineer, it would take about $600,000 to complete permanent dyke work near the Woodland Trailer Park beside McArthur Island. The flood protection was started the previous year but was only half-finished (*Kamloops News*, June 17, 1999).

On June 17, Kaslo River eroded the shoulder of Highway 31A between Kaslo-New Denver, about 10 km east of Whitewater, for about 100 m. Restoration cost was $4,000.

On June 18, high water washed out the road surface and shoulders at culverts at km 10 on Marshall Lake (Road?)-Carpenter Lake area west of Lillooet (Hogg Creek), causing major erosion damage. Restoration cost was $17,000. On June 18, a creek washed out 30 m of Lemon Creek Road, 3 km from Highway 6, for the full road width during melt flood. Restoration cost was $3,000.

On June 19, a debris flow came down near Allen Creek, a tributary to Albreda River 51 km north of Blue River. On June 19, Allen Creek jumped its banks about 1 km upstream from Yellowhead No. 5. The resulting torrent damaged approximately 600 m of main highway and a large parking lot. The maintenance contractor for the Ministry of Highways redirected the creek back into its original channel, allowing them to repair the road and parking lot. At Allen Creek, no homes were impacted. Rain on June 19-20 caused a small landslide on the Lumby-Mabel Lake Forestry Road.

On June 19, culverts washed out on Meager FSR leaving 18 vehicles with 40 people trapped. The cost to salvage the existing culverts and reconstruction of 50 m of road was $6,998. On June 19, localised flooding occurred on the Slocan River, causing erosion damage to Slocan Valley side roads. Restoration cost was $3,000. Melt triggered a landslide flowing from about 200 m above the road onto Whitewater Road, about 10 km from the Highway 6 slide. Debris covered both lanes of road providing sole access to Whitewater Ski Hill. Restoration cost was $4,000.

On June 20, saturated fill slope failed and dropped onto Webb Road at Highway 5, 3 km south of Little Fort. Restoration cost was $41,500. High water eroded 100 m of Auldgirth Road at Dunn Lake Road, 16 km south of Clearwater. Cost to haul and place 7,000 m^3 of road base and cap with gravel to re-establish the road profile was $176,500. (Kamloops district). On June 20, high water wave action eroded the toe of a fill slope at Mushbowl, Clearwater Valley Road, 41.4 km north of the Highway 5 intersection. Restoration cost was $32,000.

On June 20, flooding from the Canoe River (Creek) caused a train derailment on the CNR mainline. One locomotive left the tracks at a washout near Canoe Creek. On June 21, in Clearwater 41 residents were evacuated plus another unregistered 12. In Barriere, 21 people were evacuated.

On June 20, the Lower Mainland went officially on flood alert as the Fraser River crept above 6 m at the Mission gauge. A combination of hot weather and heavy rainfall caused the Thompson River to rise above expected levels and flood some low-lying areas. Some homes in the southern Interior were evacuated on June 20. The Fraser River was expected to crest at 6.5 m in the next couple of days. *1) On June 20, near Kamloops the North Thompson River at McLure reached 5.21 m, surpassing the 1972 peak of 5.15 m. That day, five families (23 people) were evacuated from Clearwater along with the residents of three other homes in the surrounding region. Downstream near the town of Barriere, residents of five homes were on stand-by for evacuation. On June 21, 10 people from four families were evacuated in the Barriere area.

On June 21, in the District of Langley, floodwaters threatened six (First Nations') homes at 209th at Fraser and on 248th Street. A field beside a home was flooded. In the District of Chilliwack, flooding from a gully along the side of the property on Ferry Road threatened a home. Flooding occurred on Cornell Road, impacting the strawberry harvest. On Wellington and Skway roads (Skway First Nation), there was water on the road, potentially threatening 12 houses. North of Nicomen Island, the dyke cracked, size and length unknown, putting 12 houses at risk. Raising and widening of the dyke caused the crack. At Hope, bank erosion occurred on Landstrom Road, affecting one home plus 3 ac. (1.2 ha) of property. Near Pemberton, Meager Creek Road washed out at the 11-km mark, temporarily leaving 40 persons in 18 vehicles stranded

at the Forest Service recreation site. In the afternoon of June 21, the road was repaired. On June 21, high water levels damaged the metal binwall on Highway 1. Restoration cost was $18,777 (Kamloops district)

In the period June 21-25, two runoff events occurred in the Kamloops/Thompson River district. Extreme high water caused the washout of the Monarch River Park boat launch road (60 km from Vavenby or 80 km by forest road from Skwaam Bay). Restoration cost was $5,000. At Herald Park, 12 km east of the Trans-Canada Highway on Canoe Point/Sunnybrae Road, a portion of the Margaret Falls Trail washed out. Restoration cost was $5,000.

On June 22, a saturated sideslope slip occurred on the highway (7-Mile Sluff). Cost to remove debris and restore slope was $2,488. (Kamloops district).

On the morning of June 22, Fraser River gauge at Hope reached 9.34 m, closely comparing to highest level reached in 1997 of 9.53 m. On June 20, Wardle Street in Hope closed down due to high water and a Landstrom Road homeowner was battling seepage as the water table continued to rise. Flooding was also reported at the ditching along Highway 7, 1 mi. past Chawathil Road, the Peters Reserve area, Tom Berry Road, the Hope golf course and the Rotary Trails.

On June 23, water saturated the toe and fill slope of Dunn Lake Road 13 km south of Clearwater, causing the fill slope to fail with loss of one lane for about 100 m. Cost to restore the road to the pre-existing two lanes was $445,500. (Kamloops district).

On June 23, the Thompson River at the Overlander Bridge at Kamloops reached 9.24 m or 344.52 m, 24 cm higher than the 1997 peak. At Mission, the Fraser River with a reading of 6.19 m came close to its peak. It was expected to crest below 6.3 m. At Nicomen Island, a dyke slope was found cracking. On June 23, the cresting of the Thompson River forced the evacuation of 36 families in Clearwater and Barriere, affecting 89 people. A massive amount of water continued to pour through the Shuswap River system, as the Sugar Lake reservoir was full. Though the Shuswap River was going up, it was still significantly below 1997 levels.

On June 24, in Blackpool/Little Fort, the Little Fort ferry was not operational. In Barriere, 27 persons of four homes remained evacuated. In the Clearwater area, of the 63 people evacuated 48 remained away from their homes. On June 27, in the Blackpool/Little Fort area 16 people remained evacuated and 20 in Barriere.

On June 25, Shuswap Lake flooded the 15-ha Cottonwood Campsite. *2) Cottonwood Creek eroded the shoulder of Highway 6 between Salmo-Nelson, 90 (m ?) north of the Perrier Road intersection. Cost to backfill with rockfill was $3,000. The Slocan River flooded and eroded 10 m along shoulder of Highway 6, 0.84 km north of Passmore. Cost to backfill with rock fill was $3,000.

On June 26, heavy rains caused a washout and debris dam failure on Big Bar Road (Big Bar Ferry Dam repair). Cost of replacing plastic liner and culverts was $22,000.

On June 28, cool temperatures continued to slow the snow melt keeping water levels stable. Shuswap Lake continued to rise; some localised flooding occurred in parts of South Thompson River and Shuswap Lake basins. Though the Thompson River at Kamloops continued to drop slowly, 34 people remained evacuated from Barriere, Clearwater and Pierre's Point areas. In the Blackpool/Little Fort area-Clearwater, 25 people remained evacuated and in Barriere 11 persons remained evacuated.

On June 30, high water caused a road washout at the outlet of Deka Lake, km 0.3, Womack Road, Deka Subdivision. Cost to re-install the culvert, riprap and road surface was $160,000. High water washed out the road surface on Doman Road, inlet of Horse Lake, 100-Mile House. Cost to restore the road surface was $113,000. On June 30, high water washed out a number of bridges near 100-Mile House. Gustafson bridge on Buffalo Creek Road lost its banks, riprap and approaches. Restoration cost was $10,000. The approaches on Bates Road were cut, causing $12,000 damage. High water eroded the upstream bank adjacent to and under the Lily bridge on Canim Road. Cost to restore the bank and riprap was $12,500. High water also washed out the approaches to Houseman bridge and caused the loss of a wingwall. Restoration cost was $28,500. Saturated slope and road surface gave way at km 37.5 on the Canim-Hendrix Road, causing a severe drop in the entire roadway. Restoration cost totalled $750,000. Repair work and to maintain Eagle Creek detour road during work on the Canim-Hendrix slide repair was an additional $50,000.

On June 30, high water flows caused on the Tsqescen Road, Canim Indian Reserve No. 1. The Biss Bridge floated off its foundations, destabilising the structure. The approach fill washed out. The bridge acted as a dam, contributing to flooding adjacent areas. The cost to replace bridge, riprap and approach fills and washed out paved surface was $300,000. Cost to repair washed out road surface and severe road failure, reconstruct road base and repave was $91,000. On June 30, saturated road shoulders and high lake erosion caused road shoulder failures in three areas at km 3.5 on South Canim Road. Eroded toes of fill at the lake edge caused the shoulder drop-offs and pavement lane failures. The cost to replace shoulder and paved surface was $28,000. On June 30, high water eroded bridge ballast walls at Willowford bridge at km 1 on Doman Road and McNeill bridge at km 34.3 on Canim-Hendrix Road. Restoration costs were $11,000 and $8,000, respectively. On June 30, high water also washed the culvert inlet at Fawn Creek on Horse Lake Road and caused bank erosion. The cost to replace the failed culvert and riprap at inlet was $21,500.

At the end of June after running high for two months, the Bridge Creek rose up to the bridge level and flooded, cutting off Canim Lake Reserve residents. On June 30, highway crews put a stopgap measure in place allowing residents to continue crossing over Bridge Creek. On July 3-4, rains caused the river to continue to rise, completely flooding over the bridge as well as the road on either side with 1 ft. (30 cm) of water. In early June, some 45 people were evacuated from part of the Canim Lake Reserve. The creek was undermining the sand under the asphalt on either side of the bridge, causing the asphalt to sink. Because the bridge was built on a valley bottom, the material was easily erodable soft sand and silt. *3) Bridge Creek overflowed its banks in several other spots. It reached to within about 50 m from the Eliza Archie School. About 17 families relied on the bridge for access to their community. The other two roads into the reserve were both impassable due to mud and water.

In July, heavy rains coupled with rapid snowmelt caused erosion and increased bedflow, numerous small landslides and scouring of banks resulting in debris flow conditions.

On July 2, melt triggered a shoulder failure for about 20 m along Sandon Three Forks Road (Parapet Hill). The material slid into Sandon Creek, which had eroded toes of fills. The remaining road was unstable due to the vertical scarp left from the slide and was left less than two lanes wide. The cost to re-establish the road by filling from the creek level up to the road and armour the toes of the fills was $75,000.

On July 3 and 4, heavy rains followed by a torrential downpour on July 7 caused many small lakes in the Cache Creek area already swollen by the melting snowpack, to overflow. Buffalo and Bridge creeks and Horse, Deka, Sheridan and Bridge lakes all rose, causing spot flooding but no widespread damage. On Horse Lake, some waterfront homes had flooded basements. One of the residents thought the problem was caused by a dam blocking water coming out of Horse Lake to supply drinking water to 100 Mile House. The dam was opened on May 7, after which the lake's water came up 5 in. (12.5 cm). Ministry of Environment water engineer Bill Klopps disagreed. He blamed it on a combination of heavy rain, melting snowpack, saturated soils and a number of beaver dams on Bridge Creek, which slowed the flow of water. As of July 6 at the east end of Horse Lake, Doman Road was closed, as was Horse Lake Road around Atwood Creek. The Tsqescen Road over the bridge to the Canim Lake Reserve was down to single lane traffic due to flooding. At Womack Road, temporary pipes were installed to ease the local flooding.

On July 4 in the Two Creeks-Bridge Lake area east of 100 Mile House, a private bridge washed out and the septic fields of two cottages were impacted. About 60 residents in 15 homes in the Canim Lake Reserve near 100 Mile House only had four-wheel drive access after floodwaters submerged a bridge. The flooding was caused by significant rainfall in the Forest Grove, Canim Lake and Deka Lake areas and left over snowfall. (*The Vancouver Province*, July 8, 1999).

During the period July 5-12, a number of runoff-related events occurred on the Bonaparte-Egan FSR in the 100-Mile House district. A plugged 500-mm culvert at 2.2 km caused erosion of road surface. The restoration cost of the road, accessing residents and the Moose Lake Recreation Area was $1,500. At 2.4 km, Campo Creek flooded, causing the failure of the 610-mm culvert and road fill. The cost to remove the existing road fill, install a new 1,800-mm x 20-m culvert and road surfacing was $19,500. At 5.2 km, a 610-mm culvert plugged causing flooding and subsequent erosion of fill. The cost to remove the old culvert and fill material and install a new 1,800-mm x 20-m culvert was $17,500. At 6.5 km, the 456-mm culvert

plugged. The backed up water flooded the road surface and caused erosion of surface material. Restoration cost was $5,500.

On July 6, a debris torrent came down at an unnamed creek 1.6 km north of Avola on Messiter Station Road. It covered Messiter Station Road with mud, damaged a culvert and filled 600 m of ditch with mud and also affected three private properties adjacent and in proximity to it. The slide was triggered by water runoff on the mountainside, which in turn destabilised the ground. It resulted in a large flow of mud, rocks and debris down the hill and jumped the existing creek channel in several locations. The Carl Capps property above the road suffered the most damage, with the debris affecting the buildings and machinery. One shed had only the roof and a bit of wall sticking out of the mud. Mud also fanned out over the vacant bush/swamp land Gibson property below the road. *4) Around July 8, a mudslide closed the old Clearwater highway.

On July 8, debris piled against Bridge Creek bridge. The cost to remove and dispose of debris piles in Bridge Creek, which threatened the bridge structure was $20,000. On July 8, high water washed out riprap, road shoulder and bridge flares on Highway 97, 10 km north of Cache Creek. Restoration cost was $48,500.

On July 9, a debris torrent at 2.3 km on the Seymour Arm FSR destroyed the dam and water intake for the community of Seymour Arm (Salmon Arm district). Restoration cost was $25,000. The slide at Seymour Arm on Shuswap Lake, a slide took out road access and the water supply system to two homes on Bughouse Bay Road. A fly-over determined some seasonal homes were destroyed. On July 9, the road reopened. By the middle of July, a washout on Bughouse Bay Road covered approximately 200 m of roadway and destroyed the water supply to 120 users, homes and businesses.

On July 10, the Bonaparte River reached flood stage, having risen 13 cm since the previous day. In Cache Creek, sandbagging was underway at several trailer courts in low-lying areas of town. Municipal water supply and several bridges were also threatened. On July 11, creek and lake levels in the south Cariboo remained high and bridges were being monitored. Near 70 Mile House and 100 Mile House, several lakes were flooded. Though most routes were open, on July 10 some roads were still swamped. At the hardest hit area of Horse Lake near 70 Mile House, some 200 residents were pumping and sandbagging their homes but refused to leave. About 42 people remained cut off from their houses on the Canim Lake reserve by a submerged bridge.

In June-July, two runoff events caused damage in the Williams Lake-Cariboo district. In the Atnarko campground in South Tweedsmuir Park, high water of Atnarko River eroded campsites. The site access road to the Downing Park campground washed out and the water system pump and pressure tank were damaged by the high water.

On July 9, runoff eroded the shoulder and part of a lane of Highway 31, 3.85 km north of Tenderfoot Bridge (Gerrard Road washout). Restoration cost was $5,000.

On July 10, the retaining wall at km 24 on Loon Lake Road washed out, causing $65,500 damage. On July 10, Goat River flooded and eroded the toes and embankment fills of Highway 3 east of Goat River bridge for over 100 linear ft. (30 m). Cost of riprap along the toes of the embankment fill was $25,000. On July 10, 51 people remained evacuated.

On July 11, high water levels washed out fill behind the wingwall on Loon Lake Road with a restoration cost of $5,500. At 20 km on Loon Lake Road, the road washed out from saturated shoulders and heavy rain. Cost to replace the rock retaining wall was $39,000.

On July 13, west of Salmon Arm on Shuswap Lake at Pierre’s Point, flooding impacted three mobile homes. Three people remained evacuated. East of 100 Mile House, the Canim Lake Reserve remained cut off. The Doman Road Bridge (Biss Bridge) providing access to Canim Lake Reserve lands remained closed. At km 37 on the Canim-Hendrix Road, a slide caused the settling of the roadbed and road closure. The Doman Road had 45 cm of water on the road, impacting three families.

On July 13, saturated fill slope failed at the edge of the pavement at Hall-in-the-Wall, Highway 5, 39 km east of Clearwater, causing the loss of the shoulder, spillway and downpipe. Restoration cost was $36,600.

On July 14, the tunnel built to carry Holdich Creek under Highway 23 into Lake Revelstoke was plugged. Two slides on both the north and south side of the creek covered the highway. Total restoration cost was $5 million. (MOTH Region 3-Nelson Kootenays).

On July 13, debris from Horse Lake piled up and impacted the bridge along Bridge Creek. The cost to clean and remove the debris boom installed during the flood event was $4,500. (Skaday Boom, outlet of Horse Lake) On July 13, high water caused damage on Clearwater Valley Road north of the Highway 5 intersection. Floodwaters and debris plugged the pipe arch culverts at Spahats Creek at 10.25 km. Water flowing over the road caused the downstream embankment to fail. Two 12-ft. (3.6 m) wide by 100-ft. (30 m) long multi-plate structures washed out. One washed over the falls and the other lodged downstream, both damaged beyond repair. Cost to construct a bridge and approaches was $665,000. At Candle Creek, at 4.36 km, the culvert was unable to handle the heavy runoff. Overbank flows caused the collapse of the upstream lock-block retaining walls. The east lane was undermined and collapsed and 200 m of shoulder and fill were destroyed with the loss of a 6-ft (1.8 m) and 13-ft. (3.9 m) section of pipe. Restoration cost was $420,000.

On July 14, heavy rains caused a rock bluff on Highway 1 to fail 12 km north of Spences bridge at Kingsway curve. The cost to replace damaged guard-rail, road surface and ditches was $26,000. On July 15, high water and debris flowed onto Highway 12 near Lillooet. The cost to restore ditches and basin was $9,000.

On July 15, the bridge at km 51 on North Fork FSR washed out (Salmon Arm district). The cost to salvage and re-installation of the bridge was $125,000.

On July 15-16, the Tete Angela and Haines Creek water drainage experienced an abnormally high rainfall, estimated at 1:100+ flood, increasing the water flow in the channels to limits they could no handle. This could possibly have been compounded by rain-on-snow effect. Scouring of the downstream side caused the failure and eventual collapse of the bank. Dimensions of scoured area were 7 m wide, 2.3 m deep and 14 m long. Tete Angela Creek, a tributary to Taseko River, caused erosion damage to the diversion structure and containment berms. Cost to repair the diversion structure and berm, remove logjams and to re-establish the creek channel was $37,492 and $78,680 Ministry of Environment enhancement cost.

Between July 16-20, the Haines Creek watershed and surrounding areas experienced above normal rainfall. As a result of flooding, an accumulation of logs and debris created logjams approximately 5.5 km downstream of the diversion on Haines Creek, tributary to Chilko River. *5) In addition, fines and gravel from the eroding upstream streambed and banks had settled in front of log jams. As a result of the erosion, an estimated 3,500 m^3 of silt and fines were released into the downstream areas of Haines Creek and possibly the Chilcotin River. This would have a negative impact on fish, fish habitat and carrying capacity of flow in the stream channel. The soils in the lower part of the ditch downstream from Forestry Road were very erosive. According to C.A. Bergman, P. Eng, Senior Engineer Public Safety-Water Management, the problem was caused by the lowering of the silt at the downstream end of the kettle. The high flows during the past summer had cut through the hardpan layer. Cost to install three riprap weirs to stabilise the backcutting and further erosion of the channel bed and banks was $3,708.Cost of removal and cleanup of logjams in Haines Creek upstream of Taseko Road was $37,673.

On July 17, the Fraser River gauge at Mission reached 5.95 m, up from 5.94 m on July 16. On July 18, with flood alert beginning at 6 m., the Fraser River was creeping up to flood warning levels again. High flows on the Illecillewaet River washed out 70 m of dyking on the left bank and 20 m on the right bank. Near Sicamous, high water on Shuswap Lake breached sandbag dykes on Adams Lake Band land, impacting Sandy Point Resort. Flooding affected an undetermined number of recreational campers and also impacted six homes in Sicamous proper.

Near 100 Mile House, Hood's Hollow and Buffalo Creek/Bridge Creek impacted two homes, forcing evacuation of both. Taseko Road was under water. Access to approximately 500 people at the Nemaiah Reserve and 50 others in the area was being controlled at 47 km. A washout of Highway 23 between Revelstoke-Mica Creek temporarily stranded 200 people. The highway reopened using a ministry of highways contracted ferry to bridge the washout. The initial (repair?) cost was estimated between $1.5-2.5 million.

During the period June-August, two high water-related events occurred in the Kamloops Thompson River district. Extremely high water on the Adams Lake and Adams River system caused the washout of several km of trail and the failure of a bridge at Hiuihill Creek in Roderick Haig-Brown Park, 64 km east of Kamloops on the Squilax-Anglemont highway and Holding Road. Cost of reconstruction of one bridge, including new footings and the reconstruction of several km of type 2 trail was $50,000. Extremely high water on the Shuswap Lake system caused the undermining of several concrete table bench bases. Restoration cost was $1,500.

In July, four runoff-related events occurred in the Kamloops (North) Thompson River district. High water on Shuswap Lake eroded Shuswap Marine Park campsites at Cinnemouson Narrows, Four-Mile Creek, Encounter Point and Anstey View. At Four-Mile Point Marine Park, bridge abutments and a trail washed away. Total restoration cost was $5,000. High water levels on the Thompson River caused damage to Goldpan Park campsites, 7 km south of Spences Bridge, and Juniper Beach campsites, 19 km east of Cache Creek both on Highway No. 1. Restoration cost were $5,900 and $1,750, respectively. High water on the Stein River damaged abutments of the first cable car crossing site 13 km from the trailhead in the Stein Valley Park (Nlaka'pamux Heritage Park) west of Lytton. The cost of rebuilding the platforms and abutments on both sides of the Stein River was $8,600.

In July, six high water events occurred in Wells Gray Park. Nn July 8, after rains washed out the main road into Wells Gray Provincial Park about 150 campers were temporarily stranded. The road washed out at Spahats Creek, some 20 km north of Clearwater. About 20 m of the Clearwater Valley Road had disappeared after a debris torrent blocked a culvert. The subsequent water build-up washed out the road that serves as main access to the park. Highway crews hoped to have a temporary bridge in place on July 10 at the latest. *6) Floodwaters and spring high water caused erosion, a mudslide and washouts on the Clearwater River Road on the west side of the Clearwater River north of Clearwater. Trail facilities were flooded and destroyed. The cost of reconstruction of road surface, ditches and culverts, riprapping eroded streambanks and realignment of river direction and trail reconstruction totalled $115,000. Floodwaters washed away the Trout Creek (horse/hiking) bridge on the Flat Iron Trail. Cost to rebuild the bridge and construct and repair trails to the facility with helicopter assistance to provide materials was $15,000. Floodwaters washed away the Moul Fall viewing platform and trail located off the Clearwater Valley Road at 24 km. The cost to rebuild the platform and reroute and reconstruct trails and stairs at the falls facility was $15,000. Floodwaters also destroyed the Hemp Creek (horse/hiking) bridge on the Flat Iron Trail. The cost to construct a new bridge and rebuild and reroute trails to the new bridge site was $15,000. Floodwaters washed away and destroyed the Spahats hiking bridge on the Clearwater River Trail and parts of the trails. The cost to construct a new bridge and reroute and repair trail damage was $10,000. Floodwaters and spring runoff caused erosion damage to the road surface and undermined the bridge abutments on the Battle Mountain access road located at 30 km on the Clearwater Valley Road. Cost to stabilise bridge abutments and road repairs was $21,000.

Other runoff related events and restoration costs in the Kamloops district included: Trash racks in Salus (?) Creek on Highway 99 about 30 km east of Lillooet: removal of debris to make trash racks functional ($13,000); Canim Place Road at 1 km: replace flume and restore failed embankment ($11,200); Squilax-Anglemont Road at Mud Creek, 20 km east of Chase ($10,000); Squilax-Anglemont Road at Ross Creek, 40 km east of Chase ($650,000); Highway 97A, 5 km south of Sicamous ($975,000); Adams Lake ferry landing: ($5,000); Botanie Valley Road washout ($94,000); Highway 12 at Km 11 slide ($273,000); Highway 1 at Gladwin washout ($3,000); Highway 8 at 7-Mile ($20,000); Seton Portage No. 188, Shalalth ($8,490); Rivermount Dyke at Clearwater ($5,500); Buie St. Dyke at Savona ($19,413); Dey's Court Dyke at Savona ($4,500); Lumby-Mabel Lake Road, 30 km north of Lumby: ($55,000); Highway 6, 1 km of Lumby: ($7,000); Sunnybrae-Canoe Point Road, 25 km northeast of Salmon Arm ($20,000); Enderby-Mabel Lake Road at Dale Slide, 20 km east of Enderby: ($80,000).

Summary of other runoff caused events and estimated restoration costs: (North Vancouver Lower Mainland District): Coquihalla Park: Trail flooding and washout ($20,000); Skagit Valley Park: Washout of Chittenden bridge abutments. ($40,000); E.C. Manning Park: Log jams flooding Sumallo day-use area. ($20,000); Kilby Park: flooding and washouts day-use area. ($10,000); Cultus Park: International Trail

washed out: ($15,000; Golden Ears Park: hiking trail, Golden Ears Trail, Alouette Trail and Lower Falls Trail washed out. ($20,000 each?); Pinecone/Burke Mountain Park: Trail and road washout/flooding Widgeon Creek Trail. ($7,000); Davis Lake Trail: washout and flooding of access road. ($25,000); Rolley Lake Park: trail washout and flooding day-use area ($25,000). Mount Seymour Park: bridge and trail washout Scott/Goldie Trail ($15,000); Mount Seymour and Cypress parks: vegetation damage ($10,000).
---
*1) This crest compared with a peak of 6.35 m in 1997, 7.1 m in 1972 and 7.54 m during the big flood of 1948. The 280-km system of river dykes in the Lower Mainland built since the 1940s was almost completely designed to handle levels as high as the great flood of 1894, 7.92 m (*The Vancouver Sun*, June 21, 1999).

*2) This campsite also flooded in 1977 (Flood Report June 25, 1999).

*3) Before the flooding, there was a tentative plan in place for the following year to completely rebuild the bridge, raising it and making it wider (*100 Mile House Free Press*, July 7, 1999).

*4) On August 9 during a localised rainstorm, another debris flowed on a slightly different course upstream covered the road in the same place. Further occurrences have happened since.

*5) The Haines Creek diversion ditch was constructed to divert water around two parcels of private property. The ditch is part of the Haines Creek and Eleven Sisters Lake chain.

*6) In 1997, about 500 people were stranded in Wells Gray Park by a washout.

August 1999
Source: Provincial Emergency Program, File FAV00121, August 3, 1999.
Details: Early August, a backflow in the Exlou area south of Barriere caused flood damage to several homes on the opposite riverside of Highway 5. It resulted from a culvert allowing Thompson River water to pass under the highway and rail line into this area whenever the river levels rise significantly.

November 13-14, 1999
(Rain-on-snow).
Precipitation:
Source: *The Vancouver Sun*, December 4, 1999.
Details: A major rainstorm on November 13-14 caused high waters on the Bull River and threatened the Aberfeldie Dam near Cranbrook. *1) Heavy rain and melting snow pushed the rampaging river to almost 2 m over the sill of the old dam. The water was so high that BC Hydro began 24-hour surveillance and alerted downstream residents.

By early December, the water level in the reservoir had dropped to being even with the sill of the dam but daily monitoring of reservoir levels and weather conditions continued. Work to strengthen the dam was about 75% complete.
---
*1) The 32-m-high concrete dam was built in 1954 by the East Kootenay Power Company and was acquired by BC Hydro in 1967.

December 15, 1999
Source: *The Vancouver Sun*, *National Post*, December 16, 1999.
Details: On December 15, the E-Comm centre, the new $144-million facility that handles 911 calls was put out of operation. After the backup operation in the same building also failed, this forced an evacuation of about half the 30 emergency dispatch workers to the old 911 office at the Vancouver police station on Main Street. People in the Greater Vancouver area were left without 911 service for about an hour. *1)
---

*1) E-Comm, which only went into service in June, is a state-of-the-art facility attempting to consolidate and streamline all 911 services in the Lower Mainland, drawing police, fire and ambulance calls to the same site for the first time. During the previous six months, it had handled 554,000 calls but had come under criticism because of a series of technological problems (*National Post*, December 16, 1999).

November 16, 2000

Source: *The Vancouver Sun*, November 17, 2000; Ministry of Transportation and Highways, Rockfall notification summary.

Details: On November 16, a woman suffered non-life-threatening injuries after she was caught in a rockslide 9 km south of Squamish. Her vehicle was severely damaged by falling rock from a bluff above the highway. According to RCMP Sgt. Gary Brine, the slide that occurred about 5 p.m., might have been connected to a crew working on a rockface in the area. The slide closed the highway for just over an hour. Two of the three lanes then opened while crews continued working through the night to clear the debris from the road.

The 200 m^3 of rock that Ministry of Transportation and Highways reported to have come down the same day onto Highway 99 (at 37.0 km) in the Watts Point area, probably refers to the same event.

December 16, 2000

(Rain-on-snow).

Source: *The Vancouver Sun*, December 24, 2000.

Details: On December 16, runoff from heavy rains following a snowfall caused creek banks to collapse in several places around Stoney Creek. According to a Burnaby city staff report, SkyTrain construction was partly responsible for the flooding and erosion. The report notes that the runoff was caused by a storm that reached the intensity of a 1:50-year rainfall that day. The event may have caused damage to eggs laid in the creek by salmon spawning in the autumn and early winter.

February 13, 2001

(Fatal avalanche).

Source: *The Province*, February 15, 2001; *The Vancouver Sun*, February 26, 2001; CBC Newscasts February 14, 2001.

Details: On February 13 at about 2:15 p.m., a small avalanche in back country near the Fernie Alpine Resort caught five skiers, killing two 24- and 26 year old sisters from Stockholm, Sweden. The group of 13 Scandinavian had been backcountry skiing without a guide in the Lizard Range on the south side of the mountain shared by the Island Lake lodge and Fernie Alpine Resort. They had hiked to the ridge behind Island Lakes property were attempting to cross the Easy Street shoot when another group of skiers apparently triggered the slide from above. Five of the Scandinavians who were in the gully under a steep bowl of snow at the time were swept down the mountain slope of more than 45º.

Two skiers, injured by the slide were flown out before nightfall while nine others were forced to spend the night on the mountain in –15º C temperatures. They were airlifted out at daybreak next day. The skiers involved in the slide were inexperienced and ill equipped to be skiing in the backcountry. According to the Canadian Avalanche Centre, the avalanche risk was rated as considerable.

February 18, 2001

(Fatal avalanche).

Source: CBC Newscasts February 20, 2001.

Details: On February 18, an avalanche in the Monashee Mountains killed a British skier.

February 24, 2001

(Fatal avalanche).

Source: *The Vancouver Sun*, February 26, 2002; CBC Newscast, February 26, 2001.

Details: On February 24, an avalanche near Invermere at Francis Creek in the Bugaboo mountain range caught two skiers, killing one man and injuring the second one. The victims were on a private ski touring trip, reportedly involved in heli-skiing.

November 19, 2001
Source: *Campbell River Courier-Islander*, November 21, 2001.
Details: On November 19, Campbell River airport recorded 42.4 mm of rain. The Campbell River storm water control was challenged. The corner of 12th Avenue and Ironwood was flooded.

December 19, 2001
Source: *Times Colonist*, December 18, 2001.
Details: On December 16, the rains were so heavy that the reservoir rose 0.82 m in the 24 hours ending 7 a.m. on December 17. Around the middle of December, more than 217 mm of rain fell over the Sooke Lake Reservoir in five days. The level of Greater Victoria's main drinking water reservoir rose rapidly, resulting in an 18.6% increase in storage. This made the reservoir 76% full in the early rainy season. *1) On December 17, the reservoir contained 9.34 billion gallons, compared to the 10-year average of 9.38 billion gallons.

By December 18, the Victoria International Airport, which receives far less than the Sooke Lake Reservoir, charted 181.9 mm of rain following the heavy rainfall on December 15-16, compared to the normal of 88.9 mm. In the capital region, plugged storm drains caused some minor flooding of yards and a few basements.

---

*1) the previous winter's lack of rainfall led to the severe water restrictions that started on April 2.

January 7, 2002
(Rain-on-snow).
Source: *Times Colonist*, January 10, 2002; CBC Newscasts, January 7, 8 and 9, 2002.
Details: On January 7, a "Pineapple Express" with wet and unseasonably warm weather caused flooding, mudslides and avalanches. In Chilliwack, 20 families were evacuated. The Trans-Canada Highway was closed west of Revelstoke because of avalanche danger. Duffey Lake Road was closed 10 km north of Mount Currie because of heavy avalanche danger. Highway 3 closed between Creston-Salmo. On December 8, the westbound lane reopened; the next day the highway reopened to traffic both ways.

Late on January 7, a mudslide closed the Trans-Canada Highway between Hope-Bridal Falls. Around dinnertime on January 7, a second, smaller slide came down (Patterson Creek?) and blocked nearby residential Johnson Road. Five families were evacuated. The road was covered with a 1-m deep layer of granite boulders, gravel and mud. The deep ditch between the mountain and the street could not handle a new creek fed by heavy rains and rapidly melting snow. One of the residents, through whose yard the slide came down said it sounded "like a train coming through the yard." It swept tonnes of rock and wood debris across the road to the front doors of several houses. Five homes appeared to have suffered the most structural damage from the slide. According to Hope Mayor Gordon Poole, the water coming down off the mountain each time seems to come down in a different area. As eight creeks run year-round in a rather small area, it would be hard put in a diversion. *1) Poole estimated the cost of emergency response and repair of the road at about $100,000. On January 7 and again on January 8, the Cowichan Road was closed due to flooding just west of the junction with Highway 1.

The rains brought an end to the longest and most severe water restrictions in Greater Victoria. With the Sooke reservoir finally full again (93%; later in the spring the flash (splash?) boards would be put in place again to bring it up to 100% to add 2 m depth) the water restrictions declared on April 1, 2001 were lifted. In spring, construction would start to raise the dam to give the reservoir a higher carrying capacity. It was the first time since April 2000 that water was flowing over the dam.

---

*1) In 1996, Johnson Road was hit by a slide in the same area. Mayor Poole noted the only way to prevent a recurrence of slides would be the building of a massive dyke between the street and the mountain Despite suggestions by some residents that past logging operations on the mountain may have triggered the slide, a Chilliwack–based forests ministry official said the slide originated on a slope of the mountain that had never been logged. Nearest logging was several hundred metres away from the point at which the slide began and had been logged in 1969 (*Times Colonist*, January 10, 2002).

January 14, 2002
(Fatal avalanche).
Source: *The Province*, January 15, 2002
Details: On January 14, an avalanche at Brewer Creek, about 15 km southwest of Invermere, killed a snowmobiler.

January 25, 2002
(Fatal avalanche).
Source: CBC newscasts, January 26, 2002.
Details: On January 25, an avalanche north of Pemberton buried three heli-skiers. Two were rescued and one died.

February 9-10, 2002
Source: CBC newscasts, February 11 and 12, 2002.
Details: On the afternoon of February 9, an avalanche buried and killed a Williams Lake man snowmobiling in the Horsefly area. His body was recovered on February 10. (Eureka Mountains)

On February 10, an avalanche near Revelstoke buried and killed two heli-skiers; one American and one European. This brought the number of people killed by avalanches this winter in British Columbia to nine.

March 18,2002
(Fatal avalanche).
Source: *Times Colonist*, March 20, 2002
Details: On March 20, a backcountry avalanche killed a 57-year old American skier. The man was caught in a snowslide in the Dogtooth Mountain Range outside the Kicking Horse Resort near Golden. Three others were not injured. The victim was wearing a locator beacon but was found dead under more than a metre of snow.

March 2002
Source: *Times Colonist*, March 21, 2002
Details: Twice during March, arctic high-pressure systems across Vancouver Island and the Lower Mainland caused snow and chilly temperatures. A three-day coldsnap ended on March 9. A second one arrived on March 15 and lasted till about March 21. A total of 530 new daily cold temperature records were set across British Columbia. About 40 of British Columbia's low temperature records for March were set on Vancouver Island.

On March 17, Port Hardy reached –3.5º C breaking the previous record of –2.8º C set in 1971. On the afternoon of March 20, Malahat recorded a temperature of –4º C and the Victoria airport +1º C.

Overnight March 19-20, the Victoria airport recorded 4-5 cm of snow. Shawnigan Lake reported 15 cm of snow. Between March 1-21, the Victoria airport recorded 19 cm of snow. *1)

---

*1) In a typical March, Greater Victoria records a total of 3.7 cm of snow, During the past decade, the total snowfall ranged from 0-11.4 cm. The most snow fell in March 1951 with 31.2 cm. On March 3, 1960, the greatest amount of snow in one day was recorded with 21.3 cm.

April 13-14, 2002
Source: *Revelstoke Times Review*, April 17, 2002; CBC newscasts April 14, 15 and 16.

Details: On April 13-14, snowslides came down 12 km west of Revelstoke onto the Trans-Canada Highway in the Three Valley Gap area. During the previous couple of days about 80 mm precipitation had fallen in the area. On the night of April 13, 83 mm of rain was reported. A snowstorm that had dumped 0.5 ft. (15 cm) snow on April 13-14, was followed by warm weather. Minister of Transportation and Highways Judith Read called the area, locally known as the 'killing zone,' a "challenging, difficult and dangerous stretch of road." According to Mark McKee, chairman of the Revelstoke for a safe Trans-Canada Highway Society, "that area has been susceptible to mud and rock (slides) and it is susceptible to snowslides."

On April 14 just after 9 p.m., one of the slides hit a front-end loader clearing debris from an earlier slide. A huge section of earth, rock and trees tore loose from the steep embankment bordering the south side of the highway. A senior foreman highway maintenance crew (contractor) working in the darkness was missing. The slide swept the victim into Clanwilliam (Summit) Lake. The 52-year old man had been working on a VSA Maintenance stabilisation and cleanup operation at the scene of a previous small mud and rockslide that blocked the drainage ditch and spilled over the road. The relatively small landslide was 35 m long, 40 m wide and on average 3 m deep on highway.

On April 15 at 6 p.m., the highway was expected to reopen to single-lane traffic. On April 16, the search for the body was called off indefinitely due to mud and ice in lake. The rescue efforts were hampered at the time due to the risk of another slide coming down. The entire section of the highway between Revelstoke-Three Valley was closed to traffic until it could be determined that the area was safe for cleanup crews and emergency personnel to enter again.

The highways department also closed off Highway 23 North between Revelstoke-Mica Dam because of a series of slides along that stretch of road.

May 21, 2002
Source: *Times Colonist*, May 23, 2002; *The Golden Star*, May 29, 2002.
Details: On May 21, two debris flows came down on the Trans-Canada Highway just west of Glacier National Park. *1) During previous springs, the exposed surface was eroded and lubricated by the combination of rain and melting snow, creating a mountainside gash about 2 km long and 0.5 km wide, which continued to ooze each spring. (see: January-Spring 1997 event). Depending on the rate of melt of the snowpack and concurrent rain events, the rate of oozing varied. Culverts were placed under the highway to divert the mud into the Beaver River. When the catchment basin and culverts are unable to handle the flow, the mud the mud would spread over the road and highway.

Around May 22, heavy rains occurred throughout British Columbia. A series of mudslides, including one on the morning of May 22 forced the closure of the Trans-Canada Highway in the Interior for part of the day. No one was hurt in the slides, which took place between Revelstoke-Alberta border.
---
*1) Helicopter pilot Don McTighe first observed slumping on Heather Mountain in January 1997. (*The Golden Star*, May 29, 2002).

June 2002
(Spring runoff/flooding).
Source: *Times Colonist*, June 4 and 19, 2002; *The Vancouver Sun*, June 20, 2002.
Details: Early June, melting snowpacks and recent rain caused Nicola Lake to rise. This forced Ministry of Water, Land and Air Protection officials to release water from the lake through Nicola Dam into the Nicola River. This caused the river that runs through Merritt to flood. Nearly 40 homeowners sustained flood damage. *1) To prevent further flooding, some 16,000 sandbags were placed at "strategic locations" along the river.

On June 18, the Fraser River at the Mission Bridge reached 5.9 m on the flood gauge. On June 19, after the Fraser River at Mission reached 6 m the provincial government issued a flood advisory. *2) The highest levels since 1999 only resulted in flooding of some farm fields. In Fort Langley, some flooding

occurred on 88th Avenue. In the Agassiz area, one of the most flood-prone areas of the Fraser Valley, groundwater was seeping into Agassiz Slough.

Following heavy rain on June 18, the Elk River rose to very high levels but was receding two days later.

---

*1) Flood victims in Merritt blamed the provincial government for failing to act sooner to protect their properties. One of the residents, who lives along the lake said that the ministry seemed more concerned about the protection of fish in the lake and the interest of ranchers who want the lake well-supplied for irrigation. According to Mayor Bob Blaird, said the problem happens every year and the province has full control of the dam, not the city. Ministry spokesman Brian Symonds noted that the concerns of the residents were valid and that the ministry would be doing an assessment of its recent decisions (*Times Colonist*, June 4, 2002).

*2) At this point the riverbanks are nearly full and daily dyke patrols begin. Fraser River flood officials do not take any action until and unless the river reaches 6.5 m. Although the number of cars and passengers allowed aboard the Albion ferry will be reduced when river levels reach 6.3 m, the ferry will not stop carrying traffic.

January 2-3, 2003

(Storm surge/tidal flooding).

Source: *Nanaimo Daily News*, January 4, 2003; *Times Colonist*, January 4 and 5, 2003; *The Vancouver Sun*, December 31, 2003

Details: Overnight January 2-3, high winds knocked out power to 40,000 homes in southern Vancouver, Duncan and the Gulf Islands and caused millions of dollars damage. Early on January 3 on Vancouver Island, gusts peaked at 67 km/h. On the Brooks Peninsula, gusts reached a hurricane force of 150 km/h. The lighthouse near Tofino recorded winds of 107 km/h and in Comox they topped at 89 km/h.

The storm left thousands of BC Hydro customers on Vancouver Island from Victoria to Nanaimo without power for several hours. At the peak, over 30,000 customers were cut off. Much of the damage was concentrated in the Duncan, Cobble Hill, Shawnigan Lake and Lake Cowichan areas. Hundreds lost power on Galiano, Mayne, Pender, Saturna and Saltspring islands. Between Sooke-Jordan River, about 2,000 people lost power throughout January 3.While Nanaimo saw about 250 customers without power, Duncan was the hardest hit community with about 27,000 customers losing power. Wind-toppled trees caused most interruptions.

A freak gust of wind measured at more than 100 km/h toppled five storey-high coal loaders in Delta at Westshore Terminals on Roberts Bank. Two operators were injured and had to be rescued. One of loader's arms was pushed against the side of a ship while the other was partially submerged. Ray Dykes, a representative of Westshore Terminals, said that in their 32 years of operation, "there has never been anything like it."

Near Lower Lantzville, heavy rains, strong winds and high tides measuring more than 15 ft. (4.5 m) caused flooding after Knarston Creek backed up and overflowed its banks onto nearby properties on Eby Road. *1)

In Duncan, about 14 people were evacuated from their homes on Cowichan Bay Road because of flooding. On January 2, Highway 14 was closed between Sooke-Jordan River after logs and debris swept ashore had blocked it. On January 3, flooding was still causing problems in Gyro Park and neighbourhoods along Cadboro Bay. The high tide on January 2 was the highest ever-recorded in Victoria. At 11:18 a.m., it measured 3.77 m at Environment Canada's station at the foot of Broughton Street. *2) The record level was caused by a combination of higher than usual high tides and the high gusting winds.

Early on January 4, a second windstorm that was not as strong as the one 24 hours earlier did not create any additional problems for BC Hydro crews. The strongest winds were reported off Discovery Island about 5 a.m., blowing from the southeast at 65 km/h

with gusts up to 80 km/h. Lighthouse stations on the west coast of Vancouver Island reported winds of around 70 km/h. The lighthouse near Tofino recorded 87 km/h. About 10 a.m. on January 4, heavy rain drenched Greater Victoria and elsewhere on Vancouver Island. Cowichan/Duncan RCMP received many calls about downed trees. "It's raining like crazy," commented an RCMP spokesperson. Heavy rain in the Comox Valley caused the rivers to rise. The rain and winds of 30-60 km/h were expected to ease around noon on January 4.

---

*1) Since Knarston Creek is classified as salmon habitat, dredging to prevent flooding is prohibited under environmental regulations. (*Nanaimo Daily News*, January 4, 2003).

*2) Tides have been recorded here since 1895. The previous record was set in December 1969 at 3.71 m. (*Times Colonist*, January 4, 2003).

March 10-12, 2003
Source: *Nelson Daily News*, March 12, 2003
Details: On March 10 at 1:30 p.m, an avalanche came down west of Rogers Pass in Glacier National Park. The slide barely missed two vehicles and closed the Trans-Canada Highway for several hours. According to parks spokeswoman Doreen McGillis, "A semi and a car hit the spray of it." The snow was 1 m deep across a 30-m section of highway. Crews removed enough snow to temporarily reopen one lane to alternating traffic at 2 p.m. but the highway was later closed for the rest of the afternoon. After a second slide hit the Trans-Canada Highway in as many days, the highway was reportedly closed east of Revelstoke for an additional 24 hours.

May 30, 2003
Source: *The Province*, June 2, 2003.
Details: On May 30, a rockslide at Three Valley Gap near Revelstoke killed a 66-year old transport truck driver. The truck, which was hauling a load of lumber, was westbound on the Trans-Canada Highway when the slide forced it into Three Valley Lake. RCMP divers recovered the victim's body on the morning of May 31. The highway, covered with boulders and other debris, was closed until the evening of May 31.

Summer 2003
Source: *Campbell River Mirror*, January 2, 2004.
Details: Around July 1, the Fraser River peaked at one of the lowest stages since record keeping began 90 years ago.

During most of the summer, a large Pacific high-pressure area anchored near the coast kept "weather" away from British Columbia. In July in the Interior, some weather recorded temperatures up to 40º C. In Kamloops, temperatures rose above 30º C on 19 days in July and 20 days in August. Kelowna recorded the driest June-July-August period since record keeping began in 1899 and also set a record with 44 consecutive rainless days. With only 8.2 mm of rain, Victoria had the driest summer since record keeping began there in 1914.

In early August, forest fires leveled Louis Creek and threatened Barriere and suburbs of Kamloops. Dozens of homes and businesses, including two sawmills burned to the ground. Around August 16, lightning caused more wild fires. A fire started in Okanagan Mountain Park south of Kelowna burned large areas. On August 23, burned some 250 homes near Kelowna and forced the evacuation of about one-third of that city's population. In total, more than 50,000 British Columbia residents were evacuated because of the fire threat, making it the second largest evacuation in Canadian history.

October 16-22, 2003
(Rain-on-snow).

Source: *Times Colonist*, October 20, 2003; *Campbell River Mirror*, January 2, 2004; *The Province*, December 15, 2004; January 13, 2005; *The Vancouver Sun*, November 29, 2003 and December 15, 2004; Ministry of Environment files; Allan Chapman. River Forecast Centre post-event review of the October 16-20 coastal flood event; David Jones, meteorologist Environment Canada, Interview CBC January 18, 2005.
Details: On October 16, an intense front of warm Pacific origin moved into the British Columbia south coast. It stalled over central Vancouver Island and the Howe Sound, Sunshine Coast, and Squamish-Pemberton areas, bringing high rainfall magnitudes over the four-day period of October 16-19. *1) In addition, the freezing elevation rose that resulted in the melt of most of the accumulated snow in high elevation areas affected by the frontal rain. The system coming directly from the Tropics and thus carrying more moisture and heavier rain, it was dubbed a "tropical punch," one step beyond the "Pineapple Express." It dumped a year's worth of rain in four days on the Sea-to-Sky corridor (David Jones, interview CBC January 18, 2005). The unusually heavy rain produced record rain-on-snow peak flows. In some areas, "monsoon-like rains" reached 40 mm per hour. The steady, intense downpour was perhaps the heaviest deluge to strike the west coast in more than 200 years. Damage was estimated in the tens of millions of dollars. (*Campbell River Mirror*, January 2, 2004).

On October 16, Victoria recorded 169 mm of rain, while Squamish reported 369 mm in the four days between October 16-19. *1) Elaho River and the Spuzzum Creek snow pillow recorded 157 mm and 169 mm, respectively, of rain by midnight on October 16; 206 mm and 243 mm in 36 hours by noon the next day; 260 mm and 320 mm at 9 p.m. The rain continued and by 9 a.m. on October 18 at 9 a.m., the Elaho has accumulated 419 mm of rain in 57 hours, or an average of 7.35 mm/h. Spuzzum Creek had recorded 300+ mm at the time this gauge stopped working. By October 18 at midnight, Elaho had recorded 548 mm of rain in three days, for an average of 7.6 mm/h for 72 hours. In addition, between October 16-18 about 80 mm of snow water content had melted from the Upper Squamish snow pillow.

The storm caused widespread flooding in Squamish and Pemberton (*The Vancouver Sun*, November 29, 2003). On October 18 around 3 a.m., floodwaters destroyed the road and rail bridges over Rutherford Creek, between Whistler-Pemberton on Highway 99. *2) Three vehicles went off the highway into the creek, killing five occupants. A Volvo containing two bodies was recovered the next day. The SUV carrying two of the victims was never located. One occupant of the vehicle managed to swim to safety. On December 14, 2004, more than a year later, during routine dredging work another vehicle was uncovered with one body inside. *3)

Parts of the highway north of Whistler also washed out. Provincial authorities set up emergency centres in Squamish and Pemberton, with 361 people signed in at the Squamish center by the afternoon of October 22. Early damage estimates from the floods were estimated in the $20-30 million range. Pemberton declared a state of emergency and implemented rationing for gasoline and other necessary supplies. Basic supplies were unable to reach the community for five entire days. *4) It took workers from the Ministry of Transportation almost a week to establish a temporary road bridge into the town.

By October 19, the water level on the Lillooet River had risen 4.8 m and the town of Pemberton was under water. Road and rail access was completely severed when Rutherford Creek washed away the Highway 99 bridge and the BC Rail trestle crossing the creek collapsed and was severely damaged. The high volume of water hitting the right sides of both bridges caused the riverbank to erode away.

During the flood event, nearly 800 people were forced from their homes in Squamish, Pemberton and Mount Currie. About 500 of Mount Currie's 1,700 residents were evacuated. Though water levels had subsided substantially, on the morning of October 19 several homes in Mount Currie were still surrounded by water. Some of the 317 people evacuated from Squamish were expected to return home on October 22.

Whistler was cut off in both directions after flooding along the Cheakamus River near Cheakamus Canyon took out 200 m of pavement south of the resort community. Currents took out the south shoulder, south lane and eroded part of the north lane, leaving only one-third of the pavement remaining. Other areas washed out with shoulder damage.

BC Rail estimated flood damage to its rail lines "in the millions of dollars" in the Cheakamus Canyon and Rutherford Creek areas. Near Chance Creek, Cheakamus River south of Daisy Lake undermined the track causing a large section to collapse into the water.

The Cheakamus River near Brackendale peaked on October 18 at 7 a.m. while the peak discharge on the Squamish River at Brackendale did not occur till about 9 hours later at approximately 4 p.m. The peak stage on the Squamish River at Dryden Creek, a few km downstream in the Squamish townsite, occurred at 8:30 p.m. The staff gauge recorded a maximum stage of 33.0 ft. The discharge for this maximum stage was estimated to be to be 4,300 m^3/s. Of this, 71% of the discharge was from the Squamish River and 29% from the Cheakamus River. The Cheakamus River continued a very high discharge, over 2,900 m^3/s, until noon on October 19. (Chapman). By midnight October 19, the Squamish River near Brackendale was at 1,100 m^3/s, 36 % of its peak. The river's stage at Dryden Creek had receded 9.5 ft. to 23.5 ft. The Lillooet River was at 584 m^3/s, or 38% of its peak 22 hours earlier. Through October 20-22, the rain continued and the Squamish River experienced secondary peaks of 1,570 m^3/s at midnight on October 20 and 1,260 m^3/s on October 23 at 4 a.m. The Lillooet River recorded secondary peaks of 697 m^3/s on October 21 at 3 a.m. and 836 m^3/s on October 23 at 4 a.m. Following these secondary peaks, the rain subsided and stream discharges receded steadily.

During the heavy rainstorm on October 16 –17, debris flows occurred on Field Creek, Carratt Creek, and Eng Creek on the east side of Hatzic Valley just east of Mission. Floods with high sediment loads also occurred on many neighbouring streams, including McNab, Saporano, Pattison and Dale creeks. None of the existing houses were damaged but some minor boulder impacts were recorded and liquid debris after-flow and floodwaters caused flooding and extensive deposition of large organic debris, gravel and sand-size sediment. *4)

The storm affecting the area had two peaks: one on October 16 at around 8 p.m. and another on October 17 around 7 p.m. On October 16, about 8 p.m., very loud but distant rumbling sounds were heard that lasted all night. By the next morning, water and sediment from Carratt Creek had spilled over the access road to the Virtue property. Carratt Creek was noted to be dry at the time.

On October 17 around 7 p.m., when the rainfall intensified again, extremely load crashing and banging sounds were heard coming from Field Creek. By the morning, debris was found all over the Virtue property and gravel-sized material backed the east side of their house.

At least two debris flow surges descended from Eng Creek: one on October 16 at about 8:30 p.m. and another one on October 17 at 6 p.m. On October 16 at 7 p.m., the Ramaseder home lost power. At 8:30, Ms. Ramaseder observed about 50-cm deep mud streaming by the house at "running speed." Organic materials including large logs, some of which were cut, were deposited first, followed by mineral sediments. At Sylvester Road, tree trunks were piled up some 10 m high. The property sustained extensive flooding damage. On the evening of October 17, another flow reached the property. On October 16, at about 10 p.m., the Hambalek house "was shaking as if an earthquake." On October 17 at about 5 p.m., the ground was again felt shaking when a debris flow deposited some 15 cm of mud and sandy debris on the Hambalek property, damaging the pitch-and-put six-hole golf course and filling the workshop with sand.

On October 16 at about 8:30 p.m., Marion Lund heard a sound she described as a "freight train." The power was out, and muddy water, silt, sand and organic material started pouring through their east (uphill) facing back door. Throughout the night, a backhoe was used to keep debris away from the house. On October 17 between 2:30-3 p.m., muddy water broke through a pushed-up berm and again surrounded the building. At about 6 p.m., the Lunds noted the ground shaking and left the building.

On October 17 between 5 and 6 p.m., a debris event occurred on Dale Creek. Throughout the afternoon of October 17, Dale Creek discharge increased and became increasingly muddier. Around 6 p.m., mud and sand had spread over the Gravelle property, largely as a consequence of the road embankment failure at Sylvester Road above their property. The yard was covered by mud, sand and gravel up to 10 cm deep. Water flowed over the low berm on the downstream right side of the creek, around the house and through the carport.

The October 2003 debris flows have shown that several debris avalanches may occur simultaneously in a given watershed. For a 500-year return period event, it is estimated that up to 10 individual debris avalanches may be initiated more or less simultaneously.

Frequency analysis of the recorded peak flows:

Squamish River near Brackendale: The peak discharge recorded on October 18 at 4 p.m. had a preliminary value of 3,084 m^3/s. This exceeded the previous record flow of 2,610 m^3/s from 1984. The October 18 discharge is estimated to have a return period of 110-140 years.

Cheakamus River near Brackendale: The river's peak discharge on October 18 at 7 a.m. had a preliminary value of 1,364 m^3/s. This exceeded by far the previous record flow of 861 m^3/s set in 1963. It was estimated to have a statistical return period of 100+ years. However, a statistical analysis of the peakflow data this station is not valid since the Cheakamus River is regulated by the BC Hydro dam on Daisy Lake and thus the requirements for the extreme frequency distributions are not met. The October 18 peak discharge should be noted though for its extreme nature, being 58% larger than the previous record peak flow measured over 47 years.

Cheakamus River above Millar Creek: This gauge, in the upper Cheakamus River watershed upstream of Daisy Lake, does measure natural flow. On October 18 at 1 p.m., it recorded its peak discharge of 227 m^3/s. This is only the third largest peak discharge in 22 years of record and estimated to have a return frequency of 15 years.

Lillooet River at Pemberton: The peak discharge recorded on October 19 at 2 a.m. had a preliminary value of 1,520 m^3/s. This exceeded the previous record flow of 1,410 m^3/s in 1991. The October 19 discharge is estimated to have a return frequency of 140+ years. (Chapman). The 1:200-year October 2003 flood achieved the highest water levels and discharge rates ever recorded. A previous flood in 1989, a flow rate of 992 m3/s was gauged.

---

* 1) For Victoria this was the rainiest day on record. Squamish did not only break the three-day record but also the two-day record of 318 mm and the one-day record of 239 mm as well as the Elaho Valley where up to 600 mm of rain fell in four days. (*Campbell River Mirror*, January 2, 2004).

*2) In 2004, the provincial transportation ministry installed a new $5-million bridge across Rutherford Creek designed to withstand a 1:200-year flood (*The Vancouver Sun*, December 15, 2004).

*3) Initially it was suspected that the truck had carried two of the victims, who were swept away the night the bridge collapsed. But the vehicle turned out to be an Isuzu Trooper reported stolen at the time of the flood. The vehicle had not been reported stolen until October 29 and nobody ever filed a missing person's report with Pemberton RCMP in relation to the suspect's disappearance. The RCMP later identified the victim as a 35-year old man believed to have plunged in the creek in the early hours of November of November 18 (*The Province*, December 15, 2004; January 13, 2005).

* 4) A more severe flood occurred in August 1991, when flow rates reached 1,260 m^3/s causing damage to the Pemberton airport and crop lands in the floodplain area. Pemberton was hit so badly because it is located on a large curve of the Lillooet River, which was the primary reason for the flooding. The river has the largest watersheds in the area draining into it. As well, it flows along the bottom of an essentially flat valley. So when the level of the river does rise over its banks, there is nothing stopping its rampage. The dyke system stretches over 40 km, 1.5 km of which was overtopped with water during the flood. The Lillooet River broke through two dykes in the area that have held strong since 1984. (Ministry of Environment files).

*5) As of February several residents in the Hatzic Valley were still evacuated from their homes as a result of the October 2003 flooding. Engineering reports suggest that the debris is a hazard to the safety of these residents (Ministry of Environment files).

2003

The Vancouver Sun, November 7, 2006.

In 2003, heavy rains caused a minor flood along the Chilliwack River. According to Leonard Farmer, who lives on the river side of Chilliwack River Road, "When [the dyke] went out…., they had

trucks running 24 hours a day there. But when the river started to recede, they just quit and left it the way it was."

November 28, 2003
(Storm surge/tidal flooding).
Source: *The Vancouver Sun*, November 30, 2003; *The Province*, November 30, 2003.
Details: Early on November 28, a heavy rain and windstorm originating in Hawaii dumped more than 62 mm of rain on the Vancouver International Airport. Between midnight-4 p.m., 94 mm of rain was recorded at Vancouver harbour. The heavy rainfall of 10 mm/hr abated by mid afternoon. High tides forced the closure of roads in Vancouver, Surrey, Richmond, Coquitlam and Port Coquitlam. Dozens of cars were left stranded after stalling in large, localised flooded areas caused by drains plugged with leaves.

Southwesterly winds gusted to 80 km/h at Victoria, 70 km/h at Point Atkinson and 50 km/h at Vancouver International Airport. The high winds prompted BC Ferries to cancel five sailings between Tsawwassen-Duke Point, two between Comox-Powell River and one from Tsawwassen to the Gulf Islands. Trees falling on powerlines caused power failures for 2,000 customers in Whistler, 1,000 in West Vancouver and 400 in Hope and Manning Park.

A high morning tide, 4.9 m at 10 a.m. at Point Atkinson, caused flooding along the Fraser River, such as Kent Avenue in south Vancouver. Drains clogged with leaves also caused localised street flooding in Vancouver. In the Southlands neighbourhood, some ditches were full to street level or caused spot flooding. In Surrey, floodwaters forced the closure of Highway 15 between 96th-80 Avenues in the early evening.

On the night of November 28 in New Westminster, a landslide came down. "Ten truckloads of muck" slid down a small hillside, causing an estimated $100,000 damage. A sea of mud and silty water headed down an embankment and straight into the front lobby of 71 Jamieson Court. The occupant of the condo, said, "it kind of rumbled…. And a river of mud was coming down the driveway." It came underneath the bedroom walls and in the lobby, was at least 6 in. (15 cm) deep and seeped under the doors.

Sometime between 2-2:30 p.m., a 25-m long and 2-m deep landslide swept across the Stanley Park Seawall between Prospect Point-Siwash Rock. It dislodged the top part of the seawall closing that section of the seawall. The trail would be closed till about December 3 as crews worked to stabilise and clean up the area where a detour was in place.

An avalanche at Mica Dam Hill, 136 km north of Revelstoke, closed Highway 23N. Highway 1 was temporarily closed between Revelstoke and the Alberta border because of the risk of avalanches.

December 16-17, 2003
Source: *Campbell River Mirror*, January 2, 2004.
Details: On December 16-17, Campbell River experienced two days of heavy rain. Areas flooded included downtown on Shoppers Row. The heavy rains also cancelled Revolution Studios' planned shoot of an action sequence for the movie "Are We There Yet." A section the new Island Highway was to be closed off to allow the shooting of scenes including a mini-van careening off the highway. The film company, which budgeted $600,000 for the five-day shoot, planned to return for another attempt in the spring of 2004.

January 29-30, 2004
(Tidal flooding).
Source: Ministry of Environment files, Memo from Allan Chapman**.**
Details: On January 29, rainfall and a high tide caused flooding in Hatzic Valley, forcing a couple of evacuations. The remaining homes and buildings in the area were on an evacuation alert. Homes near several creeks were affected, including Field, Carratt, Eng, McNab, Saporano and Dale creeks. Along Eng Creek, the Ramaseder property sustained flood damage five times over the winter. Four properties made claims for DFA. On McNab Creek, a mobile home was damaged. One DFA claim was received. *1) During the last week of January, Carratt Creek/Field Creek experienced at least two debris flows. *2)
On January 30, the Serpentine River and Nicomekl River in the lower South Surrey area were at bank full stage and rising, causing some localised flooding that day.

---
* 1) Lagace Creek causes ongoing flooding problems every time it rains significantly.

*2) On March 11, a second debris flow happened on Field Creek.

April 14, 2004
(Rain-on-snow).
Source: Ministry of Environment files, Memo from Allan Chapman, May 4, 2004**.**
Details: On April 14, a low level flood event occurred in the Trail and Fruitvale area.

April 30, 2004
(Rain-on-snow).
Source: Ministry of Environment files, Memo from Allan Chapman, May 4, 2004**.**
Details: On April 30, low level flood events occurred in the Christina Lake and Revelstoke areas.

June 26, 2004
(Rain-on-snow).
Source: Ministry of Environment files
Details: On June 26, a heavy rainfall-on snow event occurred near the community of Fauquier, 57 km south of the Village of Nakusp on the Lower Arrow Lake. Heart Creek overflowed its banks causing damage to the Fauquier Community Golf Course. As well, Fauquier Creek flooded and damaged a residential waterline.

August 7, 2004
Source: *The Vancouver Sun*, August 9, 2004; CBC newscasts August 7, 8, 9 and 17, 2004.
Details: Early on August 7 around midnight, two slides 3 km apart came down on Highway 3A, trapping several motorists. Twenty residents living in the slide zone voluntarily left and registered at an emergency reception center set up in Creston.

The largest one, at Kuskanook Creek 25 km north of Creston was 40 m wide. It buried the highway with several metres of mud and impacted three houses and a garage. One house was completely pushed off its foundations. A 4-m wall of mud, trees and boulders were pushed against it. One of the residents said, "You could hear it rumbling up the mountain and you could feel the earth vibrating under your feet." No one was hurt in the slide. Residents at Kuskanook harbour on the southeast shore of Kootenay Lake were evacuated by boat. The slide cut a 50 to 60-m swath through the tiny community, washing over the highway into Kootenay Lake.

A smaller slide occurred 3 km to the north at Jensen Creek. A car drove into this wall of mud in the dark but neither of its occupants was hurt. By the afternoon of August 8, that part of the highway reopened to single-lane alternating traffic. However, highway 3A remained closed indefinitely. Although the smaller one was cleared, the other site was too unstable to safely clear the road there. Traffic was rerouted through the Kootenay Pass.

On August 9, the provincial government announced that homeowners impacted by the slide would be eligible for financial aid.

According to a CBC report, the slides were due to changed water regimes following the wildfires during the previous summer. During the week prior to the slides, the area experienced heavy rain. The Ministries of Forests and Water, Land and Air Protection officials were looking for possible correlations between the slides and a large forest fire in the area the previous year.

August 17, 2004
Source: *The Vancouver Sun*, August 19, 2004; ***The Province***, August 25, 2004; CBC newscasts August 17 and 18, 2004.

Details: On August 17, heavy rains and "golf ball-size" hail caused a series of mud and debris slides cutting Highway 3 between Princeton-Hedley, stranding 70 motorists. According to Dan Bella, southern Okanagan's manager for the transportation ministry, 15 separate mudslides blocked a 3-km stretch of Highway 3. Eastbound traffic was rerouted from Princeton on Highway 5A to the Okanagan Connector, while westbound traffic from Osoyoos to the Okanagan Connector on Highway 97 North. One of the slides was 200 ft. (60 m) wide and 6-8 ft. (1.8-2.4 m) deep. It went through the Stemwinder provincial campground of a park and stranded 20 campers. Power, telephone and gas services were interrupted and traffic was rerouted. *The Province* reported three homes damaged.

On August 18 at 6:30 p.m., Highway 3 reopened to single-lane pilot car-controlled traffic after having been closed for nearly 24 hours. Although vehicles and the campground were damaged and 14 were left behind in the mud, no injuries were reported.

August 21-24, 2004

Source: *Times Colonist*, August 22, 2004; *The Vancouver Sun*, August 25, 2004; *The Province*, August 25, 2004; Ministry of Environment files, Memo Dwain Boyer, August 25, 2004.

Details: On August 21,Victoria recorded 16 mm of rain making it the first significant precipitation since 19.6 mm of rain fell back on March 7. *1) On the same day, Port Hardy reported 56 mm while Estevan Point and Port Alberni recorded 32 mm and 24 mm, respectively.

On August 24 around 4 a.m., two landslides came down onto the Trans-Canada Highway near Five-Mile Bridge in Kicking Horse Canyon east of Golden. Fifteen cars and trucks, including two police vehicles were trapped between them. The slides, which were triggered by heavy rainfall on August 21-22, closed the highway for several hours before a single-lane route was plowed through the mud. No motorists were injured and road crews were able to reopen the road by noon. The road was not fully cleared until 2 p.m.

A storm track in an east-west line along the 49th parallel resulted in cool weather and caused "copious amounts of rain." The west Kootenay area experienced heavy rain. Powder Creek across the lake from Kaslo received 40 mm, of which 34 mm fell between 2-4 a.m. on August 25. Other stations around the southern West Kootenays reported in the 20 mm-plus range during the previous 12-18 hours. The rain gauge 20 km north of Kuskanook Creek reported a lesser amount of 11.2 mm.

Fauqier Creek overflowed its bank. A house about 470 m from the creek by flooding in June was again threatened. The owner reported a substantial rise in creek waters.

Around August 22-24, large landslides in the backcountry caused the Slocan and Lardo rivers to run "chocolate." The event did not involve propert or people damage (Boyer).

---

*1) Only 19.5 mm of rain fell during all of July, with the wettest day being July 9 with 5 mm.

August 29-30, 2004

Source: *The Vancouver Sun*, August 31, 2004; *The Edmonton Sun*, August 31, 2004; *The Province*, September 1, 2004; CBC newscasts August 31, 2004; Marten Geertsema, pers. comm. September 8, 2004.

Details: On August 29, a landslide occurred near Riske Creek about 15 km upstream of the junction of the Chilcotin and Fraser rivers. The mudslide in Farwell Canyon temporarily blocked the Chilcotin River. *1) The water level reached up to 20 m. (Geerstema, pers. comm.). Overnight August 29-30, the water pooling behind the natural dam in the river, which was made up mostly of sand and silt, worked its way around it.

Since the riverbanks were considered unstable causing a risk of further slide activity, provincial emergency program officials requested the public to avoid the slide area and lower Chilcotin River. Floodwaters undercut the banks in some areas, leaving them unstable. Debris that washed into the Fraser River posed a potential hazard to fishing gear and boats from Lillooet to Hope. The Farwell Canyon bridge remained closed for several days to allow crews to remove debris.

Fisheries officials believe that up to 80% of summer Sockeye salmon in the Chilcotin River escaped the effects of the mudslide. The bulk of the run had already passed when the slide dammed the river. *2)

---

*1) On August 19, 1964, a similar slide happened at the same Farwell Canyon location.

*2) An average 1 million Sockeye salmon and between 15,000-30,000 Chinook salmon pass through the Chilcotin River. (*The Province*, September 1, 2004).

September 19, 2004
Source: Phillips. 2005.
Details: A heavy rainfall of 91.2 mm on September 19 set a single day record at the Vancouver International Airport. The previous record for a single day was set on Christmas Day 1972 with 89.4 mm. Vancouver's total rainfall for September was 196.4 mm, more than three times the normal rainfall for that month.

October 24-25, 2004
Source: *Campbell River Courier-Islander*, October 27, 2004.
Details: On October 24-25, rain and wind caused localised flooding and power outages in the Campbell River-Courtenay area. Leaves hitting catch basins caused minor flooding in the usual low-lying areas in Campbell River such as the Nunns Creek crossing of 16th Avenue. Luckily the tide was favourable. (Flooding is always worse when the water table rises when the tide and storm water has nowhere to go).

Early on October 25, parts of Black Creek, Comox, Denman, Hornby and Quadra Island lost power. In the Oyster River-Black Creek area 1,700 customers were without power and 2,700 customers in the Comox Valley for about two hours.

November 15-16, 2004
Source: Ministry of Environment files; File VI35000-20/23-40 Task #053509. Memorandum November 22, 2004 Joe MacInnes, Flood Hazard Technician to Jim White.
Details: On November 15 flooding occurred near Sayward on Stowe Creek with a channel avulsion through the Friesen property. Water and debris surged against and around the house. Access to a neighbour's house was also cut off.

On November 16, Stowe Creek continue to flow overbank and follow an old flood channel, directing flood flows at the Friesen home. A neighbour to the south of the Friesen property also complained that their driveway was cut off and that they could not access their home. The estimated cost was approximately $1,500 for up to six hours for an excavator and faller with a saw.

A medium size logjam on the right bank of the creek caused the flooding approximately 30 m upstream of the avulsion location. Channel aggradation also occurred through this reach with a large gravel bar formation immediately in front of the avulsion channel mouth. The difference between the channel invert and the top of bank at the aversion site was estimated from 0.3-0.6 m.

November 23-27, 2004
Source: *Times Colonist*, November 25, 2004; *North Islander*, November 26, 2004; *The Province*, November 26 and 29, 2004; CBC newscasts November 24 and 25, 2004; Ministry of Environment files, Memo from Duncan Ferguson, November 25, 2004.
Details: On November 23-24, a storm with a westerly flow brought heavy rains to outer Vancouver Island. On November 23, Tofino and Port Alice recorded 82.6 mm and 36.8 mm of rain, respectively. Esquimalt and Port Hardy recorded 41 and 43 mm of rain, respectively. Between November 23-24, Port Alberni airport recorded 13.8 mm, while in Campbell River and Port Hardy 34.0 mm and 64.1 mm of rain fell, respectively. Till November 24, Tofino recorded 680 mm, well above their normal 474.9 mm. *1) In contrast, Port Alberni airport total rain for November till that date was about 245 mm with the total average for the month being 309.4 mm. November rainfall in Port Hardy till November 24 was close to 455 mm, well above the normal 288.3 mm (*North Islander*, November 26, 2004).

On November 24 just after noon, heavy rain caused a mudslide near the hairpin curve at Loss Creek Hill 10 km west of Jordan River. West Coast Road (Highway 14 to Port Renfrew) and the hydro line were cut. No one was injured in the slide and the road was cleared and opened to traffic by 3:30 p.m. Electrical service to 230 customers in Port Renfrew was restored in the late afternoon.

High turbidity in the Coquitlam reservoir caused the water supply out of this watershed to be taken off the system. The turbidity was not high enough to require a boil water advisory. On November 24 at about 9-10 p.m., the Chilliwack River peaked at just about bank full stage but flows remained high through the night. The river appears to have peaked at a stage of 2.85 m at 9 p.m., being a 2+ year return period flood level.

Overnight November 24-25, debris accumulation in Lagace Creek resulted in flooding of several km of roads, causing road closures in Hatzic Prairie. No debris events occurred on the Hatzic Valley creek that torrented in October-November 2003 (Ferguson).

On November 25 at 8 a.m., after a snowfall of about 24 hours the first large avalanche of the season closed Highway 3 between Salmo-Creston. The avalanche came down across the highway on the Kootenay Pass. *2) The pile of snow, mud and trees was more than 10 m high and 30 m wide. Initially it was thought that the slide had swept away an unaccounted-for vehicle. Search crews using probes and a RCMP dog looked for potential victims. After it was determined that no one was buried in the avalanche, it was cleared. It took the entire morning to push a path through and get traffic moving again.

On November 27 at about 1 p.m., an eastbound CNR train travelling on CP Rail tracks about 16 km west of Hope hit debris caused by a rockslide. The locomotive and five empty grain cars derailed. Two CNR engineers were slightly injured.

---

*1) Tofino's record for November was set in 1995 with 786.6 mm. In November 1975 maximum rainfall records were set Port Hardy and Port Alice with 573.5 mm and 1,006.6, respectively. Campbell River recorded a maximum November rainfall of 411.8 mm in 1983 (*North Islander*, November 26, 2004).

*2) The Kootenay Pass is the highest paved road in Canada with an elevation of 1,746 m. Full-time maintenance crews work all winter trying to keep it clear (*The Province*, November 26, 2004).

November 2004-January 2005

(slow moving landslide).

Source: *The Province*, January 25, 2005; *Times Colonist*, April 18, 2005; *The Vancouver Sun*, April 18, 2005.

Details: Sometime between November 2004-January 2005, a enormous mass of earth sitting about 2 km above Whistler slipped almost 1 m. The slide generally moves a few centimetres each year but occasionally accelerates and moves several metres. *1)

Estimated at 1 million m^3, the landslide, if it would come down suddenly, it would cascade down Fitzsimmons Creek into two day-skier parking lots between Whistler-Blackcomb and the public bus loop 2.5 km below.

A report by Vancouver-based EBA Engineering Consultants commissioned by the B.C. government in the summer of 2004 recommends setting up a warning system and the closure of parking lots in the slide's path during heavy rains.

The proposed solution would be a multi-million dollar "debris basin" to be built to protect the village. In the short term, the report suggests enhanced monitoring of Fitzsimmons Creek and landslip; a public notification system put in place; continued dredging of the dyked creek in the village area to remove gravel swept down as the toe of the landslide continues to erode.

According to the report, maintenance to reduce the effects of the slide, plus a warning system, would cost the municipality of Whistler more than $300,000 per year. The report warns that failing to act would "fail to reduce the risk of loss of life or property due to a known hazard" and "increase liability on the part of (the ski resort)" – creating "significant negative publicity in the pre-Olympic period." *1)

---

*1) The resort has recorded four major movements in the previous 26 years. After heavy rain in 1991, the slide moved 2-3 m and released debris into the creek, causing an estimated $2.1 million of damages

downstream. In November 2003, the slump slipped 2.5 m (*The Province*, January 25, 2005). According to *The Vancouver Sun*, the slide moved an estimated 6 m in 1991 (*The Vancouver Sun*, April 18, 2005).

December 9-10, 2004

Source: *Times Colonist*, December 11, 2004; *The Province*, December 15, 2004; *The Vancouver Sun*, December 15, 2004.

Details: Around December 9-10, southwestern Vancouver Island reported heavy rain. A warm, wet stream of air coming from the south Pacific brought balmy temperatures. On December 10, Victoria recorded 12º C, compared to a normal daytime temperature of 6.8º C. Weather office radar estimates showed up to 100 mm of rain in a 24-hour period starting the afternoon of December 9. Tofino recorded about 50 mm of rain. December 9, Port Alberni and Victoria recorded 59.2 mm and 38.6 mm, respectively. Although there is no mechanism for reporting rain in some areas, it is believed the most rain fell near Port Renfrew.

The heavy rain delayed the December 11-12 opening of the Mount Washington ski resort. Victoria reported very few flooding problems because the storm sewer system had been extensively modified. Saanich public works received about 30 calls about plugged culverts and flooded basements. Water streaming across the Patricia Highway near Elk Lake caused a one-car accident.

On December 10, Cypress Bowl closed after a mudslide made the highway impassable. The heavy rain also caused mudslides in the Seymour watershed. On December 10, the turbidity in the Seymour Reservoir started to rise to greater than 1 Nephelometric Turbidity Unit (NTU) and continued to rise to about 24 NTU on December 14. On that day the Capilano Reservoir recorded 2.8 NTU. *1) According to Dr. John Blatherwick, GVRD's medical health officer, no boil water order was required.

On the night of December 10-11, a mudslide near Matsqui caused a CNR freight train to derail. Heavy rains caused the mudslide to hit the side of the train, sending eight cars off the tracks. Some of the auto-carriers were knocked onto their sides, losing their loads of new compact cars. No one was injured.

---

*1) The ideal (Canadian Drinking Water Guidelines) turbidity level is less than one (*The Vancouver Sun*, December 15, 2004).

December 26, 2004

Source: *The Province*, December 27, 2004.

Details: On December 26 about 5 p.m., a rockslide in West Vancouver shut the Trans-Canada Highway near the Eagle Ridge exit. Crews removed the debris into the evening. The highway was expected to reopen late that night.

January 7-12, 2005

(Tidal flooding).

Source: *The Vancouver Sun*, January 8 and 13, 2005; *The Province*, January 12, 2005; *Times Colonist*, January 8, 9 and 12, 2005; *North Shore News*, January 12, 2005; *The Vancouver Sun*, February 24, 2005.

Details: On January 7, strong outflow winds rushing down Harrison Lake and the Fraser Valley corridor made driving hazardous, especially in the flat, exposed Sumas Prairie east of Abbotsford. The wind and cold were the result of heavy, cold air flowing down from the Interior plateau. The near white-out conditions contributed to several accidents, including one involving a Greyhound bus. It slid down a 2-m hill between Highway 1-North Parallel Road, 2 km east of the Whatcom Road exit and flipped on its side. None of the six people, including the driver were injured.

On January 7, snow that hit the hardest on the east side of Vancouver Island between Victoria-Campbell River caused havoc with traffic and power outages to about 10,000 customers in the capital region and another between Victoria-Parksville. The heavy snow brought down trees in Goldstream Park. On the Malahat Highway cars were falling trees smashed cars. At the Victoria airport was temporarily shut down, affecting about 3,000 passengers and 50 flights. Hard hit was also the south part of Nanaimo where about 7,500 customers lost power for several hours.

On January 8, Environment Canada reported 40 cm of soggy snow at Qualicum Beach and throughout the Cowichan Valley. On January 8-9, massive power outages threw some 100,000 BC Hydro customers into the dark as the biggest blizzard in years felled trees over power lines up and down Vancouver Island. Late on January 11, the last repairs were made at Shawnigan Lake. On January 11, telephone service was finally restored to Thetis Lake, Shawnigan Lake and a number of isolated cases. On January 12, about 75 homes on the Gulf Islands were still without power for the fourth consecutive day.

On the night of January 8, rough waters caused by a windstorm caused the government dock at Deep Cove to split in two. During the storm, 1-m waves smashed along the sea wall in the sheltered cove. The strong current ripped apart the metal joists that connected the dock, leaving about a 3-m gap from the shore. The dock at Deep Cove Yacht Club was also damaged while the winds ripped a couple of boats off other docks (*North Shore News*, January 12, 2005).

On the night of January 11, 2005, six Kelowna residents were forced out of the two duplexes at the foot of the unstable slope. Geotechnical engineers studying the shifting slope above their homes built right into the toe of the slope warned it could slide without warning. *1) John Vos, Kelowna's director of works and utilities, said "If the slope of the base of Knox Mountain collapsed, the slide would likely push one of the duplexes off its foundations, smashing it into the neighbouring home."

The city helped the renters with some of their food and lodging costs and because of the publicity surrounding the evacuation also for security to guard the homes. Dozens of homes just above the unstable slope nor other homes at the base of the mountain were considered in serious danger. Another road was constructed in case a slide would block the existing route.

Fearing a landslide, the city later demolished the two duplexes that it purchased for $780,000. In some spots, there had been more than a metre of slope movement. The solution was to build a berm at the bottom of the slope with 22,000 m^3 of fill and relocate another 18,000 m^3 to reshape the upper slope of the hillside estimated to cost another $600,000 (*The Vancouver Sun*, February 19, 2005).

On January 12, wind and a high tide swamped the seawall around Stanley Park.

---

*1) On October, Kelowna parks workers first observed surface cracks on a small section of Fox Mountain. After Christmas the cracks grew larger and more quickly. According to Garrett Danniel, who lives at the foot of Knox Mountain at the edge of the evacuation zone, "the cracks in the hill above two duplexes have grown about 30 cm over the past few months."

January 16-31, 2005

(Rain-on-snow, ice jam/flooding and fatal landslide).

Source: *National Post*, January 20 and 24, 2005; June 8, 2005; *The Vancouver Sun*, January 21, 22, 25, 27 and 28, 2005; February 4 and 19, 2005; March 13, 2005; May 4, 2005; June 29, 2005; July 15, 2005; August 2, 2005; October 14, 2005; December 19, 2005; June 22 and 29, 2006; July 22, 2006; November 24, 2006; *The Province*, January 19, 20, 24, 25, 26, 27 and 28, 2005; July 3 and 22, 2005; September 14, 2005; April 3, 2006; *Times Colonist*, January 19, 20 and 23, 2005; March 14, 2005; *North Shore News*, September 25, 2005; Ministry of Transportation files; CBC newscasts January 18, 19, 20, 21, 23 and 24, 2005; Ministry of Environment files; Memo Allan Chapman, January 18, 2005; David Jones, meteorologist Environment Canada, interview CBC January 18, 2005.

Details: In mid-January, a flow of record moist warm air resulted in record precipitation. The system coming directly from the Tropics and thus carrying more moisture and heavier rain, it was dubbed a "tropical punch," one step beyond the "Pineapple Express." (David Jones, interview CBC January 18, 2005). Freezing levels rose to 3,000 m. On January 19 at 5 a.m., Abbotsford reported a temperature of 16° C. The unusually heavy rain, high freezing level and high temperatures produced record rain-on-snow peak flows. On January 16-17, heavy rain south coast and Lower Mainland melting snow caused flooding. Starting the afternoon of January 16, river levels throughout the lower Fraser Valley rose steeply. As the rain eased, they peaked or levelled before midnight.

On January 16 heavy rain fell on west and south Vancouver Island. Bear Creek Reservoir near Jordan River recorded 159 mm in 29 hours between midnight January 15-5 a.m. on January 17. Some areas

recorded more than 100 mm of rain in 24 hours. Tofino, for example, received 96.8 mm of rain in one day and 197.2 mm the next; Port Renfrew 143 mm; Victoria 37 mm; Powell River and Nanaimo 30 mm and Campbell River 20 mm/24 hours on January 17.

From January 17-31, severe flooding, landslides and ice jams on most major rivers affecting the north east, central south west, south east and Vancouver Island regions caused damage to individual and to infra structure at between $10-15 million (*The Province*, January 24, 2005; *Vancouver Sun*, October 14, 2005). *1)

Very heavy rainfall also occurred over the Greater Vancouver area and the Lower Fraser Valley on January 16. The Chilliwack River snow pillow recorded 97 mm in 29 hours. The heavy rain associated with the front largely skirted the edge of Howe Sound and the Squamish and Lillooet River basins. The rainfall at the Upper Squamish River snow pillow was only 44 mm (Memo Allan Chapman January 18, 2005).

Between January 17-early January 21, Vancouver and West Vancouver recorded 140 and 240 mm of rain, respectively. During that same period Port Renfrew and Henderson Lake reported 540 and 600 mm, respectively. *2) Some areas of the Fraser Valley recorded 150 mm of rain on January 18. Between January 1-22, Vancouver recorded 223 mm of rain, while the average for the entire month of January is 152.9 mm.

The heavy rains continued. In the 24 hours ending 4 p.m. on January 22, Tofino recorded 160 mm of rain. Gold River received 58.4 mm during the same period. On January 19, Victoria set a temperature record for the date. With 17.1^{o} C at Gonzales weather station and 16^{o} C at Esquimalt Harbour, toppled the Victoria high of 11.7^{o} C set in 1944. On January 23, Vancouver International Airport recorded a daytime high of 14.1^{o} C, beating the previous high of 13.2 ^{o} C for that day set in 2003.

High water warnings issued on January 17 ended on January 24. On January 21, the Cowichan River peaked at about a five-year floodlevel. Early that day, the Coquitlam River and Seymour Creek peaked at just below the two-year flood level. Later on January 21, the Lillooet River peaked, well below flood risk level, while the Squamish River was similarly receding. Early next day, the Salmon River at Sayward peaked at approximately 80% of a two-year flood discharge.

Stanley Park's Sea Wall was closed for fear of flooding. Several mudslides were reported on the seawall. The paths around Lost Lagoon and on the north side of Ceperley Creek were closed due to flooding. On January 22, the seawall remained closed until further notice because of the danger of slides.

In West Vancouver, businesses along Marine Drive were flooded. Richmond reported many flooded basements. Greater Vancouver Regional District's sewage overflowed at some facilities. On January 18, the high tide caused the Richmond and Burnaby sewers to back up. An estimated 2% of the raw sewage ended up in Burrard Inlet and the Fraser River. Throughout Richmond, its 39 pump stations were running at full capacity. Only one road closure was reported at No. 5 Road between the Steveston Highway-Blundell Avenue. Road closures were reported in the Trenton and Holland areas of Port Coquitlam. The northern end of the Mary Hill bypass in Port Coquitlam was closed from Kingsway to Lougheed due to flooding.

On January 16, a mudslide blocked 249th Street (and Alouette Road) in Maple Ridge for about four hours. Waters that blocked road access to about 30 farms in the North Alouette area subsided by early January 20. On January 19, Delta reported localised flooding with 104th Street in East Delta temporarily closed. In Surrey, a dyke breach on the Serpentine River was repaired on January 19. All Surrey roads closed due to flooding were expected to be opened late on January 20.

On the afternoon of January 18, Salmon River floodwaters took out a low-level bridge in the 4500-block 248th Street in Langley. The road was expected to be closed for several days. Flooding was reported at 216th Street south of 40th Avenue and minor flooding in the area of 83rd Avenue and 196th Street and along the 16800-block of 16th Avenue of South Surrey. Overflowing ditches left a house and car in the 22700-block of 16th Avenue in Langley stranded. Township of Langley roads and drainage manager Terry Veer said that he expected that hundreds of basements had flooded in recent days.

On January 17, Port Alberni reported flooded some basements and yards. Late on January 17, a mudslide at Loss Creek closed the West Coast Highway (Highway 14) between Jordan River-Port Renfrew, affecting a 40-ft. (12 m) section. Mud covered about half the highway. Cowichan Bay Road closed due to flooding. The highway at Mary Hill Bypass closed due to flooding. Oldfield Road near Walton closed. Late

on January 17, a mudslide east of Colwood closed a road. In Saanich (?), the 88th Avenue area reported flooding.

In the Greater Vancouver area, three slides came down in the sandcliff system throughout the area. (near Tsawwassen, UBC cliffs near northwest Marine Drive and on the North Shore). Around mid-afternoon on January 18, a mudslide in Port Coquitlam took out a retaining wall of a home and much of one resident's back garden on Shaughnessy Street between Pitt River-Eastern. The slide blocked the 1400-block Shaughnessy Street, knocking out power and gas service. The entire road was covered with mud and debris more than 2 m high. The threatened home and a few neighbouring ones were evacuated. Two days later, residents of three homes on Shaughnessy Street remained evacuated.

On January 19 at about 3:14 a.m., a mud and debris slide swept down the Berkley Avenue escarpment and completely destroyed two houses in the Riverside Drive area of North Vancouver. Saturated soil caused the embankment to come down. In the previous 24 hours 158 mm of rain had fallen in the area. The slide swept the backyard of Larry Perrault's property on 2175 Berkley Avenue 75 m down the slope. *3) Neighbours heard a "scraping sound" and a "rumbling of the earth." Some nearby residents thought it was an earthquake or the rumble of a train or a snowplow. "The roar of the slide and the cracking of the wood … It was loud – it was very loud," said Doris Murphy. (*Times Colonist*, January 20, 2005).

After training for some 10 years, the Urban Search and Rescue group was called up for the first time. Within two hours they were on scene. Sniffer dogs and helicopter mounted forward-looking infrared devices were used in the search for victims. At 1:20 p.m., the body of Eliza Kuttner was located. Earlier, her husband Michael Kuttner was pulled out of the mud in critical condition. Harvey and Colette Dykes narrowly escaped and their nine-month old baby miraculously survived when their house was demolished.

A few hours later, as a safety precaution, up to 300 people from 84 homes in the neighbourhood built in tiers on the side of a mountain were evacuated. On January 21and 22, 17 homes on Riverside Drive and Swinburne Avenue downhill from the main slide zone were ordered evacuated because of cracks in soil pushing against the Lennox Drive retaining wall and at another wall on Layton Drive. Below the retaining wall in the 1500-block Lennox Street the forested slope plunges at a 40-degree angle to houses 75 m below. The occupants of another 20 homes ordered evacuated after the January 19 landslide were still not being allowed back. Late on January 23, a total of 37 homes remained under evacuation orders.

Premier Gordon Campbell, who toured the disaster site with Public Safety Minister Rich Coleman, declared a state of emergency for the area announced that the provincial disaster program was in place. Kuttner, whose home at 2440 Chapman Way was swept away and was suffering from permanent injuries later launched legal action against the District of North Vancouver. *4)

In the North Shore slide area, two water mains broke; at Mount Seymour Parkway and one near Riverside Drive. The nearby flood-swollen Seymour River damaged a water main, forcing Capilano College to close for several days. Early on January 21, some 20 homes in the area remained evacuated. Later that day, due to further mudslide threats the District of North Vancouver ordered 10 more homes about 0.5 km from the slide site to be evacuated.

At the end of January, 10 families were allowed back in their homes. Early February a second group of 10 families returned to their homes. This left another 10 families remaining evacuated. On March 12, six more North Vancouver residents evicted from their homes nearly two months earlier were allowed to return home. Towards the end of July, the district terminated 24-hour security at Larry Perrault's home as the $2,000-a-day cost was no longer deemed justifiable.

On January 19, a larger slide than the one on Riverside Drive came down in the Lower Seymour Conservation Reserve (LSCR). The slide was 20 m wide at the top and 100 m long. The affected piece of land is situated about 46 m from the edge of a gravelpit used to produce concrete for the water filtration plant project in the LSCR. A piece of a large bluff on the site gave way and flooded a habitat project at the bottom of the bluff. According to Brian Halabourda, president of the Seymour Salmonid Society the slide in the forest was "as bad if not worse," in terms of property damage to an area known as Kilometre Five. Fisherman's Trail was closed to the public because of danger posed by about three slides of concern in the valley.

Early on January 20, 14 homes on English Bluff Road near Delta/Tsawwassen were evacuated after a minor debris slide came down in the 800-block of Tsawwassen Beach Road. A 9 x 18-m section of steep bank slipped onto the private paved loop road on the Tsawwassen Indian Band reserve. Even though the slide was located farther up the cliff and did not pose an immediate threat, seven families temporarily left their homes. According to one of the area residents, minor slides occur on the steep bluffs there every several years, without loss of homes or lives.

On January 20, at Hatzic Lake, the perennial flood zone east of Mission, up to 20% of the 365 homes in the Everglades Resort recreation development were flooded. At noon that day, the lake level was 0.7 m above normal summer level. *5)

Vancouver reported minimal road flooding but at least 100 “soaked” basements. Officials kept a close watch on the Southlands area, at the southern base of Dunbar Street. In Burnaby, trouble spots included the area around Still Creek and south of Marine Drive. *6) Coquitlam reported some minor slides.

In the Pitt Meadows agricultural area widespread flooding occurred, causing tens of thousands of dollars’ damage to homes and greenhouses. The district’s six 25-year-old pump stations, pumping water from drainage ditches into the Alouette, Pitt or Fraser rivers, were unable to keep up. Basements were inundated and after breaching a nearby drainage ditch Albert Van Marrewyk’s 500,000-ft^2 hothouse flooded. *7)

On January 21, Richmond Mayor Malcolm Brodie declared a state of emergency after heavy rains caused a huge sinkhole that threatened to collapse buildings in a stripmall in Richmond. Walls began to sag after the sinkhole opened up behind three businesses on No. 3 Road Merchants from businesses at 6280 No. 3 Road had to be evacuated. According to Richmond fire chief Jim Hancock, the sinkhole estimated to be roughly 9 x 6 m across and 2.4 m deep was caused by heavy rain and a broken sanitary sewer line. Hancock said it was not known whether the sinkhole caused the sewer line to rupture, or the other way around.

On January 19, schools in Golden and Windermere (District 6) closed due to poor driving conditions. Early on January 19, Highway 31 was still closed between Lardo-Cooper Creek due to slides. Other highways closed included the ones between Canal Flats-Golden, Highway 1 between Sicamous and the Alberta border, Highway 23 north of Revelstoke and between Anaheim Lake-Bella Coola. Highway 4 between Parksville-Port Alberni flooded. On January 19, a section of the highway just west of Cathedral Grove was flooded as water from Cameron Lake washed over the road. Cowichan Bay Road was still closed and Crofton Road near Highway 1 was closed due to flooding.

On January 17-18, rivers on eastern Vancouver Island and in the Howe Sound-Squamish area were passing flood level markers. On January 18, Pemberton Creek threatened to breach its banks as water rose 60 cm in three hours. Late on January 19, several housing complexes with hundreds of Pemberton residents remained on evacuation notice due to the rising waters of Pemberton Creek.

By early January 19, the Chemainus, Cowichan, Nanaimo and Englishman rivers reached the average flood level (i.e. level reached every two years). Emergency officials were also watching the Salmon and White rivers near Sayward. During the night of January 19, streams and river on Vancouver Island reached a first peak. Around January 22-23, the Cowichan River reached a 5 to10-year high.

On the afternoon on January 19, the Nanaimo River was 5.05 m above normal and rising between 7-17 cm/h. According the Ministry of Water, Land and Air Protection, this was a 5-year record. The Englishman River was at 3.14 m above normal, rising 8-15 cm/h. The Chemainus and Cowichan rivers peaked at 3 a.m. and were receding later on January 19.

In the Cowichan estuary, half a dozen homes were at risk and residents on standby to evacuate. A few days earlier, three homes were evacuated but those families had returned to their homes. On January 19, the flooding of the Englishman River near Parksville forced the evacuation of about 100 residents from Parry’s Trailer Park and nearby residences off Martindale Road. The Nanaimo River spilled over its banks in the Alice Road area.

On January 17-18, Port Renfrew recorded 342 mm of rain in two days. Around 6 p.m. on January 17, a mudslide came down onto the West Coast Highway to Sooke and points west, leaving about 300 area residents stranded. The slide happened on a steep, rain-soaked section of road just past Loss Creek, about 17 km from Port Renfrew. The slide took out almost 2.5 m of the bank, meaning part of the roadbed will have

to be moved. The highway was open to single-lane traffic by 11:15 a.m. on January 18. Mike Simms of Mainroad South Island Contracting noted, “This is a very unstable area throughout here. We’ve had slides here in the past, one just a month ago just around the corner.”

In the Fraser Valley, the Chilliwack, Stave and Coquihalla rivers were threatening to flood. The unusual runoff for this time of the year was due to the low snowpacks that could not hold much of the rainwater. (Chapman). With the ground frozen, the water had nowhere to go.

On January 19 between Campbell River-Gold River, one lane of a 5-km winding stretch of Highway 28 about 5 km west of Strathcona Lodge was covered with boulders including some larger ones.

A coldsnap followed by a 20-degree temperature jump was sending too much ice down too many rivers. In the Thompson-Nicola Regional District, 30 rivers and creeks had significant icejams in the previous weeks. (*The Province*, January 27, 2005). On January 19, icejams on the Similkameen and Coldwater rivers caused flooding. Low-lying areas of Keremeos were hit by a torrent of water after the Similkameen River burst its banks. The flash flood estimated at a speed of 40 km/h damaged three homes and flooded about three dozen others. In the morning, a wall of ice had built up against the historic wooden Red Bridge west of Keremeos. Then the icejam suddenly gave way and floated downstream towards the town, flooding houses and fields. At the peak of the flood, the river grew to 0.5 km in width. About 200 people were evacuated, some by helicopter. Vehicles were buried up to the door handles by ice and water. About 20-30 homes were damaged as well as farm properties and some greenhouses. Later in the day, the water levels started to drop.

A smaller icejam on the Coldwater River caused the Merritt Mountain Music Festival area to flood. A trailer park was evacuated and the state of emergency was declared in Merritt.

Along the Elk River some localised flooding occurred and floodwaters undermined some CPR track. Near Nelson, Perry Ridge, historically classified as “hazardous,” was closely watched. *8)

On January 19 at noon, highways closed included Highway 1 between Sicamous and the Alberta border, east of Revelstoke the highway was closed indefinitely; Revelstoke-Mica Dam due to avalanches; Golden-Canal Flats due to severe winter conditions; between Radium Hot Springs-Kootenay National Park and Highway 31in the Galena Pass due to high avalanche hazard. On January 18, an avalanche near Revelstoke killed a heli skier.

The soggy weather plagued British Columbia’s ski resorts. On January 21, freezing levels at Whistler dropped to 1,900 m. Although Whistler and Blackcomb remained open, with avalanches a concern and rain falling, the number of skiers was way down. Rain closed all the other southwest mountains on January 24, including Grouse, Seymour, Cypress and Mount Washington on Vancouver Island. The Mount Washington resort was forced to lay off 300 of its 800 employees until further notice. The resort’s base was only 61 cm instead of the normal 180-240 cm.

On January 17, the Trans-Canada Highway was closed in several sections. Overnight January 17-18, the Coquihalla Connector closed due to freezing rain. Due to freezing rain school busses not running in Quesnel. On January 18, Coquihalla Highway between Hope-Merritt closed by freezing rain.

An avalanche closed the highway between Revelstoke-Golden. When this section later that day reopened the highway between Revelstoke-Sicamous closed due to an avalanche. The highway between Revelstoke-Mica Creek closed. Highway 5 closed in Kootenay Pass due to avalanche control. Avalanches closed Highway 3A near Balfour and Highway 31 near Lardeau. Slide near Sicamous.

On January 21 at 8 a.m., the Trans-Canada Highway east of Revelstoke reopened after an extended closure due to avalanche risk. Highway 5 North from Avola opened eight hours earlier. A number of secondary highways, including Highway 93 North, from Jasper to Lake Louise, and Highway 93 South remained closed.

On January 20, schools in Williams Lake and Golden were closed. Later on January 20, most highways closed except the section between Golden and the Alberta border, which reopened early on January 21.

After the Mashiter River rose sharply, a boil water advisory was declared in the Garibaldi Heights area of Squamish. Officials were keeping close watch over the rising Cheakamus River. On January 21 at 8 a.m., heavy rain caused a rockfall to come down in the Cheakamus Canyon between Km 28-28.2 on the

Squamish to Duffey Lake Road. An estimated 600-800 m^3 of rock ended up in the ditch along the highway. None of the rocks reached the highway. Early on January 23, a huge rock was reported on Highway 99 north of Lions Bay.

Overnight January 22-23, a landslide near Roberts Creek came down near a beach home, forcing out an older couple temporarily from their home. Sandy soil slid down a bank behind their waterfront home on Ocean Beach Esplanade. According to *The Province*, the slide hit the side of their house. On the afternoon of January 24, a slide came down north of Sechelt in Halfmoon Bay. Gibsons and Sechelt reported a few "minor water problems." (*The Vancouver Sun*, January 25, 2005). Overnight January 22-23, a small mudslide came down near Chilliwack.

On January 24, some ice build up in the Little Slocan River, which flows into the Slocan River caused water to build up. High water in Hawkins Creek threatened flooding near Yakh.

Early on January 24, icejams on the North Thompson River caused flooding at the community of Birch Island, population 225 about 12 km north of Clearwater on Highway 5. Overnight January 23-24, the river went up 8 ft. (2.4) and was covered with solid ice. Some of the 12 homes seriously damaged by flooding could be structurally unsafe. Around 5:30 a.m., 10 homes on the south side close to the river were evacuated before the bridge closed at 6 a.m. By noon, a total of 20 homes were evacuated. More of the 95 homes on Birch Island, 65 of which on the floodplain were threatened. An evacuation alert was also issued for a wider area and residents were told to be ready to leave on short notice.

The ice took out support beams and damaged the 65-year-old wooden Birch Island bridge over the North Thompson River beyond repair. Residents were forced to take an hour-long detour to reach the other side of the river via a logging road. The span across the river was too long for a temporary crossing. It would take more than a year to build a new $2.5 million bridge. A second ice jam several kilometres upriver still threatened to further damage the bridge and cause a second flood on Birch Island. *9) Icejams also threatened the communities of Little Fort and Barriere. Some residents were on standby for evacuation.

On January 26, two other ice jams broke apart in the Barriere River; one at the Dee Jay RV Park and Campground, the other at a private residence along Leonie Creek. They floated downstream, easing the flood risk in the Thompson-Nicola with the Barriere and North Thompson rivers down about 2 m. This was, however, not enough to allow Birch Island's 100 residents to return home. Around January 28, the Birch Island evacuation order was rescinded.

On January 24, floodwaters on Mad River closed Highway 5, 70 km north of junction with Highway 24. The next day the Mad River bridge south of Avola was still closed. On January 28, a Bailey bridge was completed at Mad River, opening the Yellowhead Highway to traffic for the first time in four days.

---

*1) The federal cabinet later agreed to consider providing emergency financial assistance to British Columbia to help cover an estimated $10 million in costs to citizens and governments caused by the landslides in January. Any aid would be based on a "cost-sharing" basis (*The Vancouver Sun*, October 14, 2005). British Columbia's Disaster Financial Assistance Program support was made available to victims of the January 2005 extreme weather within the geographic boundaries of the following regional districts: Capital, Central Kootenay, Comox-Strathcona, East Kootenay, Fraser-Fort George, Greater Vancouver, Okanagan-Similkameen, Sunshine Coast, Cariboo, Columbia-Shuswap, Cowichan Valley, Fraser Valley, Nanaimo, Squamish-Lillooet and Thompson-Nicola.

*2) Henderson Lake, the rainiest place in Canada receives an annual rainfall of 8 m. In 1997, the station reported a record 9 m. (CBC newscast January 21, 2005).

*3) The owners of 2175 Berkley were shocked to discover that their property had been singled out for special concern in a report on slope stability submitted to the North Vancouver District 25 years earlier, long before they moved in. The study was commissioned in response to three other slides that had occurred in the previous year. Significantly, it found that the slides occurred in the "oversteepened" fill portions at the top of the slope following periods of heavy rain. The 1979 slides were all "surface slides originating in the lose fill at the crest of the slope." The study also found that only one house of between 120-130 on the top and

bottom of the escarpment covered in the study was on fill, the one at 2175 Berkley. (*The Vancouver Sun*, January 21 and 22, 2005). In December 1979, a slide on the same street only a few blocks away demolished a house. The houses were built prior to 1985 when the Municipal Act made geotechnical surveys prior to development mandatory. Overdevelopment of the Blueridge greenbelt made the whole hillside unstable (CBC newscast, January 20, 2005). After geotechnical studies showed nearby properties may be affected by future landslides, through the provincial emergency fund the District of North Vancouver later agreed to purchase eight of the nine properties most affected by the slide for an estimated cost of $6 million. Four of the properties are on Berkeley Avenue on top of the escarpment, where fill was used to increase lot sizes. Four others are on Chapman Way and Treetop Lane at the bottom of the slope. The homes were to be demolished, the fill removed, and the lots returned to their natural state and kept as green space. The district set up a model examining all previous landslides and the connection the connection to rainfall patterns in the Greater Vancouver Regional District over several decades. The district also installed a new system of landslide prediction technology.

In the fall of 2005, the District of North Vancouver introduced their Blueridge Escarpment Comprehensive Risk Analysis and Management Plan. Measures included the building of a short storm sewer section currently missing on upper Berkley; simultaneously, where they do not currently exist, the installation of lateral connections from the storm sewer to the property lines of all homes backing onto the escarpment on Berkley, Lennox, Layton, Hayseed Close and Carmen Place. Property owners backing onto the escarpment were asked to undertake the private property drainage improvements to collect rainwater from roofs, driveways and foundations, and connect that drainage to the storm sewer laterals at the property lines (*North Shore News*, September 25, 2005).

The district budgeted $640,000 for slope safety measures in 2006: $188,000 for monitoring the area, $160,000 for measures to improve slope stability; $216,000 for an engineering study and $76,000 for district-wide mapping. Other measures would cost a total of $20,000 (*The Province*, April 3, 2006). Redemption work to the slope included installation of a debris basin at the toe, removal of dangerous trees, improved drainage, and the installation of meters to detect rainfall and groundwater levels. Further work was carried out in the summer of 2007, which included hooking identified properties to the storm sewer system to redirect rainwater. Extensive remedial work was also carried out on six other properties (*The Vancouver Sun*, November 24, 2006).

Another area in North Vancouver was marked at possible risk of landslides. A report commissioned by the City of North Vancouver pointed to a landslide risk starting from properties along the side of the Mosquito Creek ravine. Although there are no downslope homes in the area, a public park including an unofficial trail and a salmon-bearing stream could be affected. The report by Westrek geotechnical engineers identified a high to very high risk of landslides starting from 19 properties built at the top of the ravine and a moderate risk at seven more properties. The geotechnical report identified the potential risk to the trail below from a landslide as high to very high for 22 properties at the top of the ravine. The risk to the creek was also rated high to very high for nine of the houses. Sewer adnd water mains near the crest of the slope could also be at risk in a landslide. Houses at the highest risk may need to consider pinning foundations to more stable soil. The report noted, “In some cases the value of the existing structures will not warrant the cost of remediating the risk and decisions will need to be made to either accept the risk or remove the house (*The Vancouver Sun*, July 22, 2006).

*4) The slide resulted in a large number of lawsuits and countersuits against the municipality, developers, neighbours, former owners and real estate agents. By early August 15 families had filed legal actions against North Vancouver District. In the year since the slide, real estate values in the neighbourhood plummeted, with some properties assessed at as little as $43,000. A full geotechnical study commissioned in August 2005 by the district for $450,000, and examining the stability of 80 properties along the escarpment was released in the middle of January 2006 (*The Vancouver Sun*, January 14, 2006).

In court papers defence lawyer for the North Vancouver District notes, “The slide originated on the Perrault property, not the green belt. The plaintiffs increased the instability by constructing a large approximately 4.5-6 m long 97,000 gallon concrete pool (fish pond), which was built without permission from the district.”

(*National Post*, June 8, 2005). The Kuttner suit claimed that the owners of the Perrault property had failed to construct adequate retaining walls to prevent a slide and had added to the risk by installing a large concrete pool and by disposing of fill excavated for the pool on the escarpment, thereby adding to its instability (*The Vancouver Sun*, June 29, 2005).
The owner of 2430 Chapman Way, next door to Kuttner's home, sued the District of North Vancouver after failing to reach a deal with the municipality on a buyout for her property. She claimed the district failed to take proper precautions against the landslide that damaged her property and left her house uninhabitable. The home had been among nine properties affected by the slide the municipality was prepared to buy out with $6 million from the province. The district bought and demolished eight of the homes, but no deal was ever made to purchase 2430 Chapman Way (*The Vancouver Sun*, June 29, 2006 and November 24, 2006).

*5) Flooding at Hatzic Lake occurs when the level on the Fraser River rises higher than the lake. According to Steve Diamond, an area property owner and trustee on the Dewdney Area Improvement District, noted that pumps are capable of handling no more than 20% of the water volume. He attributed part of the problem to CP Rail culverts not effectively draining the water (*The Vancouver Sun*, January 21, 2005).

*6) The cities of Burnaby and Vancouver with the assistance of the Greater Vancouver Regional District and other partners prepared a draft report for the Still Creek watershed. Titled "From Pipe Dreams to Healthy Streams: An integrated stormwater management plan for the Still Creek Watershed," the draft report outlines a vision for the reduction of the amount of flooding in the city while improving habitat for fish and wildlife. The report sets out eight goals for the future development of Still Creek. A central aim is to reduce the impact of flooding on people and property while reducing stream erosion and downstream sedimentation. The proposed environmental goals include protecting and enhancing both aquatic and terrestrial habitats, improving water quality; augmenting native species' biodiversity. The report also proposes that the creek be designated as an environmental flood channel zone, to prevent the construction of new buildings in the flood zone or along stream banks (*The Vancouver Sun*, June 22, 2006).

*7) Van Marrewyk claimed development, like CP Rail paving 40 ac. (16 ha), new subdivisions and a Superstore all lead to more runoff making the pump and floodgate capacity designed for 1980 inadequate. Pitt Meadows Mayor Don MacLean said the district will spend $160,000 this year studying the drainage problem (*The Province*, January 25, 2005).

*8) Perry Ridge had a long history of logging above the threatened residences. (CBC newscast January 24, 2005).

*9) The two ice-damaged North Thompson bridges would take a year to replace at a cost of $4 million (*The Vancouver Sun*, January 28, 2005).

February 3, 2005
Source: CBC newscasts February 4, 2005.
Details: On February 3, following heavy rain Highway 20 was cut by a series of mudslides east of Bella Coola on a section called "the Hill."

March 20, 2005
Source: *The Chief*, March 25, 2005; Phillips. 2005; CBC newscasts, March 20, 2005.
Details: On March 20 at 5:30 a.m., heavy overnight rain caused a debris flow on Turpin Creek. The mud and debris slide tore up sections of the Sea-to-Sky Highway, forcing temporarily closure of the highway. After the creek got plugged, it caused the highway to be flooded. An earlier report that the bridge had been washed out proved to be incorrect. A tour bus with only its driver got caught in the flooding. Equipment being used in the $600-million upgrade project for the 2010 Olympic Winter Games, was used to clear the mud and debris almost a metre deep on the road. The wall of debris from the slide reportedly originated well above

the highway. According to a Ministry of Transportation, construction on the highway did not contribute to the slide.

The storm trapped two separate groups of campers in the Elfin lakes area of Garibaldi Provincial Park. A helicopter located the missing people in the Red Heather area. The two groups decided to wait out the storm at the Elfin Lake hut. All six hiked out on their own in the deep snow to their vehicles in the Diamond Head parking lot.

June 28, 2005

Source: *The Daily Courier*, June 28, 2005; *The Daily Courier*, June 29; July 1 and 2, 2005; *The Province*, June 30, 2005.

Details: On the afternoon of June 28, an 80-m section of Westside Road near Bear Creek Provincial Park collapsed into Okanagan Lake. The northbound lane of the back road from Kelowna to Vernon disappeared 10 minutes after a scheduled construction blast on the steep hillside above the road. *1) The road was closed to traffic at the time. Heavy equipment was just about to start clearing away the debris when the road gave way. There were no injuries.

The collapse ruptured an 8-cm Terasen gas line and swept a Telus fibreoptic cable into the lake. Between 250-300 customers from Bear Creek to Lake Okanagan Resort lost telephone service. Approximately 65 homes were without gas until the afternoon of June 29. The road was closed north of Raymer Bay Provincial Park for about three weeks until crews finished a new section of road above the slide site. During this period, a water taxi was put into service to the homes along Westside Road. Residents of Traders Cove and other small communities were cut off from Kelowna.

During the last week of June, to prevent the water level from rising any higher, the Ministry of Environment tripled the controlled draining of Okanagan Lake dam in Penticton. The control gates were widened to permit the outflow to climb from 10-30 m^3/s. Heavy rains during the previous days had that months precipitation to date brought to just under 60 mm, above the average of 37 mm but well under the 102 mm recorded in June 1990. Some waterfront properties encountered seepage problems. *2)

---

*1) Arthon Construction of Kelowna has a $5.5 million contract to re-align, widen and install roadside barriers along a 1.1-km stretch of road between Raymer-Bear Creek Provincial Parks (*The Province*, June 30, 2005).

*2) During the month of June, the Kelowna airport recorded a total of 62 mm of rain, making it the third wettest June in the station's 37-year operation (*The Daily Courier*, July 1, 2005).

August 17, 2005

Source: *The Province*, August 18, 2005.

Details: On August 17, a mudslide east of Boston Bar derailed a westbound CN Rail train. The crew had just stopped to remove rocks from the track when the slide hit the train. The mud lifted several empty freight cars off the tracks. No one was hurt and no chemicals or regulated products were involved.

October 11, 2005

Source: *The Vancouver Sun*, October 12, 2005; *The Hope Standard*, October 13 and November 3, 2005.

Details: On October 11 around 6:30 a.m., a mud and rockslide onto CP Rail tracks near Yale caused an eastbound CN Rail train to derail. Two locomotives and seven empty railcars ended up over the embankment. The train's engineer and conductor escaped with minor injuries and were taken to hospital. Environmental crews were dispatched to assess the damage caused by a "significant" diesel spill from the two locomotives. The recovery of the locomotives created problems. As the soil was too soft to build a road into the area, a heavier-duty crane had to be brought in from the U.S.

October 17, 2005

Source: *The Vancouver Sun*, October 19, 2005.

Details: Late on October 17 near Bridal Veil Falls, a mud and debris slide came down onto the westbound lane of Trans-Canada Highway 1, closing it to traffic. The slide consisting of rocks, trees and debris knocked over powerpoles and lines that crashed down onto several cars and at least one semi-trailer. All the vehicle's occupants got out safely. The route was closed from the junction with Highway 9 at Rosedale east of Hope. Traffic was detoured via Highways 7 and 9. The highway remained closed until October 20, as the full cleanup was estimated to take 2-3 days.

November 4, 2005
Source: *The Vancouver Sun*, November 5, 2005; *Times Colonist*, November 5, 2005; CBC newscasts November 4 and 5, 2005.
Details: Just before noon on November 4, a mid-sized rock and debris slide about 22 km east of Spences Bridge covered both lanes and closed down Highway 1. No vehicles were hit but a tractor-trailer stopped seconds short of the slide, which was about of 12 m deep in one spot and 15 m long. Al Mitchell, the Ministry of Tranportation's area manager, said about 1,000 m^3 of material came down. The rail line, located just below the highway, was not affected. According to Ashcroft RCMP Sgt. Jerry Fiddick, heavy rain in the area on November 3 may have been responsible for weakening of the rock face. The highway was expected to reopen the next day.

December 14, 2005
(Fatal ice fall).
Source: *The Vancouver Sun*, December 21, 2005.
Details: On December 14 around 1 p.m., a 44-year old Canadian Pacific Railway employee was killed of head injuries after a massive 300-kg slab of ice fell on him. The accident occurred while the victim was working on an ice-clearing crew in Glacier National Park, breaking ice off the edges of a tunnel.

December 23-26, 2005
(Icejam flooding and cave-in).
Source: *The Province*, December 28, 2005; *The Vancouver Sun*, December 30, 2005; CBC newscasts December 23, 28 and 29, 2005.
Details: On December 23, a rockslide onto the CN Rail line west of Boston Bar covered 30 m of track. The crew of an oncoming train, alerted by an automatic warning system managed to stop their train in time. The line was not expected to be reopened until December 25. Train traffic was being rerouted over CPR tracks.

On December 26, icejam flooding on the Coldwater River caused flood damage to 6-8 homes in Merritt. Early on December 27, the North Thompson River jumped its banks after an icejam formed on a bend in the river. One house downstream of Birch Island was flooded with about 0.5 m of water.

Cooler weather on December 28 reduced river levels and the risk of flooding in the Nicola and North Thompson valleys.

On December 26, a cave-in occurred in Vancouver at Bute and West Pender Street. At least 20 m of Pender Street collapsed into a nearby excavation site. According to city engineer Tom Timm, the collapse may have caused by a failure to anchor the walls of the excavation as it was being dug. "… it would appear to me it was simply a failure of the shoring system." *1)

No one was injured but power was cut to hundreds of high-rise residents for the day. The cave-in also burst an 8-in. (20 cm) water main. Pools of rainwater from days of heavy rain compounded the flooding. The city issued a stop-work order to a company excavating the site for a new high-rise.
Traffic would be affected by the cave-in for several weeks. The 19 bus between Metrotown-Stanley Park was rerouted, terminating at Pender and Seymour.

---

*1) When digging holes adjacent to the street, the walls are covered with steel mesh, sprayed with concrete and then anchor rods are inserted under the road (*The Province*, December 28, 2005).

December 29, 2005-January 1, 2006
(Storm surge/tidal flooding).
Source: *The Vancouver Sun*, January 3, 2006; *Times Colonist*, January 3, 2006; *Campbell River Mirror*, January 4, 2006; *Courier-Islander*, January 4, 2006; *North Islander*, January 6, 2006.
Details: Between December 29-January 1, two powerful storm systems over a three-day period hit Vancouver Island. On December 29-30, a southeaster knocked out power to an estimated 17,000 homes on Vancouver Island, including 6,000 in the Comox Valley.

On January 1, high winds across the south coast stemming from a low-pressure system moving through Vancouver Island caused power outages and localised flooding. High winds lasting up to 15 hours hit the Victoria area. At Race Rock near Victoria, winds were blowing steadily at 81 km/h with gust as high as 98 km/h. At Point Atkinson, winds were blowing at 70 km/h, gusting to 93 km/h. At 4 p.m., a peak gust measured 93 km/h on Discovery Island. The winds severely damaged at least one sailboat near Waring Place in Cadboro Bay.

Winds also hit Vancouver's north shore where a number of trees fell on or near buildings on the evening of January 1. About 7,000 households were left without power across Sechelt and the Vancouver Island region. The southeaster knocked power out to 2,000 residences in Campbell River on January 1. Power outages also occurred in Black Creek, Sayward and on Quadra and Cortes islands. Storms since December 20 had already caused a number of outages on Cortes Island during the previous 10 days. Also affected by blackouts were Texada Island, Saltspring Island and Roberts Creek. By late afternoon on January 2, still some 4,400 customers were without power. On January 3, power was restored Cortes and Quadra islands.

On January 1 at 5:11 p.m., the Campbell River airport recorded a wind gust of 120 km/h. Coupled with a seasonably high tide, waves dumped rocks and driftwood along the Campbell River shoreline, covering the Seawalk and caused damage to Robert V. Ostler Park. It also caused damage and forced the closure of the highway at the downtown ferry terminal due to flooding and debris. Some of the logs even made it across the highway up to Banner's Restaurant.

The huge influx of precipitation to the Campbell River watershed caused BC Hydro to begin spilling water from the John Hart Dam. Between December 20-30, water levels rose 4 m from 215.4 to 219.4 m. Even though the Upper Campbell reservoir had been abnormally low only two weeks earlier, BC Hydro began spilling water from the dam on the afternoon of January 3. An additional 40 m^3/s was being spilled over Elk Falls for a total of about 160 m^3/s into the river. The spill was expected to last throughout the week.

With another weather system approaching on the evening of January 4, the spill was increased by another 60 m^3/s. With the Quinsam River adding another 80 m^3/s, this put the total river flow in the 300 m^3/sec.-range. Spill volumes could have been considerably higher had it not been for abnormally low reservoir levels earlier in December. *1)

---

*1) A particularly heavy spill in late 1996 caused an outcry after the newly finished Second Island spawning channel was washed away. This led to the formation of flow management agreements designed to better protect fish and habitat in the river (*North Islander*, January 6, 2006).

January 12-15, 2006
Source: *The Vancouver Sun*, January 14 and 21, 2006.
Details: On January 12, an evacuation alert was issued to some North Vancouver residents living along the escarpment of the Blueridge-Seymour area north and east of the Ironworkers Bridge on the road to Deep Cove. The evacuation alert covered 296 homes and between 900-1,000 people. As of 4 p.m. on January 13, the district had recorded 48.2 mm of rain. *1)

Around January 14-15, heavy rain triggered two landslides onto the Burlington Northern and Santa Fe (BNSF) railway tracks in South Surrey on the bluffs about 2 km west of the White Rock promenade. BNSF crews detected the slides before any trains arrived. The company described them as "minor." *2)

---

*1) The number that will trigger an evacuation is 70 mm. Landslides have occurred in the area when more than 70 mm of rain had fallen at one time. The District of North Vancouver uses this benchmark for an evacuation (*The Vancouver Sun*, January 14, 2006).

*2) The area has a history of landslides. In the winter of 1982, dozens occurred in a two-week period. An area community group, Semiahmoo Peninsula Citizens for Public Safety, urged that the BNSF tracks, used for freight and passenger service, be moved from the slide prone bluffs between White Rock-Surrey's Ocean Park and Crescent Beach. The new repositioned line would run parallel to 176th Street from the Canada-U.S. border, leading to existing tracks just south of Highway 10 that connect to Deltaport at Roberts Bank near Tsawwassen (*The Vancouver Sun*, January 21, 2006).

Ca. January 16, 2006
Source: CBC newscasts January 24, 25 and 26, 2006.
Details: Around January 16, a rockslide came down onto Highway 12 between Lytton-Lillooet, closing the highway to traffic for 10 days.

January 28-31, 2006
Source: *The Hope Standard*, February 2, 2006.
Details: On January 28 at approximately 7 p.m., heavy continuous rain caused a saturated rockface along Union Bar Road in Hope to give way. Nine families living above Thacker Mountain were left cut off for almost four days. Two small-size cars remained perched precariously above the roadway. Around January 28-29, the Coquihalla Highway was closed for 28 hours.

On January 31, a small rockslide came down near Sailor Bar tunnel, closing the highway for a few hours.

February 3-4, 2006
(Storm surge/tidal flooding).
Source: *The Province*, February 6, 2006; October 6, 2006; *Comox Valley* E*cho*, February 7, 2006 *The Vancouver Sun*, February 8, 9, 11 and 13, 2006; March 8, 2006; CBC newscasts, February 4 and 5, 2006; Ministry of Environment, Flooding report Feb/2006 – Boundary Bay and Beach Grove – Tsawwassen.
Details: On February 3-4, gale force winds hit the lower mainland and southern Vancouver Island. A Pacific low-pressure system passed over Vancouver Island, moving up towards the Queen Charlotte Islands. This system included a band of rain nearly 300 mi. (480 km) wide. At the same time, a high pressure front edged close to the Vancouver Island from the east, creating a rapid change in air temperatures, moisture content and a rapidly rising air mass. Overnight February 3-4, Comox recorded 40.6 mm of rain. On the evening of February 3, area experienced a seasonally unusual thunder and lightning storm.

Early on February 4, the Lions Gate bridge was temporarily closed to traffic in both directions. A number of B.C. Ferry sailings between the mainland and Vancouver Island were cancelled. The storm uprooted trees at the University of British Columbia and left up to 100,000 customers without power. The high winds knocked out power to some 50,000 homes. Courtenay's Lewis Park was almost completely under water on the morning of February 4. The Courtenay River was near the top of its banks.

On February 3-4, the high winds coincided with high astronomical tides, resulting in localised flooding which caused widespread damage to properties in the Boundary Bay and Beach Grove communities. Based on site observations and some comments by a number of local resident witnesses, the flooding was caused by wave over-wash and/or run-up to the beachfront properties. The excess water that flooded the front yards then flowed to the low-lying properties in the immediate vicinity and behind the beachfront houses. *1) The large volumes of wave water overtopping the seawall included significant amounts of floating debris that was strewn onto the front yards.

On February 4, higher than 18-ft. (5.4 m) tides and strong 80 km/h-winds caused a dyke to breach in Surrey. The area was flooded with water up to 1 m deep. Delta Mayor Lois Jackson declared a local state of emergency and residents of some 200 homes in the Beach Grove Drive area of Tsawwassen were issued

evacuation notices. At the height of the storm, 50 families actually left their homes. Delta homeowners suffered about $3 million in storm and flood damage (*The Province*, October 6, 2006).

After a tour of the area, Public Safety Minister and Solicitor General John Les estimated the property damage between $2-3 million. He stated that the province would compensate homeowners for 80% of accepted claims over $1,000 to a maximum of $300,000. *2) It was estimated that between 150-200 residences were affected. By February 11, about 100 South Delta residents affected by flooding in Boundary Bay and Beach Grove were expected to file intent-to-claim forms for emergency assistance money.

Costs to clean up the damage at Boundary Bay Regional Park were expected to reach $30,000, with most of that dedicated to clearing and dumping debris (log pickup and removal). The storm nearly wiped out the popular wooden boardwalk in the beachfront park. It was moved off its footings and literally floating. There was also damage to a portion of the raptor trail and dune trail. Even the southern end of the dike trail suffered some damage. Centennial Beach was also covered in logs and other ocean debris.

Starting February 13, the Stanley Park Seawall closed on weekdays for two weeks to allow for cliff stabilisation, removal of debris that could cause slides.

---

*1) At Boundary Bay, the concrete seawalls that protect the beachfront properties along a narrow beach, are an assortment of adjoining structures that are constructed to varying elevations. These individual seawalls are not recognised dike works that are regulated by the Inspector of Dikes. From 1A Avenue to Corbould Road, at the Canada-US border, the houses have very little setback from the seawall, making them more exposed than the properties to the north. Most houses in this community are not elevated above the general ground level and the water flooded their habitable ground floor areas. In the Beach Grove community, the beachfront properties are protected by continuous concrete seawall that is defined as a "standard" dike regulated by the Inspector of Dikes. Here also wave-run and over-wash flooded front yards and the excess water had flooded the ground floor of the houses that are generally not elevated above the local ground level. It appeared that the seawall from 16th Avenue to Kirkwood Road to have been exposed to higher wave energy and heights, and it was evident that the wave-overtopping of the seawall had been more severe (Ministry of Environment).
Les noted that measures taken to prevent flooding are inadequate. Instead of constructing a permanent seawall, Delta currently erects a $4,000 temporary sand berm each fall and flattens it in the spring allowing Boundary Bay residents their ocean views. Obviously preferring ocean views over protection, few years earlier homeowners rejected Delta Engineering Department's recommendation to build a wall. The Fraser River Estuary Management Program, which approved Delta's application in September 2005, expressed concern about the environmental impact of the process if it is continued indefinitely (*The Vancouver Sun*, February 8 and 11, 2006).

*2) By early March, 49 intent-to-claim forms for emergency assistance money had been filed by Tsawwassen residents.

February 9, 2006
(Fatal rockfall).
Source: *The Daily News*, February 10, 2006; *The Vancouver Sun*, February 11, 2006.
Details: On February 9, a 39-year old North Shuswap man was killed in Kamloops after being hit on the head by a falling rock. The victim was part of a construction crew building a retaining wall on 5100 block of Squilax-Anglemont Road near Celista. The worker walked beneath the wall when the rock toppled over the side and landed on him.

February 26, 2006
Source: *The Province*, February 27 and 28, 2006; CBC newscasts, February 26 and 27, 2006.
Details: On February 26 at about 4:30 p.m., a giant snowslide came down Paradise Mountain close to the Panorama Ski Resort near Invermere. The slide, which came down outside the ski resort area, struck a group

of snowmobilers. As at the time, it was believed that one member of the group got caught in the slide, an avalanche dog and heat-sensing equipment was brought in.

Searches continued the next day. When it became clear nobody was caught, the search was called off later on February 27.

March 3-5, 2006

Source: *The Vancouver Sun*, March 8, 2006; CBC newscasts, March 4 and 6, 2006.

Details: On the afternoon of March 3, an avalanche on McBride Mountain caught three skiers, killing two and injuring one. The victims were 42- and 46-year old B.C. men. The survivor managed to dig himself out and was later taken to the Nakusp hospital with non life-threatening injuries. Although a professional guide did not accompany the skiers, they were all equipped with proper safety equipment.

On March 5 at about 3 p.m., an avalanche near the Three Sisters area north of Fernie caught two snowmobilers, killing one. The victim, a 35-year old Sparwood heavy-duty mechanic at a local coal mining operation was found under his machine under 1 m of snow. The survivor was not seriously hurt in the avalanche. The two men were riding in an area popular with snowmobilers because of its powder bowls.

May 12, 2006

Source: *The Golden Star*, May 14, 2006; CBC newscasts, May 13 and 14, 2006.

Details: On May 12 at 10 a.m., thousands of cubic metres of debris came down 10 km east of Golden onto Highway 1 near Kicking Horse Pass. Some of the slide's boulders ripped through a protective fence, bounced off the road surface, went over a barrier along the east side lanes and cascaded down into the canyon to the CP Rail tracks below; some reached the tracks. The highway was closed for nearly two days. Dynamite was used to blast nearly 5,000 m^3 of rock from the unstable slope. According to Jeff Knight, Ministry of Transportation spokesman, the section 200 m east of 10-Mile Bridge has a "definite history of instability."

May 15-23, 2006

(Spring run off/flooding).

Source: *Times Colonist*, May 20 and 29, 2006; *Globe and Mail*, May 22, 2006; *The Vancouver Sun*, May 20 and 24, 2006; June 10, 2006; *Campbell River Courier-Islander*, May 17, 2006; CBC newscasts, May 21, 22 and 23, 2006.

Details: Unseasonably warm weather in southern British Columbia with record-breaking temperatures caused rapidly melting above-average snowpacks. This accelerated snowmelt in the middle of May, followed by moderate rain, produced significant high river flows and flooding throughout the Kootenay, Columbia, Okanagan and South Thompson basins.

The Granby River at Grand Forks saw a high flow level with a 50-year return period; the Kettle River at Grand Forks and the Salmo River had 30-year and 20-year return periods, respectively. Ten-year return periods were observed on the Bull River at Wardner, Mission Creek at Kelowna and the Slocan River, while the North Thompson River at McLure had a five-year one (*The Vancouver Sun*, June 10, 2006).

Around the middle of May, Vancouver Island mountains also had higher than average snowpacks. Comox Lake reservoir, BC Hydro's Puntledge River system showed about 130% of water inflows; the Jordan River near Sooke was about 140% of normal.

Around May 15-16, unseasonably warm weather caused water levels in creeks and rivers of southeastern British Columbia to rise. On May 18, the Environment Ministry issued a flood watch for much of the southern Interior, covering the West Kootenay and East Kootenay, Boundary, Columbia, Okanagan and South Thompson regions. The next day, an evacuation alert was issued in the West Kootenay Region.

Kettle River recorded the third highest flow since1930. As it was also feared that the heavy run off might result in contaminated water, boil water advisories were issued in Nelson, Kimberley, Invermere, Fernie and Wynndel. About 12 of the 400 drinking water systems in the east and west Kootenays were compromised.

On May 19, after the Slocan rose rapidly 53 homes were evacuated in the communities of Passmore and Slocan Park near Nelson. On May 20, the order was extended to another 25 residences. The Slocan River peaked around noon on May 22. None of the evacuated homes were believed to have been badly damaged. On May 23, flood waters started to drop steadily. That afternoon, although the evacuation order for 53 homes in Passmore and Slocan Park areas, the residents remained on alert status.

On May 20, a 21-year old man drowned after the fast flowing Ellis Creek swept him away. At midnight May 20-21, the Kettle River peaked.

In the Grand Forks area, 40 homes were on evacuation alert. By May 22, an evacuation alert remained in place for 375 homes. Fields and low-lying areas in Grand Forks flooded but no homes were seriously damaged. To protect 27 residences along the banks of the Granby and Kettle rivers more than 15,000 sandbags were placed. Water levels on the Kettle and Granby rivers, which meet in Grand Forks, crested about midnight on May 20. High flow continued on May 21 and started to drop by the afternoon of May 22. On May 23, floodwaters were still dropping but an evacuation alert remained in place for the 40 homes in the Johnson Flats area.

On May 28, after water levels had dropped significantly an evacuation alert for 166 homes near the Slocan River in the west Kootenays was lifted. The Provincial Emergency Program initially dispatched 130,000 sandbags to the Kootenays, but later upped it to 160,000. During the flood alert, a total of a quarter of a million sandbags were sent to 20 communities.

June 7–10, 2006

Source: *The Golden Star*, May 14, 2006; CBC newscasts June 7 and 10, 2006

Details: On the afternoon of June 7 a rockslide 20 km west of Revelstoke closed the Trans-Canada Highway.

On the evening of June 8, a rockslide east of Golden closed the same highway for 20 hours. Torrential rains caused 600 m^3 of "dirt and rocks" to come down across the highway from a slide path next to a large concrete wall at Bus Corner. One large boulder and three smaller ones all came down in the same area. A culvert blocked by the slide caused mud and water to wash over the road.

November 3-6, 2006

(Tidal flooding).

Source: *The Province*, November 5, 10 and 30, 2006; January 14, 2007; March 12, 2007; *The Vancouver Sun*, November 7, 14 and 15, 2006; December 30, 2006; *Campbell River Mirror Daily*, November 9, 2006; *National Post*, November 25, 2006; *Times Colonist*, March 6, 2007; *Metro*, March 7, 2007; CBC newscasts November 7, 2006

Details: On November 3, a one-day "Pineapple Express" brought intense rain and record breaking high temperatures to the Lower Mainland, Fraser Valley and southern Vancouver Island. The intense storm was the week-old remnant of typhoon Cimaron, the strongest storm to hit the Philippines in eight years, reached the British Columbia coast late on November 5. *1) As much as 10 to 15 mm of rain fell for 15 consecutive hours as temperatures soared to a record 17 ^{o} C.

This was the first of 14 storms with winds of at least 60k/h, some with torrential rains, to hit southern British Columbia during the next six weeks. *2) Environment Canada meteorologist Greg Pearce noted, "People who have worked in the Vancouver office for 25 years said they've never seen anything like it. It's one of the worst stretches of weather they've seen." (*The Province*, January 14, 2007).

Around 5 a.m. on November 6, it unleashed the heaviest rains ever recorded in British Columbia. Allan Chapman, head of the river forecast centre for the provincial Ministry of Environment, noted: "… we measured 20 to 25 mm and hour for three hours straight. We have never recorded rainfall that heavy." (*The Vancouver Sun*, November 7, 2006).

The amounts of precipitation varied widely. On November 3, Victoria airport recorded only 40 mm, Esquimalt reported 107.4 mm, while much more rain fell in the western communities. Agassiz recorded 114 mm, Abbotsford 80 mm; Vancouver 44.6 mm and Hope >100 mm. (Sooke 181 mm; Agassiz 180?)

On November 6, the Victoria International Airport recorded 38.8 mm of rain. Much higher amounts of rain fell downtown with 70 mm at UVic and Gonzales, 88 mm at Hartland Landfill and 107.4 mm at Esquimalt.

In the four days between November 3-6, Vancouver recorded 119.4 mm. On November 6, Abbotsford received 81 mm and Tofino recorded 110 mm in 24 hours.

Between 5 a.m.-6 a.m. that morning, Coquitlam recorded almost 12 mm of rain. In the 19 hours starting 5 p.m. on November 5, the Coquitlam weather station recorded a total of 101.4 mm. Adjacent areas – Port Coquitlam, Port Moody and the new UniverCity neighbourhood beside Simon Fraser University's Burnaby Mountain campus – recorded rainfalls almost as heavy as Coquitlam's. Some areas outside greater Vancouver were hit even harder with Agassiz recording almost 138 mm between the evening of November 5-noon the next day. Between the afternoon of November of November 2-November 8, some parts of the province measured up to 350 mm (*The Vancouver Sun*, November 7, 2006).

The storm triggered flooding and mudslides, closing highways and forcing evacuations on the Lower Mainland and Vancouver Island. Many rivers, including the Chilliwack River, Sooke River, San Juan River, and the Nooksack River overflowed their banks. The State of Washington was also hit hard. Around November 5, the Greater Vancouver Regional District closed the Capilano water reservoir due to high turbidity as a result of the heavy rains.

Blocked drains caused localised flooding, including at Stanley Park. In Vancouver, localised flooding occurred at Victoria and Broadway and in the 1500-block Knight Street at Knight Street and 15th Avenue. In Coquitlam, the school board offices' bottom floor was inundated with about 10 cm of water. Flood conditions on November 6 caused the closure of two low-lying roads: 88th Avenue between 168th-176th where the Serpentine River crosses and 116th Avenue around the 13600 block.

On the morning of November 6, floodwaters completely shut down two intersections: at Lougheed and Schoolhouse, the other at Lougheed and King Edward. One road in east Coquitlamd, Cedar Driver, was closed as the stream next to it overflowed its banks.

Flooding in the North Shore's sewage system dumped effluent into the environment in several areas across the North Shore. Waste water poured out of manhole covers in both North and West Vancouver. At the Lions Gate sewage treatment plant, some 13,000 L of effluent spilled onto the ground. During the largest of four successive storms, manhole covers along West Vancouver's Bellevue Avenue in the Ambleside neighbourhood were driven out of place, allowing raw sewage to spill onto the roadway. Gavin Joyce, who works in major projects for the District of North Vancouver, said that the sewage that the amount of sewage that escaped was relatively minor and very diluted (*The Vancouver Sun*, November 14, 2006).

Late on November 6, as the Squamish River was rising rapidly evacuations were under way in Squamish. The river was expected to continue rising the next day, causing some flooding upriver from Brackendale. The town of Squamish itself was not endangered.

The Chilliwack River, which hit a 25-year high and breached its banks, forced the residents of some 200 homes on Chilliwack River Road and Wilson Road area to evacuate. One resident, who had lived along the river for 23 years, noted that there had been small floods in the area every few years but she had "never seen anything like this." *3) Water poured across the road in many spots, flooding backyards and fields and leaving some houses partly under water. On the afternoon of November 6, the river peaked at 1,040 m^3/s, up from a normal rate of 50 m^3/s. Chilliwack mayor Clint Hames observed, "I've lived in the Fraser Valley for close to 50 years and I've never seen rain like that, for that sustained a period, in my life – I never have." (*The Vancouver Sun*, December 30, 2006).

The Fraser Valley Regional District declared a local state of emergency for the Chilliwack River Valley. As a precaution, Terasen Gas shut off gas to 168 homes in the area.

Heavy rains and an unusual high tide on the afternoon of November 6 combined to push the Englishman River over its banks and flooded a trailer park. Although rains eased later on that day, the Cowichan, Chemainus and Sooke rivers were expected to flood overnight November 6-7.
Sooke River overflowed its banks in several places, forcing the closure of Highway 14 between Victoria-Sooke for most of the day on November 6. Basements and backyards in Sooke were flooded.

A mudslide (Francis Lake slide) knocked out at least three spans of the hydro line to Nitinat, cutting off 326 customers. Although power was restored by 7 p.m. on November 7, at that time the road remained closed.

Along the Tulameen River, Princeton residents were put on flood alert. In Hope, 10 families near Silver Hope Creek were evacuated. Hope declared a local state of emergency at the Othello Tunnels area after debris blocked the Coquihalla River. More than 100 homes were put on evacuation alert. The Coquihalla River and Silverhope Creek overflowed their banks. A mud and debris slide 3 km east of the highway interchange covered the road with up to 50 m of mud and debris up to 3 m deep, closing Highway 3 between Hope-Princeton east of Hope. A second mudslide on Highway 3 closed the road about 15 km from Princeton. Rains on November 6 caused three road washouts on Hemlock Valley Road. *4) Late on November 7, Harrison Mills-Hemlock Valley section was still closed.

Heavy silting occurred in a brook that runs through the Rossland ski hill property of the Red Mountain Resort. The intense rain in November caused an inadequate drainage system to silt up. According to environmental consultant Sylvia Masse, this led to "unacceptable levels of turbidity" in the brook at the mountain. Uncontrolled drainage and large areas of exposed soils were the main cause (*The Province*, March 12, 2007). *5)

---

*1) Typhoon Cimaron was classed a maximum five-category storm, as intense as Hurricane Katrina, which devastated New Orleans in 2005 (*The Vancouver Sun*, November 7, 2006).

*2) According to a new study announced in the journal *Proceedings of the National Academy of Sciences*, soothy sulphurous coal smoke from Asian industry, largely in China and India, may influence weather patterns around the world. Floating soot particles change the chemistry of the air, making regular clouds form into towering storm clouds through convection. It was the first time climate scientists have been able to measure the effect of "aerosols," the minute airborne particles, on climate. Although the study so far covered a relatively short time frame by climate standards, comparing the period 1984-94 with 1994-2004, the differences were "unambiguously" due to pollution. The second period averaged between 20-50% more storm activity. The study, led by Renyi Zhang of Texas A&M, concluded that the particles helped generate more intense thunderstorms than previously. "The intensified Pacific storm track is climatically significant." (*Times Colonist*, March 6, 2007; *Metro*, March 7, 2007).

*3) Local residents have been complaining about the dyke system for years, most recently three years earlier when heavy rains caused a minor flood. In the late 1990s, the federal government stopped funding Fraser River dredging. The Fraser River Port Authority supports the creation of a sustainable dredging fund to remove the accumulated sand near the mouth of the river. According to Steve Litke, program manager of the Fraser Basin Council, dredging might help decrease the flood risk through Kent and Chilliwack, but would not be significant at the mouth of the river. He noted that the dykes in Delta and Richmond have been built high enough to withstand ocean surges that cause high water and considers the sand more a navigational issue than a flood risk (*The Province*, November 10, 2006) In 2002, the provincial government cut a flood protection assistance fund that paid up to 75% of dyke maintenance costs. In the wake of the latest flooding, the provincial government prepared for new flood protection works along the Chilliwack River. Upon completion of a $56,000 study of the problem, decisions would be made where the extra work could be done (*Campbell River Mirror Daily*, November 17, 2006**)**.

*4) The provincial ministry of transportation posted a round-the-clock watch at a slide-prone stretch of road leading to Hemlock Valley Resort near Agassiz, 115 km east of Vancouver (*National Post*, November 25, 2006).

*5) Prior to the November storm, a series of reports noted that a retention pond, where runoff water was supposed to collect and allow the silt to settle out, was built too close to the brook it was supposed to protect. Improvements Masse recommended in a series of reports starting in August 2006 were not implemented. Consequently, the pond ended up contributing to the silting problem. The provincial Ministry of Environment later fines Red Mountain Resort for permit violations. The resort was issued a ticket for $285

plus costs and told to bring its construction projects "back into compliance and make sure there is no further silting (*The Province*, March 12, 2007).

November 10-12, 2006
(Storm surge/flooding).
Vancouver, 57.0 mm/3 days (November 10-12, 2006)
Source: *Times Colonist*, November 14, 2006; *North Shore News*, November 17, 2006; *The Vancouver Sun*, December 1, 2006;
Details: On November 10-12, high winds, heavy rain and exceptionally high tides threatened homes along ocean fronts and river banks, including Tsawwassen. On November 11-12, sewers backed up in several areas across the North Shore, causing flooding.

On the evening of November 12, high winds damaged a number of small craft near Victoria, some being smashed onto Gyro Park.

November 15, 2006
(Storm surge/flooding).
Source: *The Province*, November 16 and 30, 2006; *The Vancouver Sun*, November 14, 15, 16, 24 and 25; December 1 and 30, 2006; *The Campbell River Mirror*, November 17, 2006 and December 15, 2006; *Campbell River Mirror Daily*, November 17, 2006; *North Shore News*, November 17, 2006; *North Islander*, November 17, 2006 and December 15, 2006; *Times Colonist*, November 18, 23 and 24, 2006; *Totem Times*, December 12, 2006; CBC newscasts November 15, 16, 17, 18, 22 and 24, 2006; January 3, 2007;
Details: On November 15, the third major rainfall hit the Vancouver area in November. The storm was a result of two weather systems; one coming from Hawaii and the other from Alaska. The new system brought warmer than normal temperatures. In the Vancouver area, more than 150 mm of rain fell in 15 hours. On November 15, Comox recorded 62.2 mm of rain; the Vancouver International Airport 38.8 mm and Vancouver 75.7 mm; Abbotsford received 19.3 mm; and White Rock and Hope 17.4 and 21.5 mm, respectively.

The heavy rain and wind caused havoc on Vancouver Island and the Lower Mainland. *1) Classes were cancelled at 15 schools in the Langley district and SFU's new Surrey campus. On the North Shore, 50 residents of the Sunset Highlands Seascapes condo development and Ansell Place were forced to evacuate. In East Vancouver, high winds may have contributed to the collapse of a steel-framed building under construction on Commercial Drive. In the morning, most of the BC Ferries sailings and some floatplane services were cancelled. Extreme winds caused the diversion of three Westjet 737 jets from the Abbotsford airport to Vancouver International airport. Downed trees between Horseshoe Bay-Squamish closed the Sea-to-Sky Highway for several hours. The weather system with winds gusting to 125 km/h caused flooding, power outages, downed trees across the North Shore and forced the cancellation of almost all ferry runs on November 15. In the West Vancouver area alone, an estimated 500 trees came down or were damaged.

Flooding on the North Shore was not as bad as the previous weekend after sewers backed up in several areas across the North Shore.

High snowfall at higher elevations enabled ski hills to open ahead of schedule. Between late November 9-November 13, Whistler's Blackcomb Mountain resort had received 75 cm of snow and a total of 132 cm since the beginning of the month. The snow depth is measured at an altitude of 1,650 m, about two-thirds of the way up the mountain. The increasing accumulation of snow at the top of Grouse Mountain forced the closure of the Grouse Grind trail around November 11-12.

Spot flooding occurred in many locations, including at Vancouver's Water Street. Lynn Creek breached its banks. High waves battered the White Rock shoreline. Boundary Bay residents managed to hold off the high tide from breaching the retaining (sandbag) wall that was built after the last storm, which flooded bayside homes. Heavy rains swelled Thane and Francis creeks to historic heights and washed large amounts of silt into the Lower Mainland's water supply.

Maximum wind speeds over100 km/h were reported from the Fraser Valley; In Abbotsford sustained winds peaked at 74 km/h and gusts of up to 102 km/h were recorded. White Rock had winds as high as 43 km/h with gusts up to 70 km/h. Vancouver International Airport had sustained winds as high as 57 km/h with gusts to 76 km/h. Gonzales recorded gusts up to 91 km/h; Comox 84 km/h. and 121 km/h in the Strait of Georgia.

At its peak, the storm left some 210,000 BC Hydro customers across the province without power, mainly due to fallen trees and tree limbs. Late on November 20, Nitinat and Bamfield got their power restored. On Vancouver Island alone, about 50,000 homes were without power. Ted Olynyk, BC Hydro spokesperson, noted: "We had something similar in 2004, but this is the worst I have seen." Early on November 17, some 9,000 customers were still without power.

In the Victoria area, fields along Oldfield Road were flooded. Near Parksville, the Englishman River flooded the low-lying trailer park on Martindale Road. The local Search and Rescue water rescue team evacuated the residents by boat.

Port Alberni was the epicentre of the storm, recording sustained winds of 60-70 km/h and gusts up to 105 km/h. An amateur weather watcher in Port Alberni reported 20 mm of rain falling each hour for several hours. A spokesman at the Port Alberni works yard, said that this was "the worst rain event anybody in the yard can remember." In Port Alberni, where some 132 mm of rain fell, some 200 houses flooded. The city was hit hard by a power outage and flooding that closed Highway 4. Up to 2.5 ft. (75 cm) of water covered some lower areas of the roads. The flooding and fallen trees closed Highway 4 between Ucluelet-Sutton Pass and past Cathedral Grove.

Flood warnings were issued for the Cowichan, Chemainus, Englishman and Gold rivers, which all peaked between 9 p.m. on November 15 and the next morning 1-2 a.m.

After this major storm dumped 150 mm of rain on the North Shore, at least 35 landslides came down into two of Greater Vancouver Regional District's watersheds. These caused the drinking water to become muddy and cloudy. On November 16, turbidity (discolouration from suspended silt) levels in the Seymour and Capilano water reservoirs reached unprecedented levels: 100+ NTU and 71 NTU, respectively, the highest levels ever. By late on November 18 the turbidity levels were still in the mid-10s. The maximum turbidity level in the Coquitlam watershed was 9 NTUs, also reached on November 16 (*The Vancouver Sun*, December 1, 2006)

On November 16, GVRD issued a boil-water advisory for two million people in the region, the biggest such warning in Canadian history. The next day the advisory was lifted for about half of those people. But for nearly a million Vancouver area (Vancouver, Burnaby, North Vancouver and parts of West Vancouver) residents the boil water advisories lasted for almost two weeks until November 27.

On November 18-19, more rain caused further landslides and the turbidity in the Seymour reservoir to go up again. Turbidity levels in the Seymour reservoir were coming down faster than those in the Capilano reservoir. On November 24, in the Seymour were around 10. Because it was expected to clear up slower than Seymour reservoir, the Capilano water reservoir was taken out of service. *3)

Due to a break in a major water pipeline from the Seymour reservoir the North Vancouver campus of Capilano College was closed for a few days. The break occurred in a weld between two sections of 130-cm steel pipe, dating back to the 1950s. To compensate for the loss of the pipeline, the GVRD diverted water from the Capilano reserve, which had been closed around November 5 due to high turbidity.

Boil water advisories were declared from Lions Bay to Maple Ridge, as well as Port Alberni, Parksville, Chemainus Mayne Island and Nanaimo.

On November 17, an18-ft. (5.4 m) long and 4-5 in. (10-12.5 cm) wide fissure was observed at Lions Bay.

In Campbell River on November 16, a combination of heavy rain and high tide forced the temporary closure of 16th Ave. in front of Nunns Creek Park. Earlier in the day, high winds knocked down powerlines, affecting 1,048 BC Hydro customers. Power was also knocked out to 760 homes on north Quadra Island, as well as part of Cortes Island.

A large landslide came down into the Phillips River in Phillips Arm, north of Campbell River. Besides entering the river system the slide blocked a logging road. It may not have caused as much damage

to fish habitat as first thought. Only small debris and no logs entered the river system from the slide, which started quite high above any logging operations (*The Campbell River Mirror*, December 15, 2006).

Flooding, mudslides and washouts closed many highways. Tahsis, Gold River and Bamfield were cut off from the rest of Vancouver Island by road. A landslide in Gold River near Muchalat Drive and numerous washouts closed Highway 28 between Gold River-Buttle Narrows. Saunders Bridge on Highway 28 between Campbell River-Gold River was severely damaged. Overnight November 15-16, the storm stranded about 200 workers at the Myra Falls mine due to unsafe road conditions and mudslides on Highway 28. The bridge over Thelwood Creek was damaged forcing the NVI Myra Falls mine to close for about a week, reopening on November 23. A mudslide also closed the Head Bay Road between Gold River-Tahsis. The road had first to be made safe for Ministry of Forests heavy equipment to come in and repair the washed out Conuma Bridge. On November 17, Tahsis, Gold River and Bamfield were still cut off by road from the rest of Vancouver, with people stuck on either side of impassable highways.

Highway 19 was closed between the Sayward junction and Woss due to two mudslides, including one near Eve River. The mudslide 37.5 km north of the Sayward Junction engulfed about 200 m of the road, blocking traffic in both directions. In the village of Sayward, creeks overflowed their banks, flooding basements of some homes. About 75 km north of the Sayward Junction, a mudslide left about 50 m of mud across Highway 19, totally blocking it. It was later reopened to one-way traffic.

---

* 1) The insurance cost for the storm was $20-30 million, not including the millions of dollars in revenue lost by restaurants, coffee shops and other businesses that depend on clean tap water (*Times Colonist*, November 24, 2006).

*2) Vancouver recorded 350.8 mm of precipitation in November, exactly equalling the previous record set in 1883 (*The Vancouver Sun*, December 1, 2006). By the end of November 23, Victoria had already recorded 285 mm of rain, wiping out the standing record for rainfall in November of 277 mm, set in 1998. Victoria International Airport set a new November precipitation record with 351.9 mm, breaking the previous record of 342.6 mm set in January 1953, and well beyond the November normal of 147.2 mm (*Times Colonist*, November 24 and December 1, 2006; *The Vancouver Sun*, December 30, 2006). Although not a record, the 290.9 mm of rain recorded at Comox in November, this was well above the normal monthly average of 188.1 mm (*Totem Times*, December 12, 2006).

*3) In the past, the Capilano reservoir has been out of service for months at a time because of turbidity problems. Water from the Seymour one is preferred because it comes from farther away, making its water exposed to chlorine for about three hours before it reaches its users compared with 45 minutes for Capilano. The large Coquitlam reservoir supplies about 65% of the region's tap water (*The Vancouver Sun*, November 24 and 25, 2006). A long-term solution to the problem is expected in 2009 with the opening of the $600 million Seymour-Capilano Filtration Plant (*Campbell River Mirror Daily*, November 17, 2006).

November 19, 2006

Source: *The Vancouver Sun*, December 30, 2006.

Details: On November 19, another Pacific storm brought an additional 60-90 mm of rain and strong winds to coastal British Columbia.

November 25-29, 2006

Source: *Times Colonist*, November 26 and 28, 2006; December 2, 2006; January 21, 2007; *Comox Valley Record*, November 29, 2006; *The Province*, November 30, 2006; March 29, 2007; *The Vancouver Sun*, November 28, 2006 December 1 and 30, 2006; *Times Colonist*, November 27, 28; December 2 and 5, 2006; January 7, 21 and 27, 2007; *The Hope Standard*, November 30, 2006; *Campbell River Courier-Islander*, December 6, 2006.

Details: On November 25, an Arctic front and a moist Pacific warm front did not collide but passed each other over Vancouver Island. The warm front brushed the cold Arctic air, mixing causing precipitation in the

form of snow without bringing the temperature back up resulting in extremely low temperatures. The Arctic high-pressure outflow caused temperatures to drop to -12^{o} C, a deep freeze only seen every 20 years or so at this time of the year. Snow blanketed the southwest with record depths over six days. On the night of November 26, the Coquihalla Highway closed due to a run of accidents north of the tollbooths.

The Greater Vancouver region received the most snow in almost 10 years. The amounts of precipitation and temperatures varied widely. Overnight November 25, Abbotsford received 53.1 cm of snow, breaking the previous record of 31.8 cm set in 1975, or the all-time one-day record of 49.8 cm set on January 21, 1954. Chilliwack recorded between 23.5-36 cm of snow. Comox recorded 18.8 cm of snow on November 25-26. Campbell River recorded 22 cm, Nanaimo 15 cm and Port Alberni 12 cm of snow. Up to 60 mm of snow fell in the eastern Fraser Valley.

More snow fell on November 27 and 29. The Victoria airport recorded 23 cm of snow over two days. *1) Victoria reported 28 cm of snow; Nanaimo and Campbell River, 40 and 29 cm, respectively.

For the second time in five years, a boat shed at the Freshwater Marina in Campbell River fell victim to heavy snow. The north end of "F" Shed partially sank on top of boats sheltered underneath. Three vessels sank and a number were damaged. *2)

Power blackouts throughout the Greater Victoria region kept schools and offices closed. On December 1, two schools in the Sooke school district as well as the Port Renfrew Elementary remained closed. Ruptured 2-in. (5 cm) water pipes closed the Cedar Hill Golf Course clubhouse, causing $200,000 worth of damage. The storm downed trees along the Trans-Canada Highway in Gold Stream Park. One death was blamed on the snow when a 67-year old Sooke man died on November 28 from a heart attack while shovelling his driveway. Early on November 27, Victoria's BC Transit service was sporadic, while Via Rail cancelled its E&N rail service. For much of the day, flights were cancelled at the Victoria International Airport. A blinding snowstorm forced a Harbour Air Twin Otter floatplane to make an emergency landing near the Tsawwassen coal port, well short of its destination.

On November 27, all 28 Chilliwack schools were closed. On November 26, Highway 1 throughout much of the Fraser Valley was virtually impassable. Icy conditions on Highway 1 between the Sumas exit in Abbotsford and 264 Street exit sent more than a dozen vehicles into the ditch.

The City of Victoria parks department estimated it would cost at least $250,000 to clean up broken trees and replace the ones beyond saving. In Colwood, costs directly associated with clearing branches and downed trees from roads, drains and ditches was about $200,000. In Sooke, this cost would be well over $100,000. Metchosin's cost of snow removal was estimated at $20,000 and $10,000 for wind damage (*Times Colonist*, January 7, 2007).

In Victoria, more than 200 trees came down in Beacon Hill Park and Ross Bay Cemetery along with several boulevards. A fundraising plan was launched to raise $200,000 to replace and care for the lost trees. Early December the city continued to keep parts of Beacon Hill Park and Ross Bay Cemetery closed to the public due to risk of falling tree limbs. Capital regional District' s trails washed out and the road access into Sooke Potholes was blocked. In the 140-ha Forest at Royal Roads University about 100 trees, some as old as 200 or 300 years, came down. (*Times Colonist*, January 21 and 27, 2007).

Costs of clearing fire-access roads into the Greater Victoria watershed was estimated at up to $1 million. Saanich estimated its cleanup cost "in the six figure" range. The heavy snow caused "substantial damage" to VanDusen Botanical Garden, the 55-acre garden at the corner of 37th and Oak Street. On November 27, the Vancouver park board arboriculture hotline received hundreds of calls about fallen branches and trees down.

Early on November 27, a very large 300-year old Douglas fir tree, estimated to weigh 46 tons, came down onto the 450-ft. (135 m) long Capilano Suspension Bridge. That night 18 cm of heavy, wet snow, driven by 80 km/h winds had fallen in the area. Engineers estimated that the tree struck with a force and velocity of a fully loaded gravel truck at highway speeds (i.e. 100 km/h). The bridges cables remained undamaged and the bridge stayed in place. The structure's west anchor, weighing 13 tons shifted by about 2 m (***The Province***, March 29, 2007). *3)

New power outages hit the Gulf islands and several areas in North Vancouver. On November 27, more than 90,000 customers in the Lower Mainland and on Vancouver Island were without power. On that

evening, about 18,000 Greater Victoria homes were without power, down from 30,000 earlier in the day. All together about 39,000 customers were still in the dark on Vancouver Island and the Gulf Islands, including major outages at Shawnigan Lake, Cobble Hill, Genoa Bay and Duncan.

Late on November 30, power to approximately 7,000 customers in Greater Victoria and another 3,000 in Duncan, Ganges and Pender Island still had not been restored. Early on December 2, still some 2,000 homes were without power.

---

*1) The snowfall did not break the record set on November 26, 1985, when 16.4 cm of snow fell in one day. The overall record snowfall occurred in 1996 when just after Christmas 164.3 cm fell at Victoria Airport in three days, including 60 cm in one day (*Times Colonist*, November 28, 2006). Victoria had six days of snow with back-to-back days of more than 15 cm. The accumulation of 40 cm was the second-greatest November total in 66 years of weather record keeping and 91% of an average year's accumulation (*The Vancouver Sun*, December 30, 2006). Additional snowfalls on November 27 and 29 made November 2006 the "snowiest" for Vancouver. The city recorded a total of 28.6 cm, breaking the previous record of 22.4 cm set in November 1975 (*The Province*, November 30, 2006). At the Vancouver International Airport, November snowfall totalled 38.6 cm. The November precipitation broke record at the Victoria water reservoir dating back 100 years. It boosted the water levels in the Sooke Lake reservoir from 55% to 86% over the 30 days (*Times Colonist*, December 2, 2006).

*2) Five years earlier, it was "G" Shed that came down under the weight of snow, sinking and damaging several vessels (*Campbell River Courier-Islander*, December 6, 2006).

*3) Although the top of the tree broke off, coming to rest in the canyon below, the remainder estimated at 17 tons wound up on the bridge. Removal of 17 tons of downward force will create a lot of upward cable force, creating a "slingshot effect." This could cause the entire tree to spring skyward along with whoever would be working at it. The weight of the tree had to be gradually removed. It was cut in half lengthwise, followed by a series of small crosscuts. Then, small slices were gradually removed, while a system of tree-supported cables and pulleys worked to carefully lift and swing the remainder of the tree from its perch. At the same time, the west cable anchors were replaced with even heavier anchors and re-set (*The Province*, March 29, 2007).

December 11-13, 2006

Source: *The Province*, December 12 and 14, 2006; *The Vancouver Sun*, December 12, 13 and 14, 2006; *Times Colonist*, December 12, 13, 14, 19 and 20, 2006; *Campbell River Mirror*, December 15, 2006; *North Islander*, December 15, 2006.

Details: On December 11, winds across the south coast reached highs of between 83 km/h at the Vancouver International Airport, 109 km/h at Abbottsford, and 115 km/h off the coast of Tofino. On Discovery Island, just off Oak Bay, winds gusted to 102 km/h. At the Victoria International Airport, where winds reached 67 km/h with gusts to 94 km/h, an unoccupied Cessna 150 aircraft was upended and blown 30 m away from its parking spot. Such an event "is tremendously unusual – the gusts have been amazing," said Terry Stewart of the Victoria Airport Authority. A couple of commercial flights were also cancelled.

Unlike a so-called Pineapple Express that originates around Hawaii and brings lots of rain, the December 11 storm originated off Oregon and was not nearly as wet. The heaviest rainfall was recorded at North Vancouver's Mahon Park, where 25 mm fell. The wind was accompanied by record high temperatures, The 11.9 ^{o} C and 13.8 ^{o} C temperatures measured at the Vancouver International Airport and Abbotsford, respectively broke the previous records of 11.6 ^{o} C and 13.5 ^{o} C, both set in 1995.

The winds brought down several trees in Stanley Park. After one fell onto the hood of a northbound moving vehicle at 3 p.m., the causeway through the park was closed for two hours. The high winds caused delays of up to and hour on several BC Ferries routes, including Tsawwassen to Swartz Bay and the southern Gulf Island. The high winds and rain temporarily closed down Highway 4 was closed east of Port Alberni, while downed wires closed the road to Mount Washington.

The strong winds on December 11 caused widespread power outages, leaving some 190,000 BC Hydro customers without power. In the Greater Victoria area about 4,000 homes were affected and another 14,000 in the Cowichan Valley while many of the Gulf Islands also lost power.

On December 12, BC Hydro estimated 37,000 homes would remain without power overnight in the Sunshine Coast, Powell River and northern Vancouver Island areas, and many would be without power for several days. On December 14, BC Hydro urged tens of thousands of its customers, many of whom had been without power since the December 11 windstorm, consider to leave their homes till the power would come back on. A Hornby Island resident had to be hospitalised from carbon monoxide after she tried to heat her room by burning kerosene.

Overnight December 12-13, another windstorm caused new power outages. By the evening of December 13, 53,000 customers on Vancouver Island and parts of the Sunshine Coast were without power, up from 37,000 the previous night. At 10 a.m. on December 13, BC Hydro saw 25,000 customers in the Cowichan Valley and the Saanich Peninsula fall off the power grid. At its peak, some 70,000 BC Hydro customers lost power. The Port Alberni area was hard hit. Late on December 13, about 4,000 homes were without power, 3,000 of them around Sproat Lake.

On December 15, still about 3,500 customers in the Campbell River, Quadra and Cortes Island areas were without power and 4,000 customers in the Comox Valley. Other areas affected were Mount Washington, Black Creek, Tahsis, Zeballos, Coal Harbour and Quatsino. Bamfield was particularly hard hit with 172 spans of line down. “It’s unprecedented damage,” said BC Hydro’s public affairs co-ordinator Stephen Watson. “That line was put in during the 1970s and the crews [have] never seen anything like that.” (*Times Colonist*, December 19, 2006).

Trees across roads and wind-driven debris hampered Telus technicians trying to restore service to thousands of customers on Vancouver Island. Problem areas were Nanaimo, Thetis Island, Duncan, Port Alberni and Powell River. By late afternoon on December 12, about 3,500 Telus customers, most of them around Duncan, Nanaimo and Miracle Beach, remained without phone service. Fallen trees temporarily closed West Saanich Road, Mill Bay Road and the Trans-Canada Highway near Valleyview Centre in Cobble Hill. In Duncan, more than 40 trees were blown down along a kilometre of Glenora Road.

On December 11, strong southwesterly winds also devastated dozens of Vancouver Island’s oyster farms. Damage was expected to be in the millions. Equipment was spread over a very wide area. The provincial government made $25,000 available to help pay to retrieve equipment from beaches and waters *1) (*Times Colonist*, December 20, 2006).

Campbell River reported the “usual" flooding and lots of debris on the roads. Around December 13, high streamflow advisories were out for the Cowichan, Chemainus, Nanaimo, Englishman and Tsolum rivers. On December 12, when the power went out, pumping stations also went down. At 4:30 p.m., the Comox-Strathcona Regional Districts issued a boil water order for users of the Black Creek-Oyster River water system. The area affected stretched from north of Kelland Road in Black Creek to the Driftwood Restaurant in Area D. The order was lifted on December 13 at 11:30 a.m.

On December 13, huge waves overtopped Victoria’s Dallas Road seawall near Ogden Point, soaring as high as nearby houses. Streamflow advisories were issued for the Cowichan, Chemainus, Nanaimo, Englishman and Tsolum rivers. .

---

*1) In 2005, farmed oysters had a wholesale value of $16.5 million. About 1,000 people are employed in the cultivated shellfish industry with many of the operations being small family businesses. The B.C. Shellfish Growers Association represents 170 members, who have 450 growing sites on 250 farms around Vancouver Island (*Times Colonist*, December 20, 2006).

December 15-18, 2006

(Tidal flooding).

Source: *Nanaimo News Bulletin*, December 16, 2006; *National Post*, December 16, 2006; *The Province*, December 17, 19, 20 and 22, 2006; March 11, 2007; *The Vancouver Sun*, December 16, 18 23 and 30, 2006; February 7, 2007; April 11, 2007; *Times Colonist*, December 16, 17, 18 and 19, 2006; January 20 and March 6,

2007; *Campbell River Courier Islander*, December 15 and 20, 2006; *Nanaimo News Bulletin Daily*, December 20, 2006; *The Globe and Mail*, December 21, 2006; *Campbell River Mirror Daily***,** January 4, 2007; *Campbell River Mirror*, January 17, 2007; ***Comox Valley Echo,*** February 2, 2007; newscast CBC, December 31, 2006**;** April 19, 2007.

Details: On December 15, a centre of an intense low-pressure system moved over Vancouver Island and the Lower Mainland. It was the third and strongest major Pacific storm in five days to hit the British Columbia coast. Anne McCarthy, weather services specialist for Environment Canada said, "… all of these three storms, each one hit different places with different strengths." This storm activity was somewhat unusual for Vancouver Island. The storms cut a swath straight across Vancouver Island, instead of the more usual pattern of tracking to the north coast around the Queen Charlotte Islands and Prince Rupert. The wind came straight across the cold North Pacific and hit land, rather than taking the more common route of dipping south and picking up tropical moisture.

In all three storms, the wind started over the North Pacific, gathering speed across the ocean into the "funnel" of Juan de Fuca Strait and then hit Vancouver Island in full force. "What has been interesting about (last) week are three in a row, the 'bang, bang, bang syndrome,' and two of those windstorms have involved taking the centre of the storm across Vancouver Island itself," McCarthy observed (*Campbell River Courier Islander*, December 20, 2006).

At about 9 p.m. on December 14, the barometer measured a low of 98.1 kilopascals at the Vancouver International Airport. Between 1 a.m.-4 a.m. on December 15, the strongest sustained winds were recorded at the airport weather station. By 4 a.m., winds were blowing at 67 km/h with gusts to 80 km/h. Wind gusts of 157 km/h, hurricane-force, were recorded at Race Rocks, off Vancouver Island's southwest tip. *1) Gonzales recorded gusts up to 124 km/h and Point Atkinson near West Vancouver 119 km/h. Winds at Nanaimo topped out at 80 km/h near Entrance Island.

The massive storm with 100-km/h winds and heavy rains brought down trees, taking down powerlines and damaging dozens of homes. Around Greater Victoria that suffered the most damage had winds that gusted to between 70-90 km/h. The heaviest damage occurred in the southwest corner of Vancouver Island: Sooke, Metchosin, Colwood, Langford and the Highlands. Early on December 15, Greater Victoria Harbour Authority's Fisherman's Wharf failed due to high winds. Until a pile driver could be brought in to do repairs, several float homes had to be temporarily relocated. The *SS Beaver* went adrift after a rail was ripped out of the dock.

According to spokesman for the Insurance Bureau of Canada Serge Cobeil, weather-related insurance claims since the beginning of November were estimated at $80 million. BCAA Insurance said it received more than five times the usual claims for this time of the year. Claims were mostly for collapsed fences, roof and shingle damage, trees falling on structures and power outages causing damage to electrical equipment (*Campbell River Mirror Daily*, January 4, 2007).

In Greater Vancouver, fallen trees closed key traffic arteries for part of the morning rush hour, including Dewdney Trunk Road in Maple Ridge, Gaglardi Way in Burnaby and the Stanley Park causeway. On the morning of December 15, Lions Gate Bridge was closed to traffic. By 3 p.m., road crews had cleared approximately 100 fallen trees blocking the causeway through Stanley Park and the Lions Gate Bridge was reopened. Power outages halted all SkyTrain's Expo Line in Surrey for several hours. A fallen tree across the tracks near Brentwood Station grounded the Millennium Line from VCC-Clark to Holdom Station. In Vancouver, falling trees struck at least 12 homes. By mid afternoon, City staff had received 300 calls about fallen trees.

Victoria's rural western communities from Langford to Sooke were particularly hard hit, as fallen trees downed powerlines, blocked roads, crushed cars and damaged houses. Winds gusted to more than 90 km/h and left 25,000 homes without power. Some areas – Sooke, Alberni Valley, Qualicum Beach, and Denman Island – saw tremendous damage on a weekly basis. On the morning of December 15, Metchosin was virtually impassable, with "significant damage" on rural roads. Mayor John Ranns said, "I've lived here all my life and I've never seen anything so destructive." In Colwood the damage was equally severe with about 50 sections of powerline down. Around 16 roads were closed and nine houses damaged by fallen trees.

In Sooke, a dozen large trees came down on Muir Place, destroying both sides of a duplex and severely damaging three nearby homes. Near Whiffen Spit Road, cars and a trailer were crushed.

Other heavily hit areas included the Alberni Valley, Bamfield, Port Renfrew, Jordan River, Port Alberni, Duncan and Nanaimo, along with North Vancouver and West Vancouver. More than 800 hydro workers were working throughout the week 12- to16-hour days to repair damages. Late on December 17, about 10,000 Vancouver Island customers were still without power, about 5,000 of those were in Colwood and Sooke. Around Metchosin and Sooke, also some 5,000 Telus customers were still without telephone service. Earlier that day, 15,000 customers, mostly in Greater Vancouver's North Shore and the Victoria area had been without power. Some residents of Hornby and Cortes islands had been without for about a week. Trees that trees knocked out the Telus fibre-optic line left large areas without high-speed Internet and telephone service.

At the height of the storm, 250,000 homes and businesses on Vancouver Island and the Lower Mainland were without power. *2) BC Hydro dispatched an estimated 800 employees and contract workers to respond to the failures. On December 15, BC Hydro had more than 90 crews of powerline technicians and contractors, with two or three people in each crew, and 30 tree-trimming teams on Vancouver Island alone. That afternoon some 3,000 Telus customers were without telephone service.

BC Hydro's cost of responding to the severe storms was large. Costs of returning power to customers outstripped the company's budget. BC Hydro spokesperson Elisha Moreno said "Folks who have been around with this company, they've never seen anything like this before. For example, a normal storm event, and there is nothing normal about this storm event is between $3 [million] and $5 million. We've had had three (back-to-back), and none of them have been normal storm events." *3) According to Moreno, on average British Columbia gets three storms a year strong enough to cause power failures for significant numbers of customers. To date this year, there were already nine with the December 15 one being the worst.

Moreno said that it was too early to say whether BC Hydro crews would take a more aggressive stance on removing potentially unsafe trees. It was also hoped that homeowners would be less resistant now when crews want to remove or trim trees that are hazardly close to power lines. One of the clearest lessons learned was that urban residents are not ready for extended power outages, let alone a more serious disaster. On December 17, a North Burnaby couple died of carbon monoxide poisoning after using a gas-powered generator indoors.

Due to power failures, some major Lower Mainland shopping centres, including Lougheed Town Centre and a large portion of Park Royal Shopping Centre, were forced to closed on December 15 and 16. Capilano Mall in North Vancouver also reopened at noon on December 17.

On December 15, winds that topped 150 km/h damaged the Glenidle By The Sea condo building near Sooke harbour. In the early morning hours, the hurricane-force gusts tore away the roof and shattered windows. The building was declared unsafe because water leaked through the ceiling and into some suites. The about 30 residents were forced to leave their units for possibly as long as two months.

Stanley Park suffered the "worst damage in its history" in the windstorm. Falling trees, waves and landslides damaged the Stanley Park Seawall Promenade. At least five landslides came down some of the steep cliffs. Paving stones were broken and some were tossed more than 6 m. Wave action undercut some sections of the waterfront walk, causing cracks in the pavement. The seawall around was undermined, mainly in the Third Beach area where about 50 m of asphalt was torn away from the seawall. Thousands of trees were broken off or uprooted between Prospect Point-Second Beach. At Prospect Point, the wind came straight off English Bay and started breaking off trees at the edge of that stand. This created an opening that exposed those trees to a canyon effect for the wind to push through.

The storm left the steep bluffs above the seawall dangerously unstable and covered with fallen trees hanging above the ground by branches or draped across other fallen timber. The park was closed to the public until December 30 when part of the park and all major roads, including Pipeline Road and Second Beach Road reopened. The Seawall remained closed indefinitely.

The hurricane-force winds ripped across English Bay, striking the west side of Stanley Park the hardest, causing extensive blowdowns of timber. In the interior of the park, trees were flattened, blocking the road and trails. The storm left Prospect Point Road, Pipeline Road and the trails that criss cross the park

impassable. The park's ring road was closed to traffic. Merilees Trail, from Prospect Beach to Third Beach was all but destroyed by hundreds of tree falls. In some areas, an estimated six out of ten trees had fallen. Two of four eagle's nests, which can weigh up to 500 kg, were blown down.

One homeless man, who has lived in the park for 15 years and was there the night of the storm, said, "it was the most terrifying night of my life. It felt and sounded like an artillery barrage." Several days after the storm, another man, who had been trapped among the wind-toppled trees in the park, was located only a day or two away from dying. Vancouver police reached the 59-year old man on December 20 after he made four short calls to 911on a cell phone before its battery died. *4)

The devastation of the park was worst around the Prospect Point Lookout, which looked like the "site of a massive bomb blast. Once a stand of Douglas fir, the area in front of the concession building was littered with broken stumps and rootballs of about 300 trees. Large portions of the seawall between Prospect Point-Third Beach and the escarpment above it were damaged, as were the Siwash Rock and Merilees trails. Three windstorms caused more than $9 million in damage to the park and its popular seawall, the most damage recorded in park history. *5) About 40 ha of the park were devastated and the seawall will remain closed until at least the end of the summer.

Number of trees lost varied widely. According to head groundskeeper Dennis Dooley, cleanup would take at least a year. An estimated 3,000 trees fell. About 20% of the park's trees were wiped out, damage that will take "generations" to heal. Trees up to 500 years old were shattered. About 30 ha of the park was severely damaged, including 10% of the forest. There was light to moderate damage to another 50 ha. Between 5-10% of all trees in the park knocked down. Many more were severely damaged and would have to be removed. Another source (*The Province*, March 11, 2007) puts the loss of trees in Stanley Park during the fall's combination of wind, rain and snow at 10,000, or 1% of the park's estimated 1 million trees knocked down.

The storm may also have damaged many of the ancient native sites within the park. *6) One ancient village, Ch'iexwa7elch, north of Lost Lagoon, was known to have been in an area wiped out by the storms. Two others were on the edge of areas severely damaged by the storms. One called Papiyek was located near Brockton Point, and Slhxi7elsh, near Siwash Rock. At least one tree showing evidence of native bark harvesting was destroyed near Lions Gate Bridge.

The storm also caused substantial damage to VanDusen Botanical Garden, where about 129 trees and many more shrubs, including rare and unusual species, were destroyed. At the University of B.C. Botanical Garden about 10 large conifers collapsed. Another estimated 10,000 trees were lost in Greater Vancouver Regional District (GVRD) parks. More than 9,100 trees were downed in other hard-hit areas such as North and West Vancouver, Coquitlam and Port Moody. According to the report commissioned by Susan Mudick, general manager of Vancouver's Parks and Recreation, about 1,000 of Vancouver's street trees were destroyed with another estimated 3,000 damaged. A one-time expenditure proposal called for $50,000 to be spent on both the citywide park-tree recovery program and the Van Dusen Garden recovery program. More than 230 mature park trees were destroyed, with hundreds more damaged. About 350 trees in Vancouver parks other than those in Stanley Park were destroyed in the storms. Queen Elizabeth Park alone lost 45 trees. (*The Province*, March 11, 2007).

The five other GVRD parks hardest hit were led by Belcarra, which lost about 2,000 trees, and Pacific Spirit Regional Park (1,100 trees), followed by the Capilano River Regional Park (250 trees), Lynn Headwaters Regional Park (175 trees) and Campbell Valley Regional Park in Langley (150 trees).

In Capilano River Regional Park, two slides forced the closure of two trails for up to six months: the Capilano Pacific and Coho Loop trails. The preliminary estimate to clean up the trees was about $300,000, and about $250,000 for the slides. According to Gudrun Jensen of the GVRD's park division, the total cleanup cost as "550,000 to 1 million" (*The Province*, March 11, 2007).

The North Shore also lost thousands of trees. The District of North Vancouver lost about 3,900 trees, including more than 320 in Cates Park, with a bill that could reach $500,000. At Cates Park, dozens of large trees were "blown over like matchsticks." In Cates Park-Whey-ah-wichen, about 320-340 tree were

lost. Also hit hard were Kirkstone Park, Windridge Park, the Indian River area and Princess park. “Upwards of 3,000 trees were downed in district’s parks, parkland areas and boulevards,” said North Vancouver District spokeswoman Jeanine Bratina. “In addition to that, we also responded to 900 calls for downed trees on residential property.” Damage and cleanup costs in the City of North Vancouver could hit $265,000.

In West Vancouver, about 1,500 trees were lost, with damage set at $700,000. About 600 trees were downed in parks, 500 on boulevards and streets, 400 in the Seascapes development and 20 at Gleneagles and at Ambleside par 3 golfcourses. Lighthouse Park was hardest hit but the district did not have a specific number of trees lost.

Elsewhere, Port Moody lost about 1,300 trees, mostly in the city’s green belts and parks. Seaview Park and Bert Flinn Park on the north shore lost the most trees. “There were 81 [private] properties hit with trees and houses damaged,” said Colleen Rohde, spokeswoman for Port Moody. This city’s cost was “probably going to be around the $300,000 mark.” Coquitlam lost 800 trees in parks and public lands due to the various windstorms. Therese Mickelson of Coquitlam estimated cleanup costs at about $300,000 (*The Province*, March 11, 2007).

A large floating dock snapped in two snapped in two and was thrown ashore by waves up to 3 ft. (90 cm) high. One of the two SeaBus berths at North Vancouver was damaged overnight when a group of barges broke free from their moorings and rammed it. On December 15, falling trees damaged or destroyed at least six houses in Coquitlam, including on Durant Drive near Walton Street, Westwood Plateau and Delahaye.

While Stanley Park got most of the attention, roads, the storms caused the closure of roads, trails and bridges in provincial parks on Vancouver Island. The access road to Schoen Lake northwest of Campbell River washed out. Portions of the Juan de Fuca Trail also closed due to damaged bridges and hazards from downed and damaged trees. In Goldstream Provincial Park, the Lower Goldstream Trail closed due to flooding and Prospector’s Trail closed after flooding caused downed trees and mudslides. Other areas of the park were inaccessible because of fallen trees. In MacMillan Provincial Park, one trail was close after floodwaters dislodged two bridges from their abutments. Fillongy Park on Denman Island still remained closed in January after extensive wind damage to trees on the 23-ha. property (*Campbell River Mirror*, January 17, 2007). Trails along the Puntledge River between Nymph Falls-Comox Lake, maintained by BC Hydro, were closed after “scores” of trees along the various routes were either blown down or had snapped in the storms. (*Comox Valley Echo*, February 2, 2007).

The cost to repair damage to the West Coast Trail between Port Renfrew-Bamfield was estimated at hundreds of thousands of dollars. The storms triggered a mudslide and brought down more than 2,000 trees down along the 75-km trail, leaving much of it unnavigable. About 60-100 trees come down onto the trail during an average winter (CBC newscast April 19, 2007). Two cable-car crossings were down, one of the towers that holds the cable car was demolished and a suspension bridge was missing (*Times Colonist*, January 20 and March 6, 2007). *7)

Langley’s regional parks would not all be restored from the storm damage until March. The three major Greater Vancouver Regional District’s parks in Langley had significant numbers of trees toppled by the storm; Campbell Valley (147), Derby Reach (24) and Aldergrove (40). The final clean up of the smaller trails and the chipping of the remaining trees alone was budgeted at $40,000. (*The Vancouver Sun*, February 7, 2007).

On December 14-15, the Whistler area recorded about 58 cm of snow in 24 hours. Around 4 p.m. on December 14, traffic came to standstill just south of Whistler. Hundreds of motorists were stranded overnight for up to 14 hours in treacherous road conditions between Whistler-Squamish. Heavy snow also closed the Coquihalla Highway for most of December 15.

The December 18 storm brought down more than 60 power poles in Greater Victoria. On December 18, between 5,000-6,000 customers in Greater Victoria, including Colwood, Port Renfrew, Sooke, Metchosin, Highlands and the Saanich Peninsula, were still without power.

On December 18, a storm centred in the Gulf of Alaska battered northern Vancouver Island and the Queen Charlottes with strong winds and heavy rain. Winds gusted to 90 km/h. A tree brought down by the storm near Gold River at 1 a.m. caused a power outage to all 6,500 BC Hydro customers in the communities on northern Vancouver Island. Power was restored just before 3 p.m.

---

*1) This beat Typhoon Freda's top speed of 143 km/h measured off Victoria (*The Vancouver Sun*, December 16, 2006). With gusts between 78-99 km/h, no records were set at Victoria International Airport this week. In 1967 and 1972, gusts of 109 km/h were recorded (*Times Colonist*, December 16, 2006).

*2) BC Hydro's estimate of 250,000-plus customers losing power on December 15 exceeds the previous peak of 240,000 affected during a five-day storm in January 2005 (*The Vancouver Sun*, December 16, 2006).

*3) Following the massive blackouts, BC Hydro considered a range of options, including more use of underground transmission lines, to reduce the Lower Mainland power grid's vulnerability to future storms.

*4) According to Vancouver police, about 12-15 people live in the park, all of whom were accounted for and safe (*The Vancouver Sun*, December 23, 2006).

*5) The $9 million park restoration project included contributions form the province ($2 million), federal government ($2 million) as well as $3 million from about 5,000 individuals, companies and societies. A total of $2.25 million will be spent to stabalize slopes by regrading sections, planting low-level vegetation and improve drainage. The cost to restore the seawall, clear and repair roads and trails and to reforest the park was estimated at $1 million. Another $1.25 million would be spent on removal of fallen trees and improving drainage in blowdown areas. The rest was allocated to be spent on legacy projects, contingency and the preparation of the plan (*The Vancouver Sun*, April 11, 2007). The seawall, closed between Siwash Rock-Prospect Point, would stay closed until August or September while work is carried out. Park Drive would be rerouted away from the precipice and the seasonally crowded parking lot at the lookout would be removed. This would also remove the accumulation of water on the bluffs created by the parking lot. In the spring of 2007, logging was being done on the remains of about 10,000 trees blown down on December 15. About $1 million worth of timber was expected out of the storm-damaged park. The restoration plan aimed to restore the park to is 1850 state. About 20,000 cedar, fir, maple and spruce trees would be planted. The species to be planted were selected from pictures taken 150 years ago (*The Province*, April 11, 2007).

*6) Stanley Park has many ancient Native burial grounds and more than 100 culturally modified trees within its boundaries. According to Archaeological Society of B.C. president Eric McLay, there are 15 known sites of historical importance, and many more undiscovered ones, in the park. About half the park is recognised by the province as archaeologically significant (*The Vancouver Sun*, February 9, 2007).

*7) Pacific Rim National Park Reserve, within which the West Coast Trail is located, received $700,000 in federal funds for recovery efforts stemming from the devastating windstorms. Of this amount, $500,000 would go towards general restoration work. The remaining $200,000 is part of a deal between Parks Canada and the Ucluelet-based Central West Coast Forest Society to restore Sandhill and Lostshoe creeks and improve their salmon-spawning capacity. In 2007, the West Coast Trail marks its 100th anniversary. It was established in 1907 as the Dominion Life Saver Trail to serve as an aid in rescuing shipwrecked mariners whose vessels went down in the open waters off the Island rugged coastline (*Times Colonist*, March 6, 2007). The trail would open two weeks later than normal as repairs to the suspension bridge and one of the cable car crossings took longer than expected (CBC newscast April 19, 2007).

December 20-21, 2006

Source: *The Province*, December 22, 2006; *The Vancouver Sun*, December, 2006; *Times Colonist*, December, 2006; *Campbell River Courier-Islander*, December, 2006; *The Globe and Mail*, December 21, 2006; CBC newscasts, December 21, 2006.

Details: Overnight December 20-21, yet another low-pressure system with wind and rainstorm hit Vancouver Island. Cape Scott recorded gusts up to 157 km/h; Tofino 117 km/h; Comox 91 km/h; Port Hardy 84 km/h; Parksville 80 km/h and 86 km/h at downtown Victoria.

The storm knocked out power to about 30,000 BC Hydro customers, most of these on northern Vancouver Island, including Campbell River, Zeballos, Courtenay and 3,500 on the Sunshine Coast. Major blackouts included Courtenay, Denman and Hornby islands (5,000 customers); Campbell River, Cortes and Quadra islands (6,000); Port Alberni (more than 4,000); Port Hardy and Zeballos (800); Qualicum Beach (1,500) and Nanoose (about 1,000 customers). The storm also hit Bamfield again, where power had just been restored a day earlier after having been out for nine days.

A Zeballos resident, who had been living in that community for 36 years, said she had never experienced anything like that. She had her large home never shake before. “The noise was incredible; it sounded like a train (CBC interview).

December 27, 2006
Source: *Campbell River Courier-Islander*, December 27, 2006.
Details: On December 27, a storm hit northern Vancouver Island. Early next day, some 5,500 BC Hydro customers were without power in Campbell River and 4,500 in the Comox Valley and Black Creek. Other areas hit with power outages included Cortes and Quadra Island, Sayward, Zeballos and Tahsis along with Quatsino, Coal Harbour and Sointula.

December 2006
Source: *The Vancouver Sun*, March 17, 2007.
Details: In December, a mudslide in Larsen Creek near construction for the Sea-to-Sky Highway improvement project killed more than 20 juvenile cut-throat trout and coho salmon due to the lack of oxygen in the creek. Steve Jenkins, the environmental protection officer for the District of West Vancouver, called the kill “pretty significant.” He noted that the fish were large and healthy, about a year old and “only a couple of weeks from leaving.” A local resident noticed the slide at the beginning of January and found more than a dozen fish floating belly up several weeks later. The dead fish were part of an educational salmon enhancement project by students at Gleneagles elementary, who had released the young fry from a local hatchery into the stream.

Appendix 1 **Geographical index by rivers, creeks and lakes**

Arbutus Creek: November 1-4, 1955.
Arrow Lakes: May 10-18, 1954; May 23-June 5, 1999.
Arrowhead Lake: February 28, 1903; June 13-16, 1933.
Asher (Five-Mile) Creek: May-June 1894.
Ashton Creek: June 11-13, 1990; July 11-13, 1997; May 23-June 5, 1999.
Asp Creek: May 29-June 17, 1972.
Atnarko River: June-July 1999.
Atwood Creek: June-July 1999.
Australian Creek: June 11-13, 1990.
Ballam Slough: April 19-22, 1943.
Barrett Creek: June 1-5, 1968.
Barriere River: May-June 1894; May 23-June 15, 1948; May 29-June 17, 1972.
Bear Creek (Alberni): January 8-17, 1961.
Bear Creek (Fraser Valley): January 20-27, 1935; January 14-20, 1968; November 8-13, 1990.
Bear River: June 15-24, 1916.
Beaver Creek: November 30-December 1, 1958.
Beaver River: May 2002.
Belcharton Creek: November 8-13, 1990.
Bell Brook: January 29-February 6, 1997.
Big Bar Creek: June 11-13, 1990.
Billygoat Creek: August 27-31, 1991.
Bilston Creek: December 25-29, 1949; February 20-21, 1961; November 8-13, 1990.
Birkenhead Creek: December 23-27, 1980; October 27-31, 1981.
Biss Creek?: June-July 1999.
Blackwater Creek: December 23-27, 1980; October 27-31, 1981.
Blais Creek: July 11-13, 1997.
Blue Creek: January 1-4, 1984; November 8-10, 1989.
Blurton Creek: July 11-13, 1997.
Bolean Creek: May 23-June 5, 1999.
Bolvin Creek: June 14-28, 1974.
Bon Accord Creek: January 29-February 6, 1997.
Bonaparte River: May-June, 1866; April 22-27, 1875; October 14, 1880; June 11-13, 1990; June-July, 1999.
Booth Creek: January 29-February 6, 1997.
Bostock Creek: July 11-15, 1983.
Boston Bar Creek: December 11-14, 1924.
Boulder Creek (Nanaimo): October 24-29, 1921.
Boundary Creek: May-June 1894; September 12, 1969; June-July 1999.
Bourke Creek: April 20-May 4, 1999.
Bowker Creek: December 28, 1937; December 25-29, 1949; February 6-7, 1955; December 7-10, 1956; February 18-20, 1960; February 15-16, 1972; November 29-December 8, 1975; December 12-18, 1979; January 20-26, 1982; November 16-24, 1990.
Brash Creek: July 11-13, 1997.
Brewery Creek: June 5-7, 1995.
Brewster Creek: July 11-15, 1983.
Bridge Creek: April 22-27, 1875; January 10-17, 1997; June-July 1999.
Bridge Lake: June-July 1999.
Bridge River: May-June 1894; October 17-20, 1940; May 25-June 15, 1948; May 29-June 17, 1972; August 17-18, 1991; Late May-early June 1997.
Britannia Creek (River): October 24-29, 1921; October 30-November 1, 1967; May 25, 1989; August 27-31,1991.
Brohm Creek: May 23-June 5, 1999.

Brothers Creek: July 11-12, 1972; October 27-31, 1981.
Brunette Creek/River: November 28-29, 1883; December 15-19, 1923; January 20-27, 1935; November 17-21, 1954; January 8-17, 1961; December 9-18, 1966; July 11-12, 1972; December 25-26, 1972?
Bull River: June 7-16, 1913; June 15-24, 1916; March 17-26, 1997; May 23-June 5, 1999; November 13-14, 1999; May 15-23, 2006.
Burnaby Lake: February 6-7, 1945.
Bush Creek: December 25-29, 1949.
Buttle Lake: June 23, 1946.
Byrne Creek: November 1-4, 1955.
Byron Creek: June 5-7, 1995?
Cadwallader Creek: October 17-20, 1940.
Callaghan Creek: fall 1996.
Cameron Lake: February 8-9, 1918; October 27-29, 1937; June 23, 1946; November 26-December 3, 1949; January 20-25, 1951; April 8, 1955; October 29-November-6, 1975; November 8-13, 1990; November 16-24, 1990; Early February 1991.
Cameron River: January 22-31, 1931; November 26-December 3, 1949; January 12-15, 1974; November 16-24, 1990.
Camp Creek: see: Old Camp Creek.
Camp Slough: May-June 1894.
Campbell Lake: October 29-November-6, 1975.
Campbell River (Campbell River): February 1936; October 27-29, 1937; November 14-20, 1939; December 1939; Spring 1940; January 15-16, 1944; November 14-15, 1953; October 29-November-6, 1975; December 23-27, 1980; November 8-13, 1990; January 23-26, 1998.
Campbell River (White Rock): January 20-27, 1935.
Candle Creek: June-July 1999.
Cannell Lake: December 14-16, 1947.
Canoe Creek: May-June 1894; June-July 1999.
Canyon Creek: October 4, 1990.
Capilano Lake: December 4, 1981.
Capilano River: 1896; September 5-9, 1906; October 24-31, 1908; November 27-30, 1909; October 10-12, 1913; January 3-6, 1914; November 1915; December 26, 1917-January 1, 1918; October 24-29, 1921; September 20-23, 1924; October 17-20, 1940; February 12-15, 1947; November 26-December 3, 1949; November 27-December 4, 1951; November 1-4, 1955; June 6-9, 1956; November 30-December 1, 1958; January 8-17, 1961; October 3, 1971; July 11-12, 1972.
Carnation Creek: January 20-26, 1982.
Carpenter Creek: May-June 1894; June 13-16, 1933; spring 1933; April 23, 1934; June 24-29, 1955.
Carpenter Lake: August 17-18, 1991.
Carratt (Mechanics) Creek: January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; October 16-22, 2003; Late January 2004.
Cascade (McConnell) Creek: January 1-4, 1984; November 8-13, 1990; Late January 2004.
Cataract Creek: November 22, 1989.
Cat Creek: June-July 1999.
Cat Stream: January 23-25, 1958.
Cellsta Creek: July 11-13, 1997.
Chance Creek: August 27-31, 1991; October 16-22, 2003.
Charles Creek (Strachan 2 Creek): September 16-18, 1969; November 3 and 7, 1972; December 4, 1981; February 8-11, 1983; November 15, 1983; January 1985; January 15-18, 1986.
Charters Creek: November 8-13, 1990.
Chase Creek: July 1, 1935; May 23-June 15, 1948; January 24-29, 1960; June 1996.
Chawuthen Creek: January 1-4, 1984; November 8-13, 1990.
Cheakamus Lake: December 23-27, 1980.

Cheakamus River: Winter 1855-56; September 5-9, 1906; June 9-12, 1955; November 1-4, 1955; June 6-9, 1956; August 1958; October 29-November-6, 1975; December 23-27, 1980; October 27-31, 1981; November 11-14, 1981; October 6-12, 1984; November 8-10, 1989; November 8-13, 1990; August 27-31, 1991; May 23-June 5, 1999?; October 16-22, 2003..
Cheekye River: October 27-29, 1937; August 1958; December 23-27, 1980; October 27-31, 1981; October 6-12, 1984; November 8-13, 1990; August 27-31,1991.
Chehalis River: November 1-4, 1955; December 23-27, 1980.
Chemainus River: December 11-21, 1890; November 12-13, 1896; December 14-16, 1947; December 25-29, 1949; January 20-25, 1951; November 30-December 1, 1958; December 22-23, 1963; January 5-13, 1966; December 9-18, 1966; January 18-19, 1971; December 15-22, 1972; December 25-26, 1972; January 12-15, 1974; December 2-8, 1990; March 17-26, 1997; November 15, 2006.
Cherry Creek: July 11-13, 1997.
Chester Creek: November 13-18, 1919.
Chilcotin River: May-June 1894; August 19, 1964; August 1, 1973; August 29-30, 2004.
Chilliwack River: March 8-14, 1873; November 22, 1875; December 22, 1875; May-June 1894; October 23-26, 1945; May 25-June 15, 1948; November 1-4, 1955; November 29-December 8, 1975; December 23-27, 1980; January 1-4, 1984; November 3, 1989; November 8-10, 1989; November 8-13, 1990; November 16-24, 1990; November 28-30, 1995; January 10-17, 1997; January 27-February 6, 1997; November 23-27, 2004; November 3-6, 2006.
China Creek: January 9-17, 1961.
Christina Creek: May 23-June 5, 1999.
Churn Creek: June 12, 1964.
Clachnacudainn Creek: July 11-15, 1983.
Clanwilliam (Summit) Lake: spring 1999; April 13-14, 2002.
Clapperton (Mill) Creek: May 18, 1922.
Clearwater River: May 20-30, 1928.
Clementine Creek: October 4-6, 1965.
Coal Creek (Courtenay): November 14-20, 1939.
Coal Creek (Kootenays): May 13-14, 1942; June 5-7, 1995.
Coldwater River: December 23-27, 1980; January 1-4, 1984; Early February 1991; December 23-26, 2005.
Colquitz River: January 20-27, 1935; January 20-26, 1982.
Columbia River: June 22, 1871; June 19-July 1, 1876; May-June 1894; June 19-22, 1913; June 15-24, 1916; June 13-16, 1933; May 29-June 3, 1936; May 25-June 15, 1948; May 10-18, 1954; July 7-10, 1954; June 13, 1955; May 23-June 6, 1956; June 5-6, 1961; June 1964; June 2, 1967; June 15-22, 1967; April 23, 1969; May 29-June 17, 1972; June 7, 1972; March 10, 1978; July 11-15, 1983; Late May 1996.
Comox Lake: January 20-27, 1935; January 31, 1935; fall 1935; June 23, 1946.
Cooke Creek: July 11-13, 1997.
Coon Creek: December 23-27, 1980.
Cooper Creek: May 29-June 17, 1972.
Coquihalla River: November 11-12, 1865; May-June 1894; February 26-28, 1932; November 19-20, 1962; October 30-November 1, 1967; November 29-December 8, 1975; December 23-27, 1980; November 8-13, 1990; November 28-30, 1995; November 3-6, 2006.
Coquitlam Lake: September 5-9, 1906; February 18-20, 1930; January 20-27, 1935; November 26-December 3, 1949; January 9-17, 1961; October 29-November-6, 1975; November 16-24, 1990.
Coquitlam River: November 28-29, 1883; January 9-13, 1895; January 4-6, 1896; January 3-6, 1914; December 26, 1917-January 1, 1918; October 24-29, 1921; December 9-12, 1921; February 23-27, 1932; November 26-December 3, 1949; 1952; February 3-4, 1953; November 1-4, 1955; January 8-17, 1961; December 9-18, 1966; January 14-20, 1968; October 29-November-6, 1975; November 15, 1983; January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; November 16-24, 1990; March 17-26, 1997; Late May-early June 1997.
Corn Creek: May 23-June 5, 1999.

Cott Creek: July 11-13, 1997.
Cottonwood Creek: June 1-5, 1968; June-July 1999.
Cottonwood-Smith Creek: May-June 1894.
Cougar Brook: September 1, 1983.
Cougar Creek: see Cougar Brook.
Courtenay River: January 31, 1935; November 14-20, 1939; December 7-10, 1939; November 28-December 2, 1941?; December 22-23, 1963; February 3-4, 2006.
Cowichan Lake: December 11-21, 1890; December 25-30, 1929; January 22-31, 1931; November 26-December 3, 1949; January 18-19, 1967; January 14-20, 1968; December 23-27, 1980.
Cowichan River: December 11-21, 1890; January 4-6, 1896; November 12-13, 1896; January 28-31, 1924; February 18-20, 1930; January 31, 1935; June 23, 1946; December 10-11, 1946; January 17-24, 1947; December 25-29, 1949; January 20-25, 1951; February 22-24, 1957; January 23-25, 1958; January 24-29, 1960; January 8-17, 1961; January 29-31, 1961; December 30, 1962-January 2, 1963; December 22-23, 1963; January 5-13, 1966; December 9-18, 1966; January 12-14, 1968; January 14-20, 1968; January 18-19, 1971; January 18, 1972; January 20-24, 1972; December 15-22, 1972; December 25-26, 1972; January 12-15, 1974; December 23-27, 1980; October 24, 1982; November 15, 2006.
Crabapple Creek: November 8-13, 1990.
Crazy Creek: see: Deroche Creek.
Creighton Creek: July 11-13, 1997.
Crown Creek: November 27-30, 1909.
Culliton Creek: December 23-27, 1980; January 21, 1981; October 27-31, 1981; October 6-12, 1984; August 27-31,1991.
Cultus Lake: February 7-11, 1951; January 1-4, 1984; February 7-11, 1951; Late November 1986.
Currie Creek: April 12, 1930.
Cypress Creek: December 26, 1975; October 27-31, 1981; August 31-September 1, 1983; Early September 1983; November 15, 1983; November 8-10, 1989.
Daisy Lake: winter 1855-56; October 29-November-6, 1975; December 23-27, 1980; August 27-31, 1991.
Dale Creek: November 8-13, 1990; October 16-22, 2003; Late January 2004.
Davis Creek: January 1-4, 1984; November 8-13, 1990; January 15, 1999.
Deadman Creek: July 11-15, 1983; June 11-13, 1990.
Deep Creek: April 22-27, 1875.
Deer Lake: January 8-17, 1961.
Dees Lake: July 11-13, 1997.
Deka Lake: June-July 1999.
Deroche (Crazy Creek): December 23-27, 1980; January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; July 11-13, 1997.
Devastator Creek : October 1931; 1947; July 22, 1975.
Devick Lake: May 25, 1948.
Disbrow Creek: December 20-27, 1931; December 12-18, 1979.
Dorothy Creek: November 16-24, 1990.
Dotzler Creek: January 1-4, 1984.
Dry Creek: November 26-December 3, 1949; February 8-11, 1983; March 17-26, 1997.
Dryden Creek: December 23-27, 1980; October 16-22, 2003.
Duhamel Creek: May 12-13, 1971.
Dumvill Creek: January 7-11, 1932; February 23-27, 1932; February 7-11, 1951.
Duncan River: August 25-September 5, 1976.
Duncan Head River: May 18-23, 1925.
Duprez Creek: June 8, 1999.
Dusty Creek: July 1963.
Duteau Creek: July 11-13, 1997.

Eagle Creek: May-June 1894; November 1-4, 1955; January 23-25, 1958; June 2, 1967; December 22-23, 1983; Spring 1999; June-July 1999.
Eagle Lake: May-June 1894.
Edwards Creek: May 25, 1948.
Eight-Mile Creek: December 23-27, 1980.
Elk Creek: December 26, 1917-January 1, 1918; January 7-11, 1932; February 23-27, 1932; February 7-11, 1951.
Elk River: June 7-16, 1913; June 15-24, 1916; December 26, 1917-January 1, 1918; June 2, 1923; June 13-16, 1933; May 13-14, 1942; May 23-June 15, 1948; ca. 1963? (see: November 1980); June 14-28, 1974; 1986; June 5-7, 1995; June 2002.
Ellis Creek: May 19-21, 1921; May 12, 1941; May 23-June 16, 1942; May 15-23, 2006.
Emory Creek: October 23-26, 1945.
Eng Creek: December 23-27, 1980; January 1-4, 1984; October 16-22, 2003; Late January 2004.
Englishman River: November 26-December 3, 1949; December 25-29, 1949; December 12-18, 1979; November 16-24, 1990; December 2-8, 1990; January 22-February 2, 1992; March 17-26, 1997; November 15, 2006.
Ensas Creek: May 23-June 15, 1948;
Erroch (Squakum) Lake: November 8-10, 1989; November 8-13, 1990.
Evans Creek: November 1-4, 1955.
Fair(e)y Creek: June 15-24, 1916; May 23-June 15, 1948; June 5-7, 1995.
Falls Creek: June 11-13, 1990; July 11-13, 1997.
Farrow Creek: July 1994.
Fauquier Creek: June 26, 2004; August 21-24, 2004.
Ferry Creek: July 11-13, 1997.
Field Creek: October 16-22, 2003; Late January 2004; March 11, 2004.
Fisher's Pond: 1967; January 18-24, 1972.
Fitzsimmons Creek; December 23-27, 1980; October 27-31, 1981; October 6-12, 1984; November 8-13, 1990; August 27-31, 1991; October 23-24, 1992.
Five-Mile Creek: see: Asher Creek.
Flathead River: June 5-7, 1995.
Fording River: June 5-7, 1995.
Francis Creek: November 15, 2006.
Franklin River: November 17-21, 1954.
Fraser River: ca. 1830s; June 1862; November 11-12, 1865; May-June 1866; June 1870; June 22, 1871; November 15, 1871; April 22-27, 1875; July 1875; November 22, 1875; December 22, 1875; June 19-July 1, 1876; 1878; May 28-June 1, 1879; January 30, 1880; May 25, 1880; July 7, 1880; October 1881; June 7-14, 1982; November 28-29, 1883; May 1892; January 25-February 9, 1893; May-June 1894; January 9-13, 1895; June 13, 1895; July 4-7, 1896; July 13, 1899; June 25-27, 1900; June 13-17, 1903; June 16-17, 1908; July 13-15, 1908; ca. June 12-19, 1911; June 7-16, 1913; November 25-31, 1913; 1913; January 3-6, 1914; January 26, 1914; December 7-9, 1915; June 2-10, 1916; June 15-24, 1916; July 16, 1920; October 1920; Early January 1921; June 10-14, 1921; October 24-29, 1921; June 5-7, 1922; February 10-12, 1924; September 20-23, 1924; December 11-14, 1924; May 18-23, 1925; January 8-12, 1928; February 23-27, 1932; December 2, 1932?; December 22, 1932; July 6, 1933; November 17-24, 1933; December 17-30, 1933; January 31, 1934; June 14, 1934?; January 20-27, 1935; May 29-June 3, 1936; May 29-June 3, 1938; March 27-28, 1939; October 8-15, 1941; April 19-22, 1943; February 6-7, 1945; May 31-June 4, 1945; June 3, 1946; July 13-15, 1946; December 10-11, 1946; January 2, 1948; May 25-June 15, 1948; August 29-31, 1948; November 22-December 1, 1949; May 10-16, 1949; June 16-21, 1950; January 20-25, 1951; February 7-11, 1951; November 27-December 4, 1951; May 10-18, 1954; July 7-10, 1954; June 13, 1955; June 24-29, 1955; July 7, 1955; November 1-4, 1955; May 23-June 6, 1956; December 22-24, 1957; January 8-17, 1961; June, 1964; June 2, 1967; June 15-22, 1967; January 14-20, 1968; May 12-16, 1972; November 3 and 7, 1972; May 22-25, 1974; June 14-28, 1974; February 16, 1976; December 11-15, 1977; June 21, 1982; December 16-18, 1982; January

4, 1987; June 11-13, 1990; November 8-13, 1990; May 31-June 1, 1997; Late May-early June 1997; June-July 1999; June 2002; August 29-30, 2004.
French Creek: December 12-18, 1979; December 23-27, 1980; January 14, 1998.
Frosst Creek: February 7-11, 1951; January 1-4, 1984; Late November 1986; November 8-10, 1989; November 8-13, 1990.
Ford Creek: February 7-11, 1951.
Fortynine Creek: May-June 1894.
Furry Creek: October 27-31, 1981.
Gates River: December 23-127, 1980; October 27-31, 1981.
Garibaldi Lake: winter 1855-56; December 23-127, 1980.
Gillies Creek: March 12, 1996.
Gillis Brook: Late March-middle April 1982.
Glen Brook: March 7-14, 1916.
Glen Lake: January 20-24, 1972; January 20-26, 1982.
Goat Creek: June 14-28, 1974.
Goat River: June 7-16, 1913; June 22-29, 1955; May 23-June 6, 1956; 1960; Late May-early June 1997; April 20-May 4, 1999; June-July 1999.
Gold Creek (Nelson): June 14-28, 1974.
Gold Creek (Zeballos): October 17-20, 1940.
Gold River: November 15, 2006.
Goldstream River: November 12-13, 1896; February 10-12, 1924; 1972; November 29-December 8, 1975; November 16-24, 1990; March 17-26, 1997.
Gordon Creek: November 26-December 3, 1949; January 8-17, 1961; December 23-27, 1980.
Gordon River: September 5-9, 1906.
Gorge Creek: April 23, 1969; April 19-21, 1997.
Gowan Creek: May 31-June 1, 1997.
Granby River: May 23-June 6, 1956; May 15-23, 2006.
Grandmother Slough: December 23-27, 1980; October 27-31, 1981.
Granite Creek (Tulameen): January 20-27, 1935.
Gray Creek: June 22-29, 1955.
Great Central Lake: January 31, 1935; June 23, 1946; November 16-24, 1990.
Greeley Creek: July 11-15, 1983.
Green Creek: November 8-10, 1989.
Green River: December 23-27, 1980; October 27-31, 1981; November 16-24, 1990; August 7-9, 1991.
Greenstone Creek: October 27-29, 1937.
Grey Creek: see Gray Creek.
Griffin Lake: June 1-5, 1968; June 23-26, 1973.
Haggard Creek: May 23-June 5, 1999.
Haines Creek: June-July 1999.
Hamilton Creek: June 1-5, 1968; July 11-15, 1983..
Harrison Lake: June 25-27, 1900; February 23-27, 1932; May 25-June 15, 1948; January 9-16, 1953; December 23-27, 1980.
Harrison River: May-June 1894; June 13-17, 1903; November 1-4, 1955; June 1964
Harvey Creek: September 16-18, 1969; December 15-22, 1972; May 23-25, 1973; September 9-10, 1978; December 4, 1981; October 6, 1982; October 6-12, 1984.
Haslam Creek: November 27-30, 1909; February 1-6, 1963.
Hatzic Lake: May 25-June 15, 1948; December 23-27, 1980; November 8-13, 1990.
Hatzic Slough: May-June 1894.
Hawkins Creek: May 23-June 5, 1999.
Haynes Creek: May 23-June 5, 1999.
Heart Creek: June 26, 2004.

Heather Street Creek: November 27-30, 1909.
Hedley Creek: See: Twenty-Mile Creek.
Heffley Creek: May 25, 1948; May 29-June 17, 1972.
Hell Creek: June-July 1999.
Hemp Creek: June-July 1999.
Henderson Lake: December 15-22, 1972.
Her(e)ford Creek: November 8-10, 1989; November 8-13, 1990.
Hermit Creek: August 27-29, 1984.
Hiuihill Creek: June-July 1999.
Hogg Creek: June-July 1999.
Holdich Creek: June-July 1999.
Holland Creek: December 25-29, 1949; January 20-25, 1951.
Homathko River: spring 1864; June 1971-September 1973; July 20, 1982?; July 19, 1983; August 8, 1983; August 13, 1997?
Homes Creek: July 11-13, 1997.
Hope River: June 16-21, 1950.
Hope Slough: May-June 1894; June 16-21, 1950.
Horse Lake: June-July 1999.
Horse Ranch Creek: October 27-31, 1981.
Hosmer Creek: May 23-June 5, 1999.
Hospital Creek: May 30-June 1, 1986.
Hudson Creek: Early-mid May 1997; July 11-13, 1997.
Humamilt Lake: July 11-13, 1997.
Hummingbird Creek: July 11-13, 1997.
Hunter Creek: November 29-December 8, 1975.
Hurley River: October 17-20, 1940; October 6-12, 1984.
Illecillewaet River: May-June 1894; May 29-June 3, 1936; June 2, 1967; June 1-5, 1968; Early January 1979; July 11-15, 1983, January 10-17, 1997.
Isic Creek: July 11-13, 1997.
Jamieson Creek: May 23-June 15, 1948; November 16-24, 1990.
Jensen Creek: August 7, 2004.
Joe Rich Creek: June 11-13, 1990; Early-mid May 1997.
Johnson Creek: November 8-13, 1990.
Jones Creek: See: Wahleach Creek.
Jordan River: October 24-29, 1921; November 17-21, 1954; December 6, 1963; January 7-8, 1964.
Joseph Creek: February 25-26, 1986; May 1990; Early-mid May 1997.
Judd Slough: October 27-31,1981; October 6-12, 1984.
Jump Creek: March 17-26, 1997.
Kalamalka Lake: May 20-June 2, 1983; Late May-early June 1997; July 11-13, 1997.
Kalamalka River: May 20-June 2, 1983.
Kallahne Creek: October 27-31, 1981.
Kamloops Lake: May 23-June 15, 1948; May 29-June 17, 1972; Late May-early June 1997.
Kanaka Creek: November 1-4, 1955; December 7-10, 1956; June 14-28, 1974.
Karen Creek: November 8-13, 1990.
Kaslo River: June 14, 1894; June 15-24, 1916; April 23, 1934; spring 1999; June-July 1999.
Kawkawa Lake: November 8-13, 1990.
Keith Creek: October 20-23, 1960.
Kelly Creek: April 20-May 4, 1999.
Kelowna Creek: May 20-June 2, 1983.
Kelvin Creek: December 17-30, 1933; November 27, 1973.
Kennedy Lake: October 7-13, 1967.

Kennedy River: January 9-17, 1961; October 6-13, 1967; ca. 1970.
Keremeos Lake: June 14-28, 1974.
Kettle River: May-June 1894; April 30, 1918; June 13-16, 1933; May 23-June 16, 1942; June 14-28, 1974; Early-mid May 1997; Late May-early June 1997; May 23-June 5, 1999; May 15-23, 2006.
Kicking Horse River: March 4-5, 1910; June 15-24, 1916; August 25-26, 1988; August 3, 1994.
Kilby Creek: November 27-30, 1909.
Kingcome River: October 19-22, 1965.
Kingfisher Creek: July 11-13, 1997.
Kirby Creek: November 29-December 8, 1975.
Kitsucksus Creek: November 27-December 4, 1951; January 23-25, 1958; November 30-December 1, 1958; March 27-29, 1964; December 13-16, 1966; February 8-11, 1983.
Klanawa River: October-November, 1995.
Klattasine Creek: June 1971-September 1973.
Klattasine Lake: June 1971-September 1973.
Kleena Kleene River: October 17-20, 1940.
Knarston Creek: January 2-3, 2003.
Koksilah River: December 11-21, 1890; January 4-6, 1896; November 12-13, 1896; January 22-31, 1931; February 23-27, 1932; January 31, 1935; January 17-24, 1947; December 25-29, 1949; January 20-25, 1951; January 9-16, 1953; November 1-4, 1955; February 22-24, 1957; January 23-25, 1958; January 24-29, 1960; January 9-17, 1961; January 29-31, 1961; January 5-13, 1966; December 9-18, 1966; January 18-19, 1967?; January 18-19, 1971; January 18, 1972; January 20-24, 1972; February 15-16, 1972; December 25-26, 1972; December 23-27, 1980.
Kootenay Lake: Mid May-mid June 1808; May-June 1894; June 7-16, 1913; May 18-23, 1925; June 13-16, 1933; May 29-June 3, 1938; May 25-June 15, 1948; Late May-early June 1997; spring 1999; August 7, 2004.
Kootenay River: May-June 1894; June 7-16, 1913; June 15-24, 1916; June 13-16, 1933; May 29-June 3, 1938; May 25-June 15, 1948; May 10-18, 1954; June 13, 1955; May 23-June 6, 1956; June 5-6, 1961; June 2, 1967; June 14-28, 1974; Late May 1996.
Kuskanook Creek: August 7, 2004.
La France Creek: June 22-29, 1955.
Lagace Creek: December 23-27, 1980; January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; January 29-30, 2004; November 23-27, 2004.
Laity Creek: December 11-14, 1924.
Laluwissin Creek: June 23, 1972.
Lane Creek: November 8-13, 1990.
Lantzville Creek: January 24-29, 1960.
Lardo River: August 21-24, 2004.
Larsen Creek: December 2006.
Lauretta Creek: July 11-15, 1983.
Lawson Creek: December 15-22, 1972; October 27-31, 1981.
Lemieux Creek: May 23-June 15, 1948.
Lemon Creek: June 15-24, 1916.
Leonie Creek: January 16-31, 2005.
Lewis Creek: February 23-27, 1932.
Lillooet River: November 13-18, 1919; September 20-23, 1924; October 27-29, 1937; October 17-20, 1940; June 22, 1945; May 25-June 15, 1948; December 23-127, 1980; October 27-31, 1981; January 1-4, 1984; October 6-12, 1984; August 7-9, 1991; August 27-31,1991; October 16-22, 2003.
Lilted River: December 23-27, 1980.
Lions Brook: December 25-26, 1972.
Little Creek: November 8-10, 1989.
Little Louis Creek: May 20-30, 1928.
Little Qualicum River: October 24-29, 1921; December 23-27, 1980.

Little River: May 29-June 17, 1972.
Little Slocan River: June 14-28, 1974.
Lockhart Creek: June 22-29, 1955.
Loftus Creek: July 11-13, 1997.
Long Creek: June 2, 1967.
Lonsdale Creek: October 16-19, 1956.
Loop Creek: April 18-19, 1938.
Lorenzetta Creek: January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; Late May-early June 1997.
Loss Creek: November 8-10, 1989; March 17-26, 1997; November 23-27, 2004; January 16-31, 2005.
Lost Creek: January 1-4, 1984; November 8-13, 1990.
Louis Creek: May-June 1894.
Luckakuck River: March 8-14, 1873; November 22, 1875; December 22, 1875; May 28-June 1, 1879; May 1890; May-June 1894.
Lugrin Creek: March 27-29, 1964; February 8-11, 1983; December 1990.
Lynn Creek: January 3-6, 1914; January 22-31, 1931; October 17-20, 1940; November 9-10, 1955; January 8-17, 1961; October 27-31, 1981; November 15. 2006.
M-Creek: October 27-31, 1981; August 27-31, 1991.
MT Lake: July 20, 1982; August 8, 1983.
Mackay Creek: November 1955; January 9-17, 1961; October 7-13, 1967; October 27-31, 1981; November 12, 1995; winter 1998-99.
Maggie Lake: October 16, 1995.
Magnesia Creek: October 11-13, 1962; October 27-31, 1981; October 6, 1982.
Maguire Creek: May 23-June 5, 1999.
Mamquam River: September 20-23, 1924; October 27-29, 1937; October 17-20, 1940; November 26-December 3, 1949; October 7-10, 1950; June 9-12, 1955; October 23-25, 1955; November 1-4, 1955; June 6-9, 1956; September 24-26, 1956; October 29-November 6, 1975; December 23-27, 1980; October 27-31, 1981; October 6-12, 1984; November 8-13, 1990; August 27-31, 1991.
Mara Lake: May 29-June 17, 1972; Late May-early June1997; July 11-13, 1997.
Mark Creek: May 23-June 15, 1948.
Mary Creek: April 19-21, 1997.
Mashiter Creek: December 23-27, 1980; October 27-31, 1981; November 8-13, 1990; August 27-31, 1991.
McConnell Creek: January 20-27, 1935; February 20-21, 1961.
McDey Creek: February 8-9, 1918.
McDonald Creek: October 16-23, 1975.
McFee Creek?: June-July 1999.
McGillivray Creek: February 23-27, 1932; February 7-11, 1951; Late May-early June 1996.
McGillivray Slough: February 23-27, 1932.
McIntyre Creek: May 19-21, 1921; May 23-June 15, 1948; May 23-June 5, 1999.
McLure Slough: May 25-June 15, 1948.
McNab Creek: November 8-13, 1990; October 16-22, 2003; Late January 2004.
Meade Creek: December 23-27, 1980.
Meager Creek: October, 1931; 1947;July 22, 1975; October 6-12, 1984; October 4, 1990; October 23-24, 1992; June-July 1999.
Mica Creek: May 29-June 17, 1972.
Michel Creek: May 13-14, 1942; June 5-7, 1995.
Michelle Creek: May 23-June 5, 1999.
Midday Creek: December 23-27, 1980.
Mill Creek (Clinton): June 1, 1873.
Mill Creek (Kelowna): May 23-June 16, 1942; May 10-18, 1954; July 11-13, 1997.
Mill Creek (Merritt): Early-mid May 1997.

Miller Creek: December 23-27, 1980; October 27-31, 1981; January 1-4, 1984; October 6-12, 1984; November 8-13, 1990; August 27-31,1991.
Millstone Creek: February 1-6, 1963.
Millstone River: December 22-23, 1963; December 23-27, 1980.
Mill Stream: January 31, 1935; November 1990; December 2-8, 1990.
Mine Creek: November 28-30, 1995.
Mission Creek (Kelowna): May-June 1894; July 1, 1935; May 10-16, 1949; May 20-June 2, 1983; spring 1997; June 11-13, 1990; May 31-June 1, 1997; Late May-early June 1997; July 11-13, 1997; May 23-June 5, 1999; May 15-23, 2006.
Mission Creek (Vancouver): January 8-17, 1961.
Moffat Creek: June 11-13, 1990.
Montizambert Creek: November 15, 1983.
Morello Creek: January 12-15, 1974.
Morton Creek: November 8-10, 1989.
Mosquito Creek (Kootenays): spring 1999.
Mosquito Creek (Vancouver): October 7-10, 1950; November 17-21, 1954; November 1-4, 1955; November 9-10, 1955; June 6-9, 1956; October 16-19, 1956; October 9-13, 1958; January 8-17, 1961; October 20-23, 1961; December 15-22, 1972; December 12-18, 1979; October 27-31, 1981.
Moyie Lake: June 15-24, 1916.
Moyie River: May 10-18, 1954; May 23-June 6, 1956; March-April 1997?; May 23-June 5, 1999.
Mud Creek (Chase): June-July 1999.
Mud Creek (Squamish): see: Turbid Creek.
Muir Creek: November 27-December 2, 1948; November 17-21, 1954.
Munroe Creek: November 8-10, 1989.
Murray Creek: November 8-13, 1990.
Nanaimo Lake: November 26-December 3, 1949.
Nanaimo River: October 24-29, 1921; November 22-December 1, 1949; November 26-December 3, 1949; November 1-4, 1955; January 23-25, 1958; November 30-December 1, 1958; January 9-17, 1961; February 1-6, 1963; January 5-13, 1966; January 12-15, 1974; December 12-18, 1979; December 23-27, 1980.
Nanoose Creek: January 12-15, 1974.
Naramata Creek: June 11-13, 1990.
Nash Creek: March 17-26, 1997.
Nelson Creek: November 1-4, 1955.
Nelson River: June 15-24, 1916.
Newman Creek: September 16-18, 1969; December 4, 1981; October 6, 1982; February 8-11, 1983; November 15, 1983.
Niagara Creek: November 12-13, 1896; November 29-December 8, 1975.
Nicola Lake: June 2002.
Nicola River: May-June 1894; May 18, 1922; January 1-4, 1984; Early February 1991; June 2002.
Nicolum Creek: January 9, 1965.
Nicomekl River: March 7-14, 1916; June 2-10, 1916; December 15-19, 1923; February 10-12, 1924; December 13-18, 1925; January 8-12, 1928; December 17-30, 1933; January 20-27, 1935; March 2, 1946; November 27-December 4, 1951; November 24, 1960; January 8-17, 1961; December 22-23, 1963; November 3 and 7, 1972; December 25-26, 1972; November 29-December 8, 1975; February 12-14, 1982; December 16-18, 1982; November 15, 1983; Late January 2004.
Nigger Bar Creek: May 3-4, 1969.
Nikaia Creek: Late May-early June 1997.
Nile Creek: December 23-27, 1980.
Nitinat Lake: June 23, 1946.
9-Mile Creek: November 1-4, 1955.
19-Mile Creek: December 23-27, 1980; October 27-31, 1981; November 8-13, 1990.

Noble Creek: May 23-June 15, 1948.
Noeick River: October 20, 1984.
Noisy Creek: July 11-13, 1997.
Nomash River: April 20-May 4, 1999.
Nooksack River: December 26, 1917-January 1, 1918; December 9-12, 1921; January 20-27, 1935; 1953; November 29-December 8, 1975; 1989 (three times); October 4, 1990; November 8-13, 1990; November 16-24, 1990; November 28-30, 1995; November 3-6, 2006.
Noons Creek: December 12-18, 1979.
Norrish Creek: January 1-4, 1984; November 8-13, 1990.
Nostetuko Lake: July 19, 1983; August 8, 1983; August 13, 1997.
Nostetuko River: July 20, 1982; July 19, 1983; August 8, 1983; August 13, 1997?
Nunns Creek: February 11, 1985.
One Mile Creek: January 1-4, 1984.
Okanagan Channel: June 11-13, 1990.
Okanagan Lake: May 23-June 16, 1942; May 25-June 15, 1948; July 20, 1951; April 16-18, 1974; June 14-28, 1974; May 20-June 2, 1983; June 11-13, 1990; March 12, 1996; June 1996; May 31-June 1, 1997; July 11-13, 1997; May 23-June 5, 1999.
Okanagan River: May 12, 1941; May 23-June 16, 1942; April 16-18, 1974; June 14-28, 1974; June 11-13, 1990; March 12, 1996.
Old Camp Creek: June 1-5, 1968; June 23-26, 1973.
Orchid Creek: November 12, 1995.
Osoyoos Lake: 1954; May 29-June 17, 1972; June 14-28, 1974; May 20-June 2, 1983; Early-mid May 1997.
Owikeno Lake: December 8-15, 1980.
Oyster River: November 14-20, 1939; November 28-December 2, 1941; October 29-November 6, 1975; November 9-16, 1975; December 23-27, 1980; November 8-13, 1990.
Pass Creek: June 1-5, 1968.
Patchett Creek: December 23-27, 1980.
Pattison Creek: January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; October 16-22, 2003.
Paul Creek: May 29-June 17, 1972.
Pemberton Creek: December 23-27, 1980; October 27-31, 1981; October 6-12, 1984; November 8-13, 1990; August 7-9, 1991.
Penticton Creek: May 19-21, 1921; May 23-June 16, 1942; spring 1952?
Peterson Creek: May 23-June 15, 1948.
Pierce Creek: November 28-30, 1995.
Pillchuck Creek: November 8-13, 1990.
Pine Creek (Kelowna): 1941.
Pitt Lake: September 20-23, 1924; December 23-27, 1980.
Pitt River: October 24-29, 1921; December 9-12, 1921; January 20-27, 1935; February 3-4, 1953; December 23-27, 1980; November 8-13, 1990.
Pixie Creek: November 8-13, 1990.
Postill Lake: July 11-13, 1997.
Puntledge River: January 31, 1935; December 14-15, 1962; February 1-6, 1963; December 23-27, 1980.
Pye Creek: November 8-10, 1989; November 8-13, 1990.
Quantan River: September 15-16, 1964.
Quesnel River: May-June 1894; May 18-23, 1925; January 31, 1934.
Quinsam River: mid 1970s; December 23-27, 1980; November 8-13, 1990; October 1997; January 23-26, 1998.
Rainbow Creek: June 14-28, 1974.
Renata Creek: May 10-18, 1954.
Robert Lake: March-April 1997.
Robertson River: November 26-December 3, 1949; December 25-29, 1949; December 23-27, 1980.

Rogers Creek: January 23-25, 1958; November 30-December 1, 1958; July 11-12, 1972.
Rosebud Lake: April 19, 1966.
Rosewell Creek: November 14-20, 1939.
Ross Creek: May 23-June 15, 1948; May 12-13, 1971; May 31-June 1, 1997; July 11-13, 1997; June-July 1999.
Rubble Creek: winter 1855-56.
Ruby Creek: May-June 1894; November 8-13, 1990.
Russell Creek: May 31-June 1, 1997.
Rutherford Creek: December 23-27, 1980; October 27-31, 1981; November 16-24, 1990.
Ryan Creek: December 23-27, 1980; October 27-31, 1981; October 23-24, 1992.
Ryan River: January 1-4, 1984; October 6-12, 1984; November 8-13, 1990; August 27-31,1991.
Ryder Creek: December 23-27, 1980; November 8-13, 1990; November 16-24, 1990.
St. Leon Creek: June 1-5, 1968.
St. Mary's Creek: June 14-28, 1974.
St. Marys River: June 15-24, 1916.
Sakwi Creek: November 1, 1977; January 1-4, 1984.
Salmo River: May 12-13, 1971; May 28-31, 1993; May 15-23, 2006.
Salmon River (Kootenays): May-June1894.
Salmon River (Langley): January 4-6, 1896; June 10-14, 1921; May 18-23, 1925; May 29-June 3, 1936.
Salmon River: (Falkland): May 23-June 5, 1999.
Salmon River (Sayward): December 30, 1926-January 3, 1927; November 14-20, 1939; October 19-22, 1965; October 29, 1968; October 29-November-6, 1975; November 9-16, 1975; November 29-December 8, 1975?; November 1976; November 8-13, 1990; November 16-24, 1990; December 2-8, 1990.
Salmon Slough: October 27-31, 1981.
Salus Creek: June-July 1999.
Sanca Creek: June 22-29, 1955.
Sand River: May 23-June 5, 1999.
Sandstone Creek: January 7-11, 1932.
San Juan River: December 30, 1962-January 2, 1963; November 3-6, 2006.
Saporano Creek: October 16-22, 2003; Late January 2004.
Schroeder Creek: spring 1999.
Sclufield Creek: October 6-12, 1984; December 10-17, 1984.
Scott Creek: November 8-10, 1989.
Scott's (Scott(s) Creek: January 4-6, 1896.
Serpentine River: March 7-14, 1916; June 2-10, 1916; December 13-18, 1925; January 8-12, 1928; November 18-21, 1932; December 17-30, 1933; January 20-27, 1935; January 5-11, 1945; February 6-7, 1945; November 27-December 4, 1951; December 9-18, 1966; December 15-22, 1972; December 16-18, 1982; November 15, 1983; Late January 2004.
Seton Lake: Late May-early June 1997.
Seton River: May 31-June 1, 1997; Late May-early June 1997.
Seymour Creek: November 27-30, 1909; January 3-6, 1914; January 22-31, 1931; October 17-20, 1940; November 26-December 3, 1949; October 7-10, 1950; November 1-4, 1955; June 6-9, 1956; November 30-December 1, 1958; January 8-17, 1961; October 27-31, 1981; November 15, 1983.
Seymour River: July 11-13, 1997.
Shannon Creek: October 27-31, 1981.
Shawnigan Creek: January 20-25, 1951.
Shawnigan Lake: January 20-25, 1951.
Sheep Creek: May-June 1894; June 13-16, 1933; May 23-June 16, 1942; May 23-June 15, 1948; June 1-5, 1968; April 20-May 4, 1999; May 23-June 5, 1999.
Sheridan Lake: June-July 1999.
Shingle Creek: May 23-June 16, 1942; May 23-June 15, 1948.

Shorts Creek: May 23-June 5, 1999.
Shouz Creek: December 23-27, 1980.
Shuswap Lake: May 23-June 15, 1948; December 22, 1959; May 29-June 17, 1972; June 14-28, 1974; June 21, 1982; Late May-early June1997; May 23-June 5, 1999; June-July 1999.
Shuswap River: May 20-June 2, 1983; Late May-early June 1997; June-July 1999.
Shuttleworth Creek: ca.1930; May 15, 1936; May 27, 1944; June 11-13, 1990.
Siddle Creek: January 1-4, 1984; November 8-10, 1989; November 8-13, 1990.
Silver Creek (Lower Mainland): December 26, 1919; October 23-26, 1945; November 1-4, 1955.
Silver Creek: (Okanagan): May 23-June 5, 1999.
Silver Creek (Steelhead Valley): November 13-18, 1919.
Silver (Silverhope) Creek: February 26-28, 1932; November 18-21, 1932; December 23-27, 1980; January 1-4, 1984; November 8-10, 1989; November 8-13, 1990; November 28-30, 1995; November 3-6, 2006.
Silverdale Creek: December 23-27, 1980.
Silverhope Creek: see Silver Creek.
Silver Lake: November 8-10, 1989.
Silver-Skagit (?) River: October 30-November 1, 1967.
Similkameen River: November 1, 1906; February 26-28, 1932; May 10-16, 1949; January 29-31, 1951; February 7-11, 1951; May 10-18, 1954; June 13, 1955; May 23-June 6, 1956; May 12-16, 1972; May 29-June 17, 1972; June 14-28, 1974; December 23-27, 1980; May 20-June 2, 1983; January 1-4, 1984; November 29-early December 1995; Early-mid May 1997.
Simms Creek: July 11-13, 1997**.**
Sisan Creek: December 12-18, 1979.
Six Miles Creek: May 23-June 5, 1999.
Skagit River: November 18-20, 1911; December 9-12, 1921.
Skaha Lake: April 16-18, 1974.
Slesse Creek: November 8-10, 1989; January 29-February 6, 1997.
Slocan River: June 13-16, 1933; August 21-24, 2004; May 15-23, 2006.
Somass River: January 31, 1935; November 14-20, 1939; December 7-10, 1939; November 27-December 4, 1951; November 30-December 1, 1958; January 8-17, 1961; March 27-29, 1964; January 12-15, 1974; October 29-November-6, 1975.
Somenos Lake: January 8-17, 1961; November 9-16, 1975; December 23-27, 1980.
Somenos River: January 8-17, 1961; January 29-31, 1961; January 20-24, 1972; November 27, 1973; December 23-27, 1980.
Soo River: October 27-31, 1981.
Sooke River: October 24-29, 1921; November 17-21, 1954; November 3-6, 2006.
Spahats Creek: June-July 1999.
Spallumcheen River: May-June 1894.
Spetch Creek: December 23-27, 1980; October 27-31, 1981.
Spencer Creek: July 11-12, 1972.
Spilkameen River: May-June 1894.
Spius Creek: January 1-4, 1984.
Spray Creek: June-July 1999.
Springer Creek: June 13-16, 1933.
Sproat Lake: June 23, 1946; January 9-17, 1961; December 9-18, 1966.
Squakum Creek: November 8-10, 1989.
Squakum Lake: see Erroch Lake.
Squamish River: September 5-9, 1906; October 17-20, 1940; November 26-December 3, 1949; October 7-10, 1950; June 9-12, 1955; November 1-4, 1955; June 6-9, 1956; September 5-6, 1957; October 9-13, 1958; October 29-November-6, 1975; December 23-27, 1980; October 27-31, 1981; June 28, 1984; October 6-12, 1984; November 8-10, 1989; November 8-13, 1990; August 27-31,1991; October 23-24, 1992; October 16-22, 2003; November 3-6, 2006.

Stagleap Creek: May 31-June 1, 1997.
Star Creek: June 13-16, 1933.
Stave Lake: February 10-12, 1924; February 18-20, 1930.
Stave River: January 20-27, 1935.
Stawamus River: November 13-21, 1954; November 1-4, 1955; December 23-27, 1980; October 27-31, 1981; October 6-12, 1984; November 8-10, 1989; Early 1990s; November 8-13, 1990; August 27-31, 1991.
Steele Creek: July 1967.
Sterling Creek: May 10-16, 1949.
Stewart Creek: June 16-21, 1950; February 7-11, 1951.
Still Creek: January 7-11, 1932; January 20-27, 1935; February 6-7, 1945; November 17-21, 1954; November 1-4, 1955; October 16-19, 1956; December 7-10, 1956; December 9-18, 1966; January 14-20, 1968; December 25-26, 1972; December 12-18, 1979; December 22-23, 1983.
Stillwater Lake: winter 1855-56.
Stone Creek: June 11-13, 1990.
Stoney Creek (Burnaby): December 16, 2000.
Stoney Creek (Sea-to-Sky): November 1-4, 1955; September 16-17, 1968; October 23, 1968; October 16-23, 1975; October 29-November-6, 1975.
Stony Creek (Trail): April 23, 1969.
Stowe Creek: January 12-14, 1968; November 15, 2004.
Strachan 1 Creek: see Turpin Creek.
Strachan (Strachan 2) Creek: see Charles Creek.
Street Creek: November 8-10, 1989.
Stumble Creek: Early-mid May 1997.
Sugar Lake: May 20-June 2, 1983; June-July 1999.
Suicide Creek: January 20-27, 1935.
Sumallo River: January 1-4, 1984; November 8-13, 1990.
Sumas Canal: January 20-27, 1935.
Sumas Lake: June 19-July 1, 1876; June 15-24, 1916; January 20-27, 1935.
Sumas River: June 19-Juky 1, 1876; December 11-14, 1924; November 18-21, 1932; January 20-27, 1935; November 8-13, 1990.
Summers Creek: May 29-June 17, 1972.
Summit Lake: see Clanwilliam Lake.
Sutton Creek: December 23-27, 1980.
Sweitzer Creek: February 7-11, 1951.
Swift Creek: December 23-27, 1980; October 27-31, 1981.
Sylvester Brook: November 8-13, 1990.
Tete Angela Creek: June-July 1999.
Texas Creek: November 17-24, 1959; November 19-20, 1962; November 29-December 8, 1975; June-July 1999.
Thacker Creek: November 8-10, 1989.
Thane Creek: November 15, 2006.
Thompson River (North and South): June 19-July 1, 1876; August 1, 1880; October 14, 1880; October, 1881; October 19, 1886; 1888; May-June 1894; December 31, 1899; June 25-27, 1900; June 15-24, 1916; June 10-14, 1921; August 13, 1921; May 20-30, 1928; July 1, 1935?; May 29-June 3, 1936; June 3, 1946; May 25-June 15, 1948; May 10-18, 1954; May 29-June 17, 1972; June 14-28, 1974; September 22-25, 1982; Late May-early June 1996; Late May-early June 1997; May 23-June 5, 1999; June-July 1999; August 1999.
Thuya Creek: 1972.
Tofino Creek: January 1991.
Trail Creek: April 15-20, 1904; April 23, 1969; April 19-21, 1997.
Tranquille Creek: July 1, 1935.
Trent River: December 23-27, 1980.

Trepannier Creek: May 23-June 15, 1948.
Trite Creek: January 1-4, 1984.
Trout Creek: May-June 1894; May 23-June 15, 1948; June-July 1999.
Trout Lake: February 23-27, 1932.
Tsitika River: November 8-13, 1990; November 16-24, 1990.
Tsolum River: January 31, 1935; November 14-20, 1939; November 28-December 2, 1941?; December 14-15, 1962; February 1-6, 1963; December 22-23, 1963; December 23-27, 1980.
Tulameen River: February 26-28, 1932; January 20-27, 1935; May 10-16, 1949; January 29-31, 1951; February 7-11, 1951; June 13, 1955; May 12-16, 1972; May 29-June 17, 1972; June 14-28, 1974; December 23-27, 1980; January 1-4, 1984; November 8-13, 1990; December 1995; April 1, 1996; Early-mid May 1997; November 3-6, 2006.
Turbid (Mud) Creek: July 1963; June 28, 1984; October 6-12, 1984; November 29-early December 1995.
Turpin Creek (Strachan 1 Creek): February 8-11, 1983; Late December 1994.
Twenty-Mile Creek (Hedley Creek): May 10-16, 1949; May 29-June 17, 1972; December 23-27, 1980; November 8-13, 1990.
Two Bit Creek: May 23-June 5, 1999.
Two Mile Creek: January 1-4, 1984.
Unnamed # 1 Creek: ca.1935.
Uztlius Creek: December 23-27, 1980.
Vaseaux Lake: June 11-13, 1990; Late May-early June 1997.
Vedder Canal: June 16-21, 1950.
Vedder Creek: see: Vedder River.
Vedder River: November 22, 1875; June 19-July 1, 1876; May-June 1894; November 12-14, 1906; November 27-30, 1909; June 2-10, 1916; December 26, 1917-January 1, 1918; October 24-29, 1921; December 9-12, 1921; February 10-12, 1924; December 11-14, 1924; February 23-27, 1932; November 18-21, 1932; December 2, 1932; October 23-26, 1945; October 16-20, 1947; May 10-16, 1949; June 16-21, 1950; December 1950; February 7-11, 1951; July 7-10, 1954; November 17-21, 1954; November 1-4, 1955; June 14-28, 1974; November 29-December 8, 1975; December 23-27, 1980; January 1-4, 1984; November 8-10, 1989; November 8-10, 1989; November 8-13, 1990; November 8-13, 1990; November 28-30, 1995.
Veitch Creek: November 8-13, 1990.
Vick's (Vic?) Creek: May-June 1894.
Wahleach (Jones) Creek: October 23-26, 1945; July 11-15,1983; Late May-early June 1997.
Washout Creek: April 2, 1956.
Waugh Creek: November 12-13, 1896.
Weaver Creek: November 1, 1977; January 1-4, 1984.
Whistler Creek: November 8-13, 1990.
White Creek: May-June 1894.
White River: May-June 1894.
White River (Sayward): November 14-20, 1939; November 9-16, 1975; November 8-13, 1990.
Whonnock River: November 8-10, 1989.
Wild Horse Creek: May 23-June 6, 1956; June 14-28, 1974.
Wilson Lake: April 20-May 4, 1999.
Windermere Lake: Mid May-mid June 1808.
Wolverine Creek: December 23-27, 1980.
Woods Creek: January 23, 1998.
Woolsey Creek: July 11-15, 1983.
Yale Creek: November 17-21, 1954.
York Lake: January 9-17, 1961.
Youbou Creek: December 23-27, 1980.

Zeballos River: Ca. October 15, 1938; Ca. December 16, 1938; December 30, 1938-January 4, 1939; November 14-20, 1939; October 17-20, 1940; December 10-11, 1946?; Early November 1965; December 23-27, 1980; April 20-May 4, 1999.

Appendix 2 Geographical index by community

Abbotsford: October 4, 1990; November 8-13, 1990; November 16-24, 1990.
Agassiz: May-June 1894; February 23-27, 1932; May 29-June 3, 1936; June 3, 1946; May 23-June 15, 1948; July 7, 1955; June 1964; June 15-22, 1967; June 14-28, 1974.
Aldergrove: February 12-14, 1982.
Ashcroft: May-June 1894.
Anglemont: May 23-June 15, 1948.
Arrowhead: February 28, 1903.
Athalmer: May 29-June 17, 1972.
Barriere: May 23-June 15, 1948; June-July 1999.
Big Bend: May-June 1894.
Boston Bar: June 19-July 1, 1876.
Brackendale: 1937; October 17-20, 1940; December 23-27, 1980; January 15-18, 1986; November 16-24, 1990; October 23-24, 1992**.**
Britannia Beach: September 5-9, 1906; October 24-29, 1921; December 17-30, 1933; December 22-23, 1963; October 30-November 1, 1967; May 25, 1989; August 17-18, 1991; August 27-31, 1991.
Burnaby: February 6-7, 1945; December 10-11, 1946; May 23-June 15, 1948; November 1-4, 1955; December 7-10, 1956; December 15-22, 1972; December 25-26, 1972; December 12-18, 1979; February 12-14, 1982; December 22-23, 1983; December 10-17, 1984; November 1, 1985; December 16, 2000.
Cache Creek: July 13, 1920.
Campbell River: November 16-21, 1908; February 1936; November 14-20, 1939; December 1939; spring 1940; November 28-December 2, 1941; January 15-16, 1944; November 27-December 4, 1951; December 27-28, 1952; November 14-15, 1953; December 10-11, 1970; October 29-November-6, 1975; March 1980; February 11, 1985; February 7, 1989; December 2-8, 1990; March 17-26, 1997; December 29, 2005-January 1, 2006; November 15, 2006.
Campbellton: see Campbell River.
Canim Lake: June-July 1999.
Castlegar: April 19-21, 1997.
Cedar: December 12-18, 1979; December 23-27, 1980; 1990.
Chase: July 1, 1935; May 23-June 15, 1948; June 1996; Early-mid May 1997.
Cheekye: August 27-31, 1991.
Chemainus: December 25-29, 1949; December 25-26, 1972; January 12-15, 1974; December 2-8, 1990.
Chilliwack: June, 1870; March 8-14, 1873; November 22, 1875; December 22, 1875; June 19-July 1, 1876; June 7-14, 1982; May-June 1894; July 4-7, 1896; June 15-24, 1916; December 13, 1917; December 26, 1917-January 1, 1918; June 10-14, 1921; October 24-29, 1921; February 23-27, 1932; November 18-21, 1932; January 20-27, 1935; May 29-June 3, 1936; October 23-26, 1945; May 23-June 15, 1948; February 7-11, 1951; February 3-4, 1953; January 9-17, 1961; June 15-22, 1967; January 12-20, 1968; November 29-December 8, 1975; December 2-3, 1982; November 8-10, 1989; November 8-13, 1990; November 12, 1995; Late May-early June 1997; ca. 2003; November 3-6, 2006.
Christina Lake: April 30, 2004.
Clearwater: June-July 1999.
Clinton: June 1, 1873.
Cloverdale: March 2, 1946; November 17-21, 1954; November 24, 1960; December 9-18, 1966.
Coalmount: November 29-early December 1995.
Colwood: November 8-10, 1989; November 16-24, 1990.

Comox: October 10-13, 1905.
Coquitlam: December 1-2, 1890; May 23-June 15, 1948; April 29-30, 1959; January 9-17, 1961; December 22-23, 1963; October 6-13, 1967; January 12-20, 1968; November 27, 1973; December 12-18, 1979; December 2-3, 1982; November 22-23, 1986; January 27-February 6, 1997; March 17-26, 1997.
Courtenay: November 14-20, 1939; December 7-10, 1939; November 28-December 2, 1941; February 1-6, 1963; December 22-23, 1963; November 9-16, 1975; August 25, 1976; December 23-27, 1980.
Cowichan Bay: December 11-21, 1890?; January 4-6, 1896?; February 18-20, 1930; January 12-20, 1968?; January 18-19, 1971; December 25-26, 1972; December 2-8, 1990; March 17-26, 1997.
Cranbrook: May 23-June 16, 1942; May 29-June 17, 1972; February 25-26, 1986.
Creston: May 23-June 15, 1948; May 23-June 6, 1956; 1960; June 5-6, 1961; June 14-28, 1974.
Crofton: December 22-23, 1947.
Cumberland: January 23-25, 1958; November 15, 2006.
Delta: December 27, 1938-January 2, 1939; December 22-23, 1963; December 15-22, 1972; December 25-26, 1972; November 27, 1973; December 16-18, 1982; February 3-4, 2006.
Dewdney: May-June 1894; June 15-22, 1967.
Douglas: June 1862; November 11-12, 1865.
Duncan: February 22-24, 1957; November 30-December 1, 1958; January 24-29, 1960; January 9-17, 1961; October 11-13, 1962?; December 30, 1962-January 2, 1963; January 5-13, 1966; December 9-18, 1966; January 12-20, 1968; January 18-19, 1971; January 18-24, 1972; December 25-26, 1972; January 12-15, 1974; November 9-16, 1975; November 29-December 8, 1975; January 27, 1976; August 26?, 1976; December 23-27, 1980; October 24, 1982.
Elkford: ca. 1960 (see November 1980).
Enderby: Late May-early June 1997.
Esquimalt: November 12-15 and 20, 1958; November 29-December 8, 1975; December 12-18, 1979; winter 1982-83?
Fernie: June 15-24, 1916; June 2, 1923; May 13-14, 1942; May 23-June 15, 1948; May 23-June 6, 1956; 1974; 1986; June 5-7, 1995.
Fort Langley: May 1890; May 1892.
Fort Steele: June 15-24, 1916.
Fruitvale: April 14, 2004.
Golden: May-June 1894; May 30-June 1, 1986.
Grand Forks: May 23-June 6, 1956; Late May-early June 1997; May 15-23, 2006.
Grasmere: June 14-28, 1974.
Greenwood: September 12, 1969.
Haney: May-June 1894; February 18-20, 1930; January 20-27, 1935; January 9-17, 1961; June 14-28, 1974; October 29-November-6, 1975.
Harrison: May-June 1894.
Harrison Mills: Late May-early June 1997.
Harrison Hot Springs: May 23-June 15, 1948; June 16-21, 1950; Late May-early June 1997.
Hatzic: May-June 1894.
Hatzic Prairie: see: Hatzic.
Hedley: August 13, 1921; May 29-June 17, 1972.
Hope: June 16-21, 1950; June 1964; October 30-November 1, 1967; May 29-June 17, 1972; December 23-27, 1980; January 1-4, 1984; Late May-early June 1997; November 3-6, 2006.
Howser: May 29-June 17, 1972.
Kamloops: July 1, 1935; May 29-June 3, 1936; May 23-June 15, 1948; 1968; May 29-June 17, 1972; January 15-16, 1973; August 3, 1978; July 21, 1997.
Kelowna: July 1, 1935; May 23-June 16, 1942; December 25-29, 1949; May 10-18, 1954; June 21, 1974; May 20-June 2, 1983; June 11-13, 1990; May 31-June 1, 1997; Late May-early June 1997; July 11-13, 1997; July 21, 1997.
Keremeos: May 29-June 17, 1972; June 14-28, 1974.

Kimberley: 1916; May 23-June 15, 1948; May 23-June 6, 1956; May 29-June 17, 1972.
Kyuquot: June 15, 1896.
Ladner: November 15, 1871; May 23-June 15, 1948; November 27-December 4, 1951.
Lake Cowichan: December 11-21, 1890; January 31, 1935; December 25-29, 1949; January 8-17, 1961.
Langford: January 24-29, 1960.
Langley: May-June 1894; January 4-6, 1896; June 2-10, 1916; June 10-14, 1921; May 18-23, 1925; June 14, 1934; May 29-June 3, 1936; February 6-7, 1945; March 2, 1946; May 23-June 15, 1948; February 3-4, 1953; June 14-28, 1974; December 12-18, 1979; February 12-14, 1982; June 21, 1982.
Lantzville: January 24-29, 1960; December 12, 1969; December 2-8, 1990.
Lillooet: July 13-15, 1946.
Lions Bay: December 15-22, 1972; December 25-26, 1972; February 8-11, 1983.
Little Fort: May 23-June 15, 1948; May 29-June 17, 1972.
Louis Creek: May 23-June 15, 1948.
Lytton: May-June 1894; May 23-June 15, 1948.
Magna Bay: May 23-June 15, 1948.
Maple Ridge: May-June 1894; March 2, 1946; May 23-June 15, 1948; February 7-11, 1951; December 7-10, 1956; April 29-30, 1959; January 9-17, 1961; November 3-6, 2006.
Matsqui: May-June? 1877; 1878; July 7, 1880; May 1890; May-June 1894; July 4-7, 1896; July 16, 1920; January 20-27, 1935; May 23-June 15, 1948; August 29-31, 1948; June 1964; June 15-22, 1967.
Merritt: May 23-June 15, 1948; Late September 1972; December 23-27, 1980; November 16-24, 1990; Early February 1991; Early-mid May 1997; June 2002; December 23-26, 2005.
Metchosin: December 10-14, 1969.
Mission: May-June 1894; June 13-17, 1903; June 10-14, 1921; January 20-27, 1935; May 29-June 3, 1936; May 23-June 15, 1948; June 14-28, 1974; December 12-18, 1979; November 8-13, 1990.
Mission City: see Mission.
Mission (Kootenays): June 15-24, 1916.
Nakusp: May-June 1894.
Nanaimo: November 27-30, 1909; February 1-16, 1916; November 26-December 3, 1949; November 1-4, 1955; January 23-25, 1958; January 24-29, 1960; January 9-17, 1961; December 22-23, 1963; January 12-20, 1968; December 10-14, 1969; January 12-15, 1974; October 29-November-6, 1975; December 12-18, 1979; December 23-27, 1980; October 21, 1985;
Nanoose: March 17-26, 1997.
Nelson: May 29-June 3, 1936; May 23-June 6, 1956; June 1-5, 1968; November 8-13, 1990?; May 15-23, 2006 November 16-24, 1990?; December 2-8, 1990; March-April 1997; April 19-21, 1997.
New Westminster: June 19-July 1, 1876; May-June 1894; January 9-13, 1895; January 4-6, 1896; June 13-17, 1903; November 27-30, 1909; ca. June 12-19, 1911; February 1-16, 1916; March 7-14, 1916; June 10-14, 1921; October 24-29, 1921; February 10-12, 1924; May 18-23, 1925; February 18-20, 1930; November 18-21, 1932; January 20-27, 1935; December 27, 1938-January 2, 1939; February 6-7, 1945; December 3-4, 1946; May 23-June 15, 1948; November 27-December 2, 1948; February 7-11, 1951; November 17-21, 1954; November 1-4, 1955; January 9-17, 1961; October 7-12, 1961; June 1964; October 6-13, 1967; January 12-20, 1968; July 11-12, 1972; December 11-15, 1977; December 12-18, 1979; June 4, 1993.
Nicola: May-June 1894; May 18, 1922.
North Cowichan: January 18-24, 1972; December 25-26, 1972; January 12-15, 1974.
North Delta: see Delta.
North Vancouver: January 22-31, 1931; November 17-21, 1954; November 1-4, 1955; November 9-10, 1955; June 6-9, 1956; October 16-19, 1956; October 9-13, 1958; November 30-December 1, 1958; January 9-17, 1961; October 30, 1962-January 2, 1963; October 7-13, 1967; September 16-17, 1968; December 15-22, 1972; December 25-26, 1972; July 4-6, 1978; December 12-18, 1979; October 27-31, 1981; February 12-14, 1982; November 12, 1995.
Oak Bay: November 12-15 and 20, 1958; January 6-7, 1959; November 29-December 8, 1975; December 12-18, 1979.

Okanagan Falls: May 15, 1936; May 27, 1944.
Oliver: May 23-June 16, 1942; January 28-31, 1974; Late May-early June 1997.
Osoyoos: May 29-June 17, 1972; Early-mid May 1997.
Owikeno: December 8-15, 1980; November 8-10, 1989; November 8-13, 1990.
Parksville: November 26-December 3, 1949; December 25-29, 1949; January 12-15, 1974; December 12-18, 1979; December 23-27, 1980; 1985; November 16-24, 1990; December 2-8, 1990; March 17-26, 1997; November 15, 2006.
Pemberton: 1937; October 17-20, 1940; July 13-15, 1946; September 5-6, 1957; January 12-20, 1968; October 27-31, 1981; January 1-4, 1984; October 6-12, 1984; November 8-13, 1990; November 16-24, 1990; August 7-9, 1991; August 27-31, 1991; October 23-24, 1992.
Penticton: May 19-21, 1921; May 12, 1941; May 23-June 16, 1942; July 20, 1951; August 31, 1989; March 12, 1996.
Pitt Meadows: June 19-July 1, 1876; May 1890; May-June 1894; July 4-7, 1896; June 13-17, 1903; January 20-27, 1935; March 2, 1946; May 23-June 15, 1948; February 7-11, 1951; February 3-4, 1953.
Popkum: May 23-June 15, 1948.
Port Alberni: January 22-31, 1931; November 14-20, 1939; December 7-10, 1939; November 26-December 3, 1949; January 23-25, 1958; November 30-December 1, 1958; January 6-7, 1959; January 9-17, 1961; March 27-29, 1964; December 9-18, 1966; October 7-13, 1967; January 12-15, 1974; October 29-November-6, 1975; February 8-11, 1983; Early February 1991; March 17-26, 1997 November 15, 2006.
Port Alice: 1927; 1935; December 15, 1973; November 9-16, 1975; November 8-10, 1987; November 8-10, 1989; December 2-8, 1990.
Port Coquitlam: October 24-29, 1921; December 9-12, 1921; May 23-June 15, 1948; November 1-4, 1955; January 9-17, 1961; December 9-18, 1966; December 12-18, 1979; December 2-3, 1982; November 15, 1983.
Port Haney: see: Haney.
Port Moody: December 1-2, 1890; January 4-6, 1896; December 12-18, 1979.
Port Renfrew: March 17-26, 1996.
Princeton: February 26-28, 1932; May 10-16, 1949; January 29-31, 1951; February 7-11, 1951; May 29-June 17, 1972; January 1-4, 1984; Late March 1986; November 16-24, 1990; November 29-early December 1995.
Procter: May 29-June 17, 1972; June 14-28, 1974.
Qualicum Beach: December 23-27, 1980; December 2-8, 1990; March 17-26, 1997.
Quatsino: November 8-10, 1989.
Radium Hot Springs: May 30-June 1, 1986.
Renata: May 10-18, 1954.
Revelstoke: May-June 1894; May 29-June 3, 1936; March 27, 1959; June 2, 1967; June 1-5, 1968; May 29-June 17, 1972; Early January 1979; April 30, 2004.
Richmond: November 25-31, 1913; January 26, 1914; February 6-7, 1945; November 27-December 4, 1951; January 23-25, 1958; December 25-26, 1972; February 16, 1976; December 11-15, 1977; December 2-3, 1982.
Saanich: February 15-23, 1949; December 25-29, 1949; November 27-December 4, 1951; November 12-15 and 20, 1958; January 18-19, 1967; February 12, 1971; December 7-8, 1971; November 29-December 8, 1975; December 12-18, 1979; December 23-27, 1980; January 20-26, 1982.
Salmon Arm: May 29-June 17, 1972; June 21, 1982.
Sandon: June 22-29, 1955.
Sapperton: May-June 1894; March 9-11, 1900.
Sardis: June 10-14, 1921; December 11-14, 1924.
Savona: May 23-June 15, 1948; May 29-June 17, 1972.
Sayward: November 9-16, 1975; November 8-13, 1990; November 16-24, 1990; December 2-8, 1990; November 15, 2006.
Sicamous: May 29-June 17, 1972; June 14-28, 1974; Late March-middle April 1982; February 1983; June-July 1999.
Sidney: January 24-29, 1960.
Sixteen-Mile House: November 11-12, 1865.

Sooke: March 17-26, 1997.
Sorrento: May 23-June 15, 1948.
Sparwood: September 11, 1996.
Spences Bridge: December 31, 1899.
Squamish: June 25-27, 1900; September 5-9, 1906; November 16-21, 1908; December 17-30, 1933; 1937; October 17-20, 1940; November 26-December 3, 1949; November 27-December 4, 1951; October 23-25, 1955; June 6-9, 1956; September 24-26, 1956; September 5-6, 1957; October 9-13, 1958; October 29-November-6, 1975; November 9-16, 1975; December 23-27, 1980; October 6-12, 1984; November 16-24, 1990; August 27-31, 1991; November 3-6, 2006.
Steveston: January 9-13, 1895.
Sumas: June 1870; June 19-July 1, 1876; May 28-June 1, 1879; June 7-14, 1982; May 1890; May-June 1894; July 13-15, 1908; ca. June 12-19, 1911; June 2-10, 1916; June 15-24, 1916; December 9-12, 1921; December 11-14, 1924; February 23-27, 1932; November 18-21, 1932; January 20-27, 1935; October 23-26, 1945; October 16-20, 1947; May 23-June 15, 1948; February 7-11, 1951; November 8-13, 1990; November 16-24, 1990.
Summerland: May 23-June 15, 1948; 1970; 1982; September 16, 1992.
Surrey: December 15-19, 1923; February 10-12, 1924; January 8-12, 1928; November 18-21, 1932; December 27, 1938-January 2, 1939;January 5-11, 1945; May 23-June 15, 1948; November 27-December 4, 1951; January 30-February 1, 1952; November 1-4, 1955; November 24, 1960; January 9-17, 1961; December 30, 1962-January 2, 1963; December 22-23, 1963; December 9-18, 1966; October 6-13, 1967; January 12-20, 1968; July 11-12, 1972; November 21, 1972; December 25-26, 1972; February 12-14, 1982; December 2-3, 1982; December 16-18, 1982; November 15, 1983; October 14, 1996.
Tete Jaune: June 7-16, 1913.
Tulameen: November 29-early December 1995.
Trail: April 15-20, 1904; June 18, 1939; May 23-June 15, 1948; June 24-29, 1955; May 23-June 6, 1956; June 5-6, 1961; June 1964; April 23, 1969; April 19-21, 1997; April 14, 2004.
Union Bay: February 10, 1912.
Vancouver: January 9-13, 1895; March 9-11, 1900; September 15-16, 1905; September 5-9, 1906; October 24-31, 1908; November 1-4, 1908; November 16-21, 1908; November 27-30, 1909; December 7-9, 1915; February 6-16, 1916; March 7-14, 1916; December 26, 1917-January 1, 1918; November 13-18, 1919; October 24-29, 1921; February 10-12, 1924; January 7-11, 1932; February 23-27, 1932; January 20-27, 1935; October 17-20, 1940; October 8-15, 1941; February 6-7, 1945; May 23-June 15, 1948; November 26-December 3, 1949; January 20-25, 1951; November 27-December 4, 1951; November 17-21, 1954; November 1-4, 1955; October 16-19, 1956; December 7-10, 1956; October 20-23, 1960; February 20-21, 1961; November 19-20, 1962; December 22-23, 1963; December 9-18, 1966; January 12-20, 1968; December 5-6, 1970; July 11-12, 1972; December 15-22, 1972; December 25-26, 1972; November 10, 1982; December 2-3, 1982; October 14, 1996; January 27-February 6, 1997; November 3-6, 2006; November 15, 2006.
Vernon: July 21, 1997.
Victoria: September 15-16, 1905; November 27-30, 1909; Winter 1909; February 1-16, 1916; March 7-14, 1916; December 9-12, 1921; December 11-19, 1923; January 7-11, 1932; January 20-27, 1935; December 10-11, 1946; January 17-24, 1947; December 14-16, 1947; December 25-29, 1949; February 6-7, 1955; December 7-10, 1956; December 22-24, 1957; November 12-15 and 20, 1958; January 24-29, 1960; February 20-21, 1961; December 30, 1962-January 2, 1963; January 18-19, 1967; November 29-December 8, 1975; December 12-18, 1979; December 23-27, 1980; January 20-26, 1982; December 2-3, 1982; November 8-13, 1990; November 16-24, 1990; December 2-8, 1990.
Warfield: June 18, 1939.
West Vancouver: November 1-4, 1955; September 16-17, 1968; July 11-12, 1972; December 15-22, 1972; December 25-26, 1972; October 16-23, 1975; October 27-31, 1981; August 31-September 1, 1983; November 15, 1983; January 4, 1987; November 8-10, 1989.
Whistler: October 6-12, 1984.

White Rock: January 7-11, 1932; January 20-27, 1935; November 27-December 4, 1951; January 20-26, 1982; February 12-14, 1982; January 4, 1987; June 8, 1999.
Williams Lake: October 24, 1982; July 15, 1995.
Woodfibre: August 22, 1955.
Yakh: May 10-18, 1954; May 23-June 6, 1956; December 28-29, 1996; March-April 1997; May 23-June 5, 1999.
Yale: November 11-12, 1865.
Yarrow: October 23-26, 1945; February 7-11, 1951.
Youbou: January 9-17, 1961; December 9-18, 1966.
Zeballos: 1920s; ca. 1934; March 19, 1938; Ca. October 15, 1938; December 9, 1938; December 30, 1938-January 4, 1939; November 14-20, 1939; December 7-10, 1939; December 21, 1939; December 10-11,1946; March 27-29, 1964; Early November 1965.

Appendix 3 Abbreviations streamflow gauging stations

For the years 1913-1990, streamflow data (maximum daily and maximum instantaneous) were reported with weather events where available. Since for each year there is only one maximum streamflow value per station, these numbers only give an indication of the severity of the maximum runoff for this particular event.

BC/BB: 08FB007, Bella Coola River above Burnt Bridge Creek;
BC/H: 08FB008, Bella Coola River at Hagensborg;
Capil.: 08GA010, Capilano River above intake;
CR/CL: 08HD001, Campbell River at outlet of Campbell Lake;
CR/CR: 08HD003, Campbell River near Campbell River;
Chem.: 08HA001, Chemainus River near Westholme;
Cowich.: 08HA002, Cowichan River at Lake Cowichan;
Kok.: 08HA003, Koksilah River at Cowichan Station;
L. Qual.: 08HB004, Little Qualicum River at outlet of Cameron Lake;
Nan.: 08HB005, Nanaimo River near Extension;
Nan. C.: 08HB034, Nanaimo River near Cassidy;
Rainy: 08GA020, Rainy River at the mouth;
Sall.: 08FB004, Salloompt River near Hagensborg;
Shawn.: 08HA004, Shawnigan Creek below Shawnigan Lake;
Sooke: 08HA005, Sooke River near Sooke Lake;
Sproat: 08HB008, Sproat River near Alberni;
Squam.: 08GA022, Squamish River near Brackendale;
Stamp A.: 08HB010, Stamp River near Alberni;
Stamp G.: 08HB009, Stamp River near Great Central;
Wan.: 08FA002, Wannock River at outlet of Owikeno Lake;
Zeb.: 08HE006, Zeballos River near Zeballos.

Literature Cited

Adams, John. 1998. Historical Guide to Ross Bay Cemetery. Sono Nis Press. Victoria. 48 p.

Affleck, E.L. 1994. The great flood of 1894. *B.C. Historical News.* 27(3): 33-34.

Anderson, B.C., Haig, T.R. and C.D. Smith. 1992. Geogrid reinforced soil and lock-block debris deflector for transmission towers. Geotechnique and natural hazards. Bitech Publishers. Vancouver, B.C. pp. 331-338.

Andrews, Jeanne (ed.). 1993. Flooding. Canada water book. Environment Canada. Ecosystem Sciences and Evaluation Directorate. Economics and Conservation Branch. Ottawa, Ont.

Armstrong, J.E. 1984. Environmental and engineering applications of the surficial geology of the Fraser Lowland, British Columbia. Geological Survey of Canada. Paper 83-23. 64 p.

Barlee, N.L. 1970. Gold creeks and ghost towns. *Canada West Magazine,* Summerland, B.C. 183 p.

Bayrock, L.A. 1983. Lions Bay debris torrents, preliminary report, prepared for Mr. A. Brigola, February 15, 1983. Bayrock Surficial Geology, West Vancouver. unpublished. 7 p.

B.C. Ministry of Energy, Mines and Petroleum Resources. 1993. Landslides in British Columbia. Geological Survey Branch. Information Circular 1993-7.

B.C. Ministry of Environment. 1975. Memorandum from E. Karanka, Water Management Branch, to R. Buchanan, Geotechnical and Materials Branch, B.C. Ministry of Transportation and Highways, re: Report on North Vancouver floods, May 1975. unpublished.

B.C. Ministry of Forests. 1990a. Clear-cutting and Floods. News Release, November 14, 1990.

B.C. Ministry of Forests. 1990b. Technical Review Highlights November 23, 1990 Tsitika Slides. News Release, November 30, 1990.

B.C. Ministry of Public Works. 1943. Report for the fiscal year 1941-42. Victoria, B.C. p. T 4, T 7.

B.C. Ministry of Public Works. 1957. Report for the fiscal year 1955-56. Victoria, B.C. p. N 33.

B.C. Ministry of Public Works. 1958. Report for the fiscal year 1956-57. Victoria, B.C. p. J 37.

Beal, B. 1990. A summary of the heavy rainfalls over British Columbia during the months of May and June 1990. Atmospheric Environment Service, Pacific Region.

Begbie, M.B. 1871. On the “benches” or valley terraces of British Columbia. Royal Geographical Society. Proceedings. (15): 133-145.

Berger, T.B. 1973. Reasons for Judgement of the Honourable Justice Berger on the matter of the Land Registry Act and an application for approval of a proposed subdivision by Cleveland Holdings Ltd. Supreme Court of British Columbia.

Bland, C. Robert. 1992. Britannia Creek. Report on flood hazard at Britannia Beach File 55.4804 OIC 1298 August 1991 Squamish Area Flood. 19 May 1992.

Blown I. and M. Church. 1985. Catastrophic lake drainage within the Homathko River basin, British Columbia. *Canadian Geotechnical Journal.* 22(4): 551-563.

Borrell, H. 1992. “Silver Thaw” - Fraser Valley’s Paralysis of Ice. *B.C. Historical News* 25(1): 11-14.

Bowers, Vivien. 1994. Avalanche! Starting a slide for safety’s sake. *Canadian Geographic***.** 114(2): 22-31.

Bowman, J. 1992. The Chilliwack: The river that couldn’t be tamed. *B.C. Historical News* 25(4): 23-25.

Brawner, C.O. 1975. Case examples of instability of rock slopes. *The B.C. Professional Engineer* (26): 12-13.

Brooks, G.R. and E.J. Hickin. 1991. Debris avalanche impoundments of Squamish River, Mount Cayley area, southwestern British Columbia. *Canadian Journal of Earth Sciences.* 28 pp.

Broscoe, A.J. and S. Thomson. 1969. Observations on an Alpine mudflow, Steele Creek, Yukon. *Canadian Journal of Earth Sciences.* (6): 219-229.

Cambie, H.J. 1902. An unrecorded property of clay. Transactions, Canadian Society of Civil Engineers. (16): 197-215.

Cambie, H.J. 1903. An unrecorded property of clay and irrigation as a cause of landslides. *Engineering News*. (9): 38.

Canadian Geographic/Emergency Preparedness Canada. 1996. Natural Hazards.

Canadian Hydrographic Service. 1983. Tides and Current Tables, 1984. Vol. 6. Barkley Sound and Discovery Passage to Dixon Entrance. Department of Fisheries and Oceans.

Carter, N.M. 1932. Exploration in the Lillooet River watershed. *Canadian Alpine Journal*. (21): 8-18.

Cass, D.E., Kenning, B.F. and G. Rawlings. 1992. The Philpott Road debris failures - Kelowna B.C. 1990: the impacts of geology, hydrology and logging activities. Geotechnique and Natural Hazards. Geo Hazards '92 Symposium. Vancouver, May 6-9, 1992. BiTech Publishers Ltd. Vancouver, B.C. pp. 319-329.

Chapman, Allan. 2003. River Forecast Centre post-event review of the October 16-20 coastal flood event. 4 p.

Charlwood, Robin G and Gail M. Atkinson. 1983. Earthquake hazards in British Columbia. *The BC Professional Engineer*. 34 (12): 13-16.

Church, M. 1988. Floods in cold climates. Flood geomorphology. Edited by V.R. Baker, R.C. Kochel, and P.C. Patton. John Wiley & Sons, London. pp. 205-229.

Church, M and M.J. Miles. 1987. Meteorological antecedents to debris flow in southwestern British Columbia; some case studies. Geological Society of America. Reviews in engineering. (VII): 63-79.

CHWK staff: "Fraser Valley Storm and Floods; January 20 to 26, 1935" Souvenir booklet of "Emergency Bulletins" issued by CHWK staff. Chilliwack, B.C.

Clague, J.J. 1982. Erosion at Point Grey. *Geoscience Canada*. 9(2): 129-131.

Clague, J.J. 1991. Natural Hazards. : Geology of the Cordilleran Orogen in Canada, H. Gabrielse and C.J. Yorath (ed.) Geological Survey of Canada No. 4, Chapter 21, pp. 803-815.

Clague, J.J. 1996. (Comp. Ed.) Paleoseismology and seismic hazards, southwestern British Columbia. Geological Survey of Canada. Bulletin 494. 88 p.

Clague. J.J. and P.T. Bobrowsky. 1996. Tsunamis. Paleoseismology and seismic hazards, southwestern British Columbia. Geological Survey of Canada. Bulletin 494. pp. 34-43.

Clague. J.J. and S.G. Evans. 1994. Formation and failure of natural dams in the Canadian cordillera. Geological Survey of Canada. Bulletin 464. 35 p.

Clague, J.J. and J.G. Souther. 1982. The Dusty Creek landslide on Mount Cayley, British Columbia. *Canadian Journal of Earth Sciences* (19): 524-539.

Clague, J.J., Evans, S.G. and I. Blown. 1985. A debris flow triggered by the breaching of a moraine-dammed lake, Klattasine Creek, British Columbia. *Canadian Journal of Earth Sciences.* 22(10): 1492-1502.

Clague J.J., Naesgaard, E. and A. Sy. 1996. Liquefaction. Paleoseismology and seismic hazards, southwestern British Columbia. Geological Survey of Canada. Bulletin 494. pp. 43-51.

Clark, Cecil. 1986. B.C. Provincial Police stories. Vol. 3, p. 29. Heritage House Publishing Co. Ltd., Surrey B.C. 158 p.

Clark, F.M.1965. 1964, 1948 and 1894 High-water profiles for the Lower Fraser Valley. Department of Northern Affairs and Natural Resources. Water Resources Branch. Vancouver, B.C. March 1965. 15 p.

Coulter, H.W. and Migliaccio, R.R. 1966. Effects of the earthquake of March 27, 1964 at Valdez, Alaska. United States Geological Survey. Professional Paper 542-C. 35 p.

Cruden, D.M. and Z-y Lu. 1989. The geomorphic impact of the catastrophic October 1984 flood on the planform of the Squamish River, southwestern British Columbia: Discussion. *Canadian Journal Earth Sciences* (26): 336-337.

Dawe, Helen. 1990. The worst storm in Sunshine Coast history. Raincoast Chronicles Twelve. Harbour Publishing. Madeira Park, B.C. pp. 30-31.

Denison, F.N. 1919. The British Columbia earthquake of December 6, 1918. Bulletin of Seismological Society of America. **(**9): 20-23.

Denison, F.N. 1932. The remarkably heavy precipitation at Henderson Lake, Vancouver Island, British Columbia. *Monthly Weather Review.* (60): 252.

Desloges, J. R., and M. Church. 1992. Geomorphic implications of glacier outburst flooding: Noeick River Valley, B.C. *Canadian Journal of Earth Sciences.* (29): 551-564.

Desloges, J. R., Jones, D.P. and K. E. Ricker. 1989. Estimates of peak discharge from the drainage of ice-dammed Ape Lake, British Columbia, Canada. *Journal of Glaciology.* 35(121): 349-354.

Drysdale, C.W. 1914. Geology of the Thompson River Valley below Kamloops Lake, B.C. Summary Report 1912. Geological Survey of Canada, Ottawa, Ont. pp. 115-150.

Eddy, F.W. 1979. Record-breaking rainstorm at Vancouver on Christmas Day 1972. Tec 872. Environment Canada. Atmospheric Environment Service. Downsview, Ont.

Eisbacher, G.H. 1982. Howe Sound Debris Flows. *Geoscience Canada.* 9 (2): 132

Eisbacher, G.H. 1983. Slope stability and mountain torrents, Fraser Lowlands and southern Coast Mountains, British Columbia. Geological Association. of Canada. Annual Meeting. Fieldtrip Guidebook. No. 15. 46 p.

Eisbacher, G.H. and J.J. Clague. 1981. Urban landslides in the vicinity of Vancouver, British Columbia, with special reference to the December 1979 rainstorm. *Canadian Geotechnical Journal*. (18): 205-216.

Environment Canada. 1986. Snow War. A guide to the history of Rogers Pass. Parks. 8 p.

Environment Canada. 1988. Historical water levels summary in British Columbia to 1987. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Ont. 171 p.

Environment Canada. 1991. Historical streamflow summary British Columbia to 1990. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Ont. 1116 p.

Evans, S.G. 1982. Landslides and surficial deposits in urban areas of British Columbia: A review. *Canadian Geotechnical Journal.* (19): 269-288.

Evans, S.G. 1984. The 1880 landslide dam on Thompson River, near Ashcroft, British Columbia. Current Research, Part A. Geological Survey of Canada Paper 84-1A. pp. 655-658.

Evans, S.G. 1986. Landslide damming in the Cordillera of western Canada. Landslide Dams: Processes, Risk and Mitigation. (ed.) R.L. Schuster. American Society of Civil Engineers. Geotechnical Special Publication 3. pp. 111-130.

Evans, S.G. 1989. The 1946 Mount Colonel Foster rock avalanche and associated displacement wave, Vancouver Island, British Columbia. *Canadian Geotechnical Journal*. (26): 447-452.

Evans, S.G. 1992. High magnitude-low frequency catastrophic landslides in British Columbia. Geologic Hazards in British Columbia. Proceedings University of Victoria. B.C. Geological Survey Branch. Open File 1992-15. pp. 71-98.

Evans, S.G. and G.R. Brooks. 1991. Prehistoric debris avalanches from Mount Cayley volcano, British Columbia. *Canadian Journal of Earth Science.* (28): 1365-1374.

Evans, S.G. and J.J. Clague. 1994. Recent climatic change and catastrophic geomorphic processes in mountain environments. *Geomorphology.* (10): 107-128.

Evans, S.G. and J.J. Clague. 1989. Rain-induced landslides in the Canadian Cordillera. July 1988. *Geoscience Canada*. (16): 193-200.

Evans, S.G. and J.J. Clague. 1999. Damaging landslides and related processes in the Canadian Cordillera: impact and mitigation in the historical period 1855-1999. Geological Survey of Canada Bulletin.

Evans, S.G. and J.S. Gardner. 1989. Geological hazards in the Canadian cordillera. Chapter 12 Quaternary Geology of Canada and Greenland. R.J. Fulton (Ed.). Geological Survey of Canada. Geology of Canada. Vol. 1 p. 704.

Evans, S.G. and D.R. Lister. 1984. The geomorphic effects of the July 1983 rainstorms in the southern cordillera and their impact on transportation facilities. Geological Survey of Canada. Current Research, Part B. Paper 84-1B. pp. 223-235.

Evans, S.G., J.J. Clague, G.J. Woodsworth, and O. Hungr. 1989. The Pandemonium Creek rock avalanche, British Columbia. *Canadian Geotechnical Journal*. Vol. (26): 427-446.

Ewert, Henry. 1986. The story of the B.C. Electric Railway Company. Whitecap Books, Vancouver. B.C. 336 p.

Fannin, R.J. and J.M.T. Wilkinson. 1995. An analysis of the Jamieson Creek landslide. 48th Canadian Geotechnical Conference. Vancouver, B.C. Preprint Vol. 2. pp. 635-642.

Fannin, R.J., Rollerston, T., Hogan, D. and D. Daust. 1992. Characteristics of a large debris flow channel. Geotechnique and natural hazards. Geo Hazards '92 Symposium. Vancouver. May 6-9, 1992. BiTech Publishers Ltd. Vancouver, BC. pp. 311-318.

Farquharson, K.G. 1976. Development of a Natural Hazards Policy for B.C. *The B.C. Professional Engineer*. January 1976. pp. 13-14.

Forester, Joseph E. and Anne D. Forester. 1975. Fishing – British Columbia's commercial fishing history. Hancock House Publishers Ltd. Saanichton, B.C. 224 p.

Fraser Basin Management Board. 1994. Review of the Fraser River flood control program. A Task Force report to the Fraser Basin Management Board. Fraser Basin Management Program. 62 p.

Garden, J.F. 1991. Nicholas Morant's Canadian Pacific. Footprint Publishing, Revelstoke B.C. 455 p.

Godfrey, D.D., P.A. Schaerer, R. Tremblay, G.L. Freer and S.G. Evans. 1974. British Columbia Department of Highways Avalanche Task Force, report on findings and recommendations. Mimeo Rep. Victoria, B.C. 33 pp.

Hardy, R.M., Morgenstern, R.N. and Patton, F.D. 1978. Report of Garibaldi Advisory Panel. British Columbia Department of Highways. Victoria, B.C. 371 p.

Harris, S.A. and C.A. Gustaffson. 1988. Retrogressive slumps, debris flows and river valley development in icy unconsolidated sediments on hills and mountains. *Zeitschrift fuer Geomorphology*. (32): 441-445.

Harrison, J.E. 1973. Geologic aspects of mountain coalmine waste disposal. Proceedings International conference on land for waste management. pp. 26-36.

Hay, Duncan. 1983. Tsunamis. *The BC Professional Engineer* 34 (12): 17-20.

Hay, John E. and Timothy R. Oke. 1976. The climate of Vancouver. B.C. Geographical Series, No. 23. Tantalus Research Limited, Vancouver, B.C. 49 p.

Hickin, E.J. and H.M. Sichingabula. 1988. The geomorphic impact of the catastrophic October 1984 flood on the planform of the Squamish River, southwestern British Columbia. *Canadian Journal of Earth Sciences.* (25): 1078-1087

Hickin, E.J. and H.M. Sichingabula. 1989. The geomorphic impact of the catastrophic October 1984 food on the planform of the Squamish River, southwestern British Columbia: Reply. *Canadian Journal Earth Sciences*. (26): 337.

Hodgson, E.A. 1946. British Columbia earthquake, June 23, 1946. *Royal Astronomical Society of Canada Journal*. (40): 285-319.

Hungr, O., Morgan, G.C. and R. Kellerhals. 1984. Quantitative analysis of debris torrent hazards for design of

remedial measures. Can. Geotech. J. (21):663-667.

Hunter, Kevin. 1997. Riding on fate. *British Columbia Forest History Newsletter*. No. 55. December 1997.

Hutchison, B. 1950. The Fraser. Clarke, Irwin & Company Limited, Toronto, Ont. 349 p.

Jackson, L.E., M. Church, J.J. Clague and G.M. Eisbacher. 1985. Slope hazards in the southern coast mountains. Geological Society of America Cordilleran Section. Annual meeting. Vancouver B.C. Guidebook. Field trip 4. 34 pp.

Jakob, M., Hungr, O. and B. Thompson. 1997. Two debris flows with anomalously high magnitude. Proceedings First International Conference on Debris Flow Hazards Mitigation: mechanics, prediction, and assessment. American Society of Civil Engineers. San Francisco, Calif.

Jones, W.C. 1959. Cheekye River mudflows. Unpublished Report. British Columbia Department of Mines. 9 p.

Jones, D.P., K.E. Ricker, J.R. Deslonges and M. Maxwell. 1985. Glacier Outburst Flood on Noeick River: The Draining of Ape Lake, British Columbia, October 20, 1984. Open File Report 1139. Geological Survey of Canada. 81 p.

Jordan, P. 1987. Impacts of mass movement events on rivers in the southern Coast Mountains, British Columbia. Summary Report. Water Resources Branch, Inland Waters Directorate. Environment Canada. Report IWD-HQ-WRB-SS-87-3. 62 p.

Jordan P. 1994. Debris flows in the southern Coast Mountains, British Columbia: dynamic behaviour and physical properties. Ph.D. Thesis, Department of Geography, University of British Columbia. 260 p.

Karanka, E.J. and Associates. 1995. Weather events, British Columbia coast. Water year 1875-1876. 53 pp.

Keefer, D.K. 1984. Landslides caused by earthquakes. Geological Society of America. Bulletin. (95): 406-421.

Lang, Margaret. 1967. Along the way. An historical account of pioneering White Rock and surrounding district in British Columbia. White Rock, B.C. 208 p.

LeBlond, P.H. 1984. (Chairman) Final Report of the Investigation on the Storm of October 11-12, 1984 on the West Coast of Vancouver Island.

Leighton, Grace E. 1979. Mountain treasures. The history of Kimberley, B.C. Kimberley Senior Citizen History Book Committee. Marysville, B.C. 357 p.

Lewis, C. J. and M.D. Moran. 1985. Severe storms of Canada's west coast: a catalogue summary for the period 1957 to 1983. Canadian Climate Centre Report No. 85-7. Environment Canada. Atmospheric Environment Service. Downsview, Ont. 381 p.

Lister, D.R., Morgan, G.C., VanDine, D.F. and J.W.G. Kerr. 1984. Debris torrents along Howe Sound, British Columbia. IVth International Symposium on Landslides, Toronto, Ont. 7 p.

Lu, Z-y. 1988. Rock avalanche on Mount Caley, British Columbia. MSc Thesis. University of Alberta. Edmonton, Alta. 158 p.

MacFayden, B.E. 1981. Southwest British Columbia October 1981 flooding. Squamish to D'Arcy Area. Ministry of Environment. Rivers Subsection Engineering Division. Water Management Branch. 12 p.

Lynott, R.E. and O.P. Cramer. 1966. Detailed analysis of the 1962 Columbus Day windstorm in Oregon and Washington. *Monthly Weather Review.* (94): 105-117.

MAST Ship Listing 1946-1983.

Mathews, W.H. 1952. Ice-dammed lavas from Clinker Mountain, southwestern British Columbia. *American Journal of Science*. (250): 553-565.

Mathews, W.H. 1979. Landslides of central Vancouver Island and the 1946 earthquake. *Bulletin of the Seismological Society of America*. 69(2): 445-450.

Mathews, W.H. and K.C. McTaggart. 1978. Hope Rockslides, British Columbia. Rockslides and avalanches. 1, Natural Phenomena, B. Voight (Ed.) Elsevier Scientific Publishing Co. Amsterdam. pp. 259-275.

Matthes, F.E. 1939. Report of Committee on Glaciers. American Geophysical Union Transactions (20): 518-523.

McGill, David E. 1979. 126 Stops of interest in beautiful British Columbia. Frontier Publishing Ltd. Aldergrove, B.C. 127 p.

McMullen, B.R.W. 1990. Southwestern B.C. Flooding November 9-10, 1990. Proposed Restoration Works under O.I.C. 1819. B.C. Environment Water Management Branch.

Melady, John. 1997. Heartbreak and heroism. Canadian Search and Rescue stories. Dundurn Press, Toronto. Ont. 217 p.

Melone, A.M. 1985. Flood producing mechanisms in coastal British Columbia. *Canadian Water Resources Journal*. (10): 46-64.

Miles, M.J. et al. 1979. Effects of the proposed Coquihalla Highway on the fluvial environment and associated fisheries resource. Vols. 1 and 2. Unpublished rep. to Ministry of Highways and Public Works. January 1979.

Milne. W.G. 1956. Seismic activity in Canada, west of the 113th Meridian, 1975-1981. Publications of the Dominion Observatory. Ottawa, Ont. (16): 51-59.

Ministry of Environment, Lands and Parks. n.d. Dam safety in British Columbia. Who is responsible? Water Management pamphlet.

Mitchell, Helen A. 1975. Diamond in the rough. The Campbell River story. Frontier Publishing Ltd. Aldergrove, B.C. 192 p.

Mokievsky-Zubok, O. 1977. Glacier-caused slide near Pylon Peak, British Columbia. *Can. Journal Earth Sciences.* (14): 2657-2662.

Moore, D.P. and A.S. Imrie. 1982. Rock slope stabilisation at Revelstoke damsite. Transactions, 14th International Congress on Large Dams. Paris, France. (2): 365-385.

Moore, D.P. and W.H. Mathews. 1978. The Rubble Creek landslide, southwestern British Columbia. *Canadian Journal of Earth Sciences.* 15(7): 1039-1052.

Murty, T.S. 1977. Seismic sea waves-tsunamis. Fisheries Research Board of Canada. Bulletin 198, 337 p.

Nasmith, H. 1972. Engineering geology of the southern Cordillera of British Columbia. 24th International Geological Congress, Montreal, Que. Excursion A08-C08. 34 p.

Nasmith, H.W. and A.G. Mercer. 1979. Design of dykes to protect against debris flows at Port Alice, British Columbia, *Canadian Geotechnical Journal.* (16): 748-757.

Nesbitt-Porter, H.H. 1989. Southwestern B.C. flooding, November 9, 1989. Province of British Columbia, Ministry of Environment. Rivers section, Water Management Branch. O.I.C. No. 1790-File No. P89-8

Nisbet, J. 1994. Sources of the river. Sasquatch Books. Seattle, Wash. 280 p.

Orchard, Robert Imbert. 1983. Floodland and forest: Memories of the Chilliwack valley. Provincial Archives of British Columbia. Sound Heritage Series No. 37. 92 p.

Parkin, Tom W. 1993. Bridges to our past. *B.C. Historical News* 26(4).

Patton, F.D. 1976. The Devastation Glacier slide, Pemberton, B.C. (abstract). Geomorphology of the Canadian Cordillera and its bearing on mineral deposits. Geological Association of Canada, Cordilleran Section, Vancouver, B.C.

Pethick, Derek. 1894 The Fraser Valley Flood. In: British Columbia disasters. (pp. 91-134). Stagecoach Publishing Co. Ltd. Langley, B.C.

Phillips, David. 2005. The Canadian weather trivia calendar 2006.

Pollock, D.M. 1975. An index to storm rainfall in Canada. CLI-1-75, Environment Canada. Atmospheric Environment Service. Downsview, Ont. 37 p.

Province of British Columbia, Sessional Papers 1895-95.Report of Col., the Hon. James Baker, Provincial Secretary, Victoria B.C. October 10, 1894

Province of British Columbia, Sessional Papers 1896. Public Works Report for 1985.

Provincial Emergency Program. 1997. Overview of Greater Victoria's emergency response to the "blizzard of '96." PEP Headquarters, Victoria, B.C. March 21, 1997. 26 p.

Quinn, William H. 1992. A study of southern oscillation-related climatic activity for A.D. 622-1990 incorporating Nile River flood data. pp. 119-149. Diaz, H. F. and V. Markgraf (eds.). Cambridge University Press. 476 p.

Ramsey, Bruce. 1962. PGE. Railway to the North. Mitchell Press, Vancouver, B.C. 264 p.

Ramsay, B. 1967. Britannia, the story of a mine. Britannia Beach Community Club. 177 p.

Reid, Collins and Associates Ltd. 1969. Report of investigation on the Harvey Creek flood of September 17-18, 1969. Lions Bay Improvement District Dawson Developments Limited. November 1969. Unpublished. Vancouver, B.C. 35 p.

Reksten. Terry. 1992. A century of sailing 1892-1992. A history of the oldest yacht club on Canada's Pacific coast. Orca Book Publishers. 242 p.

Rice, A.H., Weran, L.H.E., Savage, K. and M. Miles. 1992. Relocation of buried high-pressure oil pipeline subjected to potential flood hazard Coquihalla River Valley, British Columbia. Geotechnique and natural hazards. Geo Hazards '92 Symposium. Vancouver. May 6-9, 1992. BiTech Publishers Ltd. Vancouver, BC. pp. 347-354.

Rogers, A.C. 1973. Shipwrecks of British Columbia. J.J. Douglas Ltd., Vancouver. 256 p.

Rogers, A.C. 1992. More shipwrecks of British Columbia. Douglas & McIntyre. 242 p.

Rogers, Garry C. 1980. A documentation of soil failure during the British Columbia earthquake of 23 June, 1946. *Canadian Geotechnical Journal.* (17): 122-127.

Russell, S.O. 1972. Behavior of steep creeks in a large flood. *Mountain geomorphology*. O. Slaymaker and H.J. McPherson, eds. B.C. Geographical Series. (14): 223-227.

Ryder, J.M. and B. Thomson. 1986. Neoglaciation in the southern Coast Mountains of British Columbia: chronology prior to the late Neoglacial maximum. *Canadian Journal of Earth Sciences.* 23(62): 273-287.

Sanford, Barry. 1978. McCulloch's wonder. The story of the Kettle Valley Railway. Whitecap Books. 260 p.

Saywell, John F. T. 1967. Kaatza. The chronicles of Cowichan Lake. The Cowichan Lake District Centennial Committee. 211 p.

Scanlon, J., J. Jefferson and D. Sproat. 1976. The Port Alice Slide. EPC Field Report 76/1. Emergency Planning Canada. Ottawa, Ont.

Scanlon, J., Prawzick, A., Whitten, J. and S. Cote. 1984. Too late to return: Fishermen and weather warnings on Canada's West coast. Emergency Communications Research Unit, Carleton University. Ottawa, Ont.

Schaefer, D.G. 1973. A record-breaking summer rainstorm over the Lower Fraser Valley. Environment Tec 787. Environment Canada. Atmospheric Environment Service. 29 p.

Schaefer, D.G. 1983. Storms. *The BC Professional Engineer.* 34(12): 21-22.

Schaefer, D.G. 1984. Meteorological conditions leading to local flooding in southwestern B.C. during the first week of January 1984. Scientific Services Division. Atmospheric Environment Service. Vancouver, B.C. February 1984.

Schaerer, P.A. 1983. Snow avalanche hazards in British Columbia. *The BC Professional Engineer.* 34(12): 23-24.

Schultz, Henry. 1984. A new frontier. The Canadian chronicles of Henry Schultz. Ptarmigan Press. 217 p.

Scott, R. Bruce. 1970. Breakers ahead. A history of shipwrecks on the graveyard of the Pacific. Third Edition. Fleming-Review Printing. 174 p.

Scott, R. Bruce. 1994. Gentlemen on imperial service. A story of the Trans-Pacific Telecommunications Cable. Sono Nis Press, Victoria, B.C. 131 pp.

Septer, D. and J. W. Schwab. 1995. Rainstorm and flood damage Northwest British Columbia 1891-1991. Province of British Columbia. Ministry of Forests Research Program. Land Management Handbook 31. 196 p.

Shelford, A and C. Shelford. 1988. We pioneered. Orca Book Publishers. 214 p.

Skermer, N. A. 1988. 28th of October. *The BC Professional Engineer*. 39(5): 21-23.

Smith, E. 1970. Early Logging in the Comox Valley. PABC Add. MSS 960. Provincial Archives of British Columbia, Victoria, B.C.

Smith, H.R. and F.D. Patton. 1984. Comparison of the Devastation Glacier slide with other high velocity debris flows. [Abstract]. 4th International Symposium on Landslides. Toronto. Abstracts Volume, p. 96.

Smith, W.E.T. and W.G. Milne. 1970. Canadian earthquakes-1965. Dominion Observatory (Canada) Seismological Series of the Dominion Observatory, Catalogue 1965-2.

Smith, A.G. and G. Vallieres. 1986. Flood of October 8, 1984 on the Lillooet River, British Columbia. Internal Report. Planning and Studies Section. Water Resources Branch, Vancouver. December 1986. 83 p.

Souther, J.G. 1980. Geothermal reconnaissance in the central Garibaldi Belt, British Columbia. Current Research, Part A Paper 80-1A. Geological Survey of Canada. pp. 1-12. (1-11?)

Stanton, R.B. no date. Minutes of Proceedings of Inst. of Civil Eng., England, CXXXII, 1897-98, part II, pp. 7-8;

Stanton, R. B. 1898. The great land-slides on the Canadian Pacific Railway in British Columbia [includes discussion]. Institution of Civil Engineers. Proceedings, Vol. 132, pt. 2. 48 p.

Stethem, C.J. and P.A. Schaerer. 1979. Avalanche accidents in Canada I. A selection of case histories of accidents 1955 to 1976. National Research Council. Can., Div. Building Res. Ottawa, Ont. NRCC 17292. (DBR Paper No. 834) 114 p.

Stethem, C.J. and P.A. Schaerer. 1980. Avalanche accidents in Canada II. A selection of case histories of accidents 1943 to 1978. National Research Council. Can., Div. Building Res. Ottawa, Ont. NRCC 18525. (DBR Paper No. 926) 75 p.

Talbot, R.J. 1986. Storm damage assessment October 8, 1984 flooding Pemberton, Whistler, Squamish areas. R O.I.C. 2012-84. File P84-6.

Terzaghi, K. 1960a. Report on the proposed storage dam south of Lower Stillwater Lake on the Cheakamus River, B.C. : From theory to practice in soil mechanics-selections from the writings of Karl Terzaghi. J. Wiley, New York. pp. 395-408.

Terzaghi, K. 1960b. Storage dam found on landslide debris. *Journal Boston Society of Civil Engineers.* (47): 64-94.

Terzaghi, K. 1962. Stability of slopes on hard unweathered rock. *Geotechnique*. pp. 251-270.

Thompson, R.E. 1981. Oceanography of the British Columbia Coast. Canadian Department of Fisheries and Oceans. Canadian Special Publication of Fisheries and Aquatic Sciences. 56. 291 p.

Thurber Consultants Ltd. 1983. Debris torrent and flooding hazards Highway 99, Howe Sound. Report to B.C. Ministry of Transportation and Highways.

Thurber Consultants. 1990. Goose Spit: assessment of liquefaction due to the 1946 earthquake, Goose Spit, Vancouver Island. B.C. Report to the Geological Survey of Canada. BC Hydro and Power Authority, and Greater Vancouver Regional District. 41 p.

Trenhaile, Alan S. 1998. Geomorphology: A Canadian perspective. Oxford University Press. 340 p.

US Army Corps of Engineers. 1991. Flood summary report Nooksack, Skagit and Snohomish River basins. November 1990 events. US Army Corps of Engineers, Seattle District. 23 p. excl. appendices

VanDine, D.F. 1985. Debris flows and debris torrents in the southern Canadian Cordillera. *Geotechnical Journal.* 22. (1): 44-68.

VanDine, D.F. 1992. Low magnitude/high frequency mass movements. Geologic hazards in British Columbia. Proceedings University of Victoria. B.C. Geological Survey Branch. Open File 1992-15. pp. 99-107.

VanDine, D.F. and D.R. Lister. 1983. Debris Torrents - a New Natural Hazard? *The BC Professional Engineer*. 34(12): 9-11.

Wallace, The Honorable Mr. Justice. 1987. Reasons for Judgement, C.P.R. vs. The Highland Cattle Company, B.C. Supreme Court.

Watt, W.E., K.W. Lathem, C.R. Neill, T.L. Richards and J. Rouselle (editors). 1989. Hydrology of floods in Canada, a guide to planning and design. National Research Council Canada. Ottawa, Ont. 245 p.

Webb, H. N.D. History of the Chilliwack River with the Vedder and Luckakuck as I saw them in 1870. Unpublished manuscript. Chilliwack Archives. Add. MSS. 9.

Wetmiller, R.J. and S.G. Evans. 1989. Analysis of the earthquakes associated with the 1965 Hope landslide and their effects on slope stability at this site. *Canadian Geotechnical Journal*. (26): 484-490.

Whelan, Nancy. 1989. The day the tip fell off Mapleguard Spit. *Canadian Geographic*. August-September 1989.

Wigen, S.O. 1979. Tsunami frequency at Tofino and Port Alberni. Institute of Ocean Sciences.

Wigen, S.O. and W.R. White. 1964. Tsunami of March 27-29, 1964, west coast of Canada. Canadian Department of Mines and Technical Surveys. Ottawa, Ont. 6 p.

Williams, M.Y. 1966. The grand campus washout. *U.B.C. Alumni Chronicle*. 20 (4): 9-11.

Wilson, Hugh and Andrew Wilson. 1998. Gaslights to gigawatts. A human history of BC Hydro and its predecessors by the BC Hydro Power pioneers. Hurricane Press. 236 p.

Won, T.K. 1971. Meteorology in British Columbia: A Centennial Review. Canadian Meteorological Service, Pacific Region. Vancouver, B.C.

Wood, Daniel. 1996. Earthquake coast. *Beautiful British Columbia*. 38 (1): 9.

Woods, J.G. and J.S. Marsh. 1983. Snow War. An illustrated history of Roger's Pass, Glacier National Park, British Columbia. National and Provincial Parks Association of Canada. Toronto, Ont. 52 p.

Young, G.J. 1980. Monitoring glacial outburst floods. *Nordic Hydrology*. (11): 285-300.