

Chronology of Flood Events as noted in the Superintendent's Annual Reports 1940-1991

Compiled by
Barbara A. Samora
Natural Resource Planning Division
Mount Rainier National Park

March, 1991

B.A. Samora
3/18/91

The following information was compiled from the Superintendent's Annual Reports (1940-1991), in the Mount Rainier National Park Archives. The information was needed to develop a "Flood-prone Facility Assessment" for park infrastructure, and as a first step in prioritizing floodplain planning activities.

The information is listed chronologically beginning in 1942.

1942: The Kautz and Tahoma Creek Bridges were reconstructed during July-August, 1942 with replacement of the girders and new guard rails. This widened the bridges to approx. 21ft.

June 1946 - July 1947: Beginning Dec. 1 the park experienced an almost unprecedented series of heavy snowstorms which caused extreme damage to facilities at lower elevations throughout the Park. For two weeks, 121-15, the main entrance route to the park was closed to the public due to the danger of falling trees. Avalanches at higher elevations periodically swept down canyon walls bringing trees and debris in many locations and completely obliterating the winter highway to Paradise Valley. Similar devastation was found on park trails (estimated 200 trees/mile).

Under Roads and Trails section of report: "Allotments for the maintenance of roads and trails are barely sufficient to provide for the accomplishment of required work on paved roads and the main trails; little or no maintenance can be accomplished on the West Side Road which is rapidly deteriorating and the road beyond Ipsut Creek in the Carbon River District is likewise rapidly going back to its natural state.

Three trail bridges on the Wonderland Trail were destroyed by high water in December. Additional funds in the amount of \$1500 were provided for the replacements which may be completed in time to permit the opening of the trail for the summer season."

Under Conditions Influencing Park Operations: "Flood control appropriation is being requested in an effort to repair damage done by the Nisqually during high waters of recent months, and in order to repair existing revetments protecting headquarters and Nisqually Entrance areas."

July, 1947 - June, 1948: Kautz Creek Flood: Oct. 2, 1947, The Kautz Creek Valley was virtually denuded of trees in many sectors and approximately 1/2 mile of the Nisqually Entrance highway totally destroyed by flood waters and covered to depths up to 17 ft. with mud, boulders and trees. This flood, originating high on the slopes of Mount Rainier, devastated at least 600 acres of forest lands, destroyed approximately one mile of the Kautz Glacier, and marooned the Park Headquarters for several days. Considerable damage was caused by the flood to park structures downstream along the Nisqually River, and to private holdings outside the Park. Telephone and power lines were destroyed. Along the upper Nisqually River high waters also damaged the Glacier Bridge and caused complete destruction of two 5-ton dump trucks caught in the rapidly rising waters. . .

This raised the question more strongly about the location of park headquarters, as a change of location seems desirable in view of the damage done by Kautz Creek, and the action of the Nisqually River. Conditions on the Nisqually very nearly approached the situation on Kautz Creek. The threat of a destructive flood along the Nisqually remains. Therefore the decision will have to be reached as to how much work should be done to protect the present headquarters and what should be done about the entrance road leading to Longmire and Paradise."

Under Roads and Trails: "The Kautz Creek flood completely destroyed approximately 1/2 mile of the Nisqually entrance highway, necessitating the construction of a new section of gravel-surfaced highway. Construction was not resumed on the Stevens Canyon Road. The Mowich Lake road has deteriorated to the point where portions are in danger of being lost through inability to properly maintain them. Severe criticism was heard from visitors on the lack of good roads leading into the White River and Paradise Valley campgrounds. . . . Because of inadequate maintenance funds the West Side Road was closed to public travel at Round Pass.

. . . Bridges crossing Carbon River, Tahoma Creek and Kautz Creek, which were reconstructed during the summer of 1947, were destroyed by floods in October, as was the Kautz Creek section of the Wonderland Trail. This year new section of trail to go to Indian Henry's was routed from the road fill of the Kautz flood area. Bridges are being constructed, where needed, and general effort being made toward trail betterment."

1950: Pg. 5: "On June 16, 1950, the College of Forestry, UW, instituted a research project on the Kautz Creek devastated area (300 acres inundated with mud fill approximately 15 ft. deep in the 1947 flood."

1953: Flood Control, Headquarters: The USGS has been making some investigation regarding the flood dangers from the Nisqually River at Longmire. They wish to investigate further, but their preliminary report indicates they do not think the potential danger from floods at this location is great. The Park staff is quite anxious to have this matter settled as development at Longmire has been held in abeyance pending such decision."

Disposition of Trees, Tahoma Creek Blowdown: "A rather extensive blowdown occurred in the Tahoma Creek campground during the winter of 1953 and due to the fire hazard and danger of insect infestation, it was decided to dispose of the down trees. . . ."

Erdmann, C.E. and A. Johnson. 1953. Preliminary Report Flood Problem on Nisqually River at Longmire, Washington. February 1953. USGS. Makes reference to a topographic map that accompanies this report. Summary and Conclusions: "Information now at hand indicates that conditions along the Nisqually River between Longmire and the Nisqually glacier are not comparable with those existing along Kautz Creek prior to the 1947 flood and as a consequence the probability of a flood occurring on the Nisqually River similar to the one that occurred on Kautz Creek is not as great. The location of Longmire with respect to the river makes it possible to provide

protection within reasonable expenditures. The possibility of the occurrence of some "geologic accident" coincident with unusual climatic conditions and resulting floods and mud-flows of devastating proportions cannot entirely be ruled out. However, the possibility of such an occurrence seems very remote and the continuance of the Park Headquarters at Longmire seems well worth a reasonable calculated risk."

Report (p.10) " Flood surges are of rather frequent occurrence on the Upper Nisqually River and in recent years several reasonable good observations and reports on them have been made. In the three accounts that follow it is not stated just how far downstream from the present highway bridge the character of the surge was maintained, possibly a mile or so, but all were entirely dissipated two or three miles above Longmire.

A report prepared by Henry Lands and J. Hoover Mackin dated January 23, 1936, describes two such surges, one of which occurred on October 14, 1932 and the other on October 25, 1934. Both of these resulted from slides from the west lateral moraine onto the glacier, causing water to be impounded which, after a certain stage was reached, was suddenly released. This seems rather unusual, as ordinarily one would expect water on a glacier so thoroughly crevassed to escape by subglacial drainage. The 1932 surge destroyed the highway bridge which was of reinforced concrete. The entire main span of the bridge, which was 55 ft. long, 27 ft. wide, and weighed approximately 40 tons, was dislodged as a unit and rafted downstream for about half a mile, where it can still be seen after 20 years. This surge was witnessed by two engineers from the Bureau of Public Roads who saw the moving mass of water and rock come over the terminus of the glacier and move downvalley toward the bridge but, due to trees obstructing their view, did not actually see the destruction of the bridge. . . From the Landes report it appears there was only one surge in 1932 whereas in 1934 there were three distinct surges, but these caused only moderate damage to the bridge.

In 1932 there was no recorded rainfall at Paradise from 9/25 to 10/9. During 10/10-14, rainfall totaled 8.70 inches and the discharge of the Nisqually River at Alder during this period rose from 297 to 761 second-feet. In 1934, during the period October 1-19, rainfall was recorded on seven days totaling 1.51 inches and during the period October 20-25, it totaled 9.92 inches. The discharge of the Nisqually River at Alder during this latter period rose from 682 to 12,000 second-feet. IT is of interest to note that in 1934 with heavier rainfall the surges were less destructive than in 1932.

Another surge occurred on the Nisqually at the time of the Kautz Creek flood, October 2, 1947. At this time, channel improvement work was in progress just downstream from the bridge. Two trucks were engulfed by the surge and damaged beyond repair. A gas shovel was covered to above the turntable was later rehabilitated."

P. 12: " The map also shows a low saddle on the right bank about half a mile upstream from Longmire, just south of the camp incinerator. The drainage course originating in this saddle has its mouth about 200 feet from the Administration Building. The low point of this saddle is only

about 10 feet above water surface and, at extremely high stages, the river conceivable could overflow through it. Insofar as known, there has been no overflow through this saddle since the establishment of the Park. Moreover, as has been pointed out, the probability is that the competence of Nisqually River will prevent raising of the river bed opposite this saddle, so it appears to be safe under normal conditions, or those that have prevailed for about the last 100 years. Nevertheless, if the saddle were to be overtopped by a flood, Park Headquarters and many residences of park employees would stand in danger of destruction. Therefore, it seems essential to recommend that adequate protective works be placed in this saddle to guard against possible overflow."

Authors note that this was a preliminary evaluation of the flood problem and that further analysis and field observations should be made, and the geology of the Longmire area should be mapped. Particular attention should be directed to the composition and stability of the lateral moraines just below the terminus of Nisqually glacier, which have been exposed by its recent retreat. Authors also recommend a geologic reconnaissance along Kautz Creek valley to determine, if possible, if the mud-flow originated from above the box canyon, as is presumed, or if possibly it was material from along the valley itself that was moved forward only a comparatively short distance."

1955: Flood Damage: "On October 25, 1955 after heavy rains, the Nisqually River was in flood stage and surges which came from the glacier swept away the Glacier Bridge, six miles above Longmire. IT was believed the bridge had disintegrated but recently a large section of battered concrete was found about a mile above Longmire. The log bridge leading to the (Paradise) power plant was swept away and the Longmire campground and road were damaged. An extensive washout occurred on the main road about 1/4 mile below Longmire, where for 150 ft. about half of the road was carried away.

Many Longmire residents left the park, or retreated to higher ground, for several hours, as it was thought the community would be flooded. Snow starting to fall at higher elevations suddenly reduced the danger the same afternoon. . .

There was extensive damage to the road in the Carbon River district, due to flooding from the Carbon River."

References: Giles, Gordon C. 1955. Longmire Flood. November 14, 1955. This report discusses the October 25, 1955 Nisqually River flood at Longmire which resulted from a debris flow (large blocks of ice and debris destroyed Glacier Bridge, log bridge to Paradise power plant, washed out portions of road below glacier bridge and in two locations in Longmire. Part of the dike protecting Longmire was undermined, causing it to slip into the stream bed.

1959: Flood Damage: "High water due to heavy rains of November 21-22, 1959 caused extensive damage to roads, trails, bridges and powerlines throughout the park. The Nisqually River overflowed its banks at Longmire and water ran through the utility area and down the main entrance road leading into park headquarters. Extensive damage was done to road

shoulders on the Longmire-Paradise road and large sections of road surface slid into valleys below along the Stevens Canyon road. The Carbon River Road was severely damaged by flood waters and many trail bridges were demolished. The full extent of trail damage will not be known until mid-summer or until inspection of snow-free trails can be accomplished."

1960: Letter from Richard S. Fiske to V.R. Bender, Chief Naturalist, MORA: Fiske spent a day at the "Cougar Flat Campground site" conducting field reconnaissance in the northeast part of this area which is in most danger of being encroached upon by the Nisqually River. He states, "My findings are fragmentary at best, and in fact might better be called impressions. But these impressions may be of some value to you." Fiske discusses his understanding of the development of a campground and picnic area planned for this area and the question regarding the possibility of damage or destruction of these installations by the nearby Nisqually River. "This danger is real, but its likelihood should be investigated." The area is apparently the upper surface of a recent (150 yrs old) mudflow deposit, not unlike the flat surface formed by the Kautz flood of 1947. The danger of the Nisqually River seems to be from mudflows, complete and permanent diversion of the river northwestward upon Cougar Flat, and temporary overflow of the river during unusually high flood stages.

"The potential danger area from such an encroachment of the Nisqually lies near the junction of Van Trump Creek with the Nisqually River. Here, the bed of the river lies at least 15 feet below the road level (estimated on a profile perpendicular to the Nisqually at this point). However, as an observer stands on the highway at the northeast end of the lowermost hairpin turn on the Longmire-Paradise highway, he can look farther northeast (slightly upstream along the Nisqually) and see that the road at that point is only about 5 ft. above the river bed. In addition, the Nisqually River above this point is headed directly for this critical area. The impression is that a projection of the river would carry it directly to the point where the observer is standing.

The important question is whether or not the Nisqually could flow along this projected path, breach the low barrier of the highway, and continue flowing across the northwest edge of Cougar Flat (i.e. through much of the proposed campground)."

Fiske emphasizes that a detailed contour map of this local area is needed before an adequate appraisal can be made. He concludes that the greatest threat to the development on Cougar Flat would likely be temporary overflow of the river at a point near the northeast end of the Flat. The danger of the entire river being permanently diverted along this route is slim. Overflow water could be a hazard to the campsites, but the likelihood of total destruction is remote. "The potential danger to the Cougar Flat site therefore seems no worse than the similar dangers threatening Longmire."

1961: No mention in Superintendent's Annual Report but the following reference was located. Patton, T.L. 1961. Report on aerial inspection of Kautz Creek following the surges which occurred August 23, 1961.

1962: Storm Damage: "Gale-force winds on 10/12/62 did considerable damage on the west side of the park. Trees blocked roads in most sections,

however the West Side and Mowich Lake Roads were hardest hit, with 209 trees across the West Side Road and 100 trees on the Mowich Lake Road.

November 19 and 20, 1962, torrential rain on the 25 inch snow cover at higher elevations caused water to cascade down every mountainside, overflowing rivers and creeks. Extensive sections of road shoulder were washed away, numerous rock and mud slides blocked roadways and the Stevens Canyon Road was partially washed out at two locations."

1964: Operations: "Mount Rainier again experienced late fall storm damage to roads and other facilities but not as extensive as in 1962."

1967 - 1972 : No Superintendent's Annual Reports were required.

1967: Reference: Crandell, DR. 1967. Mudflow and Flood at Tahoma Creek Campground, Mount Rainier National Park, Washington.

1977: Maintenance section refers to flood damage: "The Park received valuable assistance from Regional Public Health Officer Roger Lee after the December floods. Water systems and sewer systems were surveyed to make sure they were not a threat to public health.

"Due to December flood damage, a new transformer was installed at Nisqually, 2000 ft. of new power line was rebuilt at Sunshine Point Campground, the Tahoma Creek line crossing and crossing structures were rebuilt as the Kautz Creek crossing structures."

under Other: "December Flood Damage: Heavy flooding in early December washed all but five or six sites on the first loop of Sunshine Point down the Nisqually River. The power line was washed out at Tahoma Creek, Kautz Creek and Nisqually. About one mile of line had to be replaced.

The bridge over Ipsut Creek at the Campground washed out, and trees fell on the Carbon River shop and trail quarters. The road to the sewer treatment plant at Ohanapecosh was washed out and there was some serious flooding of the Longmire sewage lagoon. To top it off, there was considerable leaking in the Paradise Visitor Center and the power was off at Paradise and Longmire for long periods."

1978: General: "Park visitation decreased 14% in 1978, mostly in the first four months of the year, primarily due to heavy rains and floods of late December, 1977. State highway construction caused some traffic restriction on Highway 123 where a washout of December, 1977 was rebuilt and on Highway 706 where a one-land Bailey bridge crossed the washout over Goat Creek."

Roads and Trails: "A bailey bridge was installed across Ipsut Creek for temporary use. The dikes at Longmire and Sunshine Point campground were rebuilt from December 1977 flood damage. The Sunshine Point Campground was rebuilt by NPS and YACC assistance. The Mowich Lake Road was rebuilt from the December 1977 floods. Work included a 2 inch overlay of gravel road surface, new 48 inch culvert and rebuilding drainage and diversion ditches.

The Ipsut Creek road was realigned at Ranger Creek to correct damage from December 1977 flood. All trails were repaired from the December 1977

flood. Gabions were installed along the West Side road for slope stabilization."

"Sunshine Point Campground Rehabilitation: As a result of last year's flood damage, the campground was closed during August and September for complete rehabilitation. All sites were realigned, a new picnic area was established, paving was completed on a new loop road and all parking pads, the entire area was hydroseeded for revegetation and new comfort stations were installed."

"Carbon River Road: Portions of the road were closed during the year for extensive repair work to flood damage sections. One section was closed early in the year to install a temporary Bailey bridge where culverts had washed out. A second section was closed for several periods in October for widening."

"Mowich Lake Road: Extensive repairs to flood damaged sections delayed the spring opening of this road until late July."

1980: Roads and Trails: "Unusual heavy winter rainfall during the period from Dec. 20 through 28 caused flood damage to park facilities along the Nisqually River at Longmire, along the Carbon River from the entrance to the Ipsut Creek campground, and along Tahoma Creek above the Sunshine Point Campground near the Nisqually Entrance station. Channel work and other repairs were begun during the last week of December utilizing both park-owned and contractor-leased equipment. Damages were estimated at approximately \$100,000.00."

Public Affairs: "A minor glacial outburst flood swept down Tahoma Creek on September 21 putting some mud up into a picnic area along the West Side Road and causing a large gravel accumulation behind the Tahoma Creek road bridge."

1982: Roads and Trails: "Two major trail reroutes were completed in the Carbon River District. One was above the Ipsut Creek campground, skirting 1200 ft. of storm ravaged trail. The other reroute was 1800 ft. at the snout of the Carbon Glacier due to a landslide area."

"White River campground road, 0.92 miles, from White River Bridge to the campground reconstruction began. Completion should be mid summer 1983."

1986: General: Outburst flood on Kautz Creek took out the foot bridge on the Wonderland trail.

10/26/86 debris flow on Tahoma Creek notes details of damage to picnic area.

Heavy rains in November left extensive flood damage to Carbon River Road above Ipsut Creek Campground.

1987: General: Five debris flows on Tahoma Creek (June - October)
Maintenance: Carbon River Road storm damage

1988: General: 10/22/88 debris flow on Tahoma Creek left one million dollars worth of damage to the Tahoma Creek Bridge, Sunshine Point

Campground dike, West Side Road, Carbon River Road, Carbon River trail, Longmire Dike, and Tahoma Creek Trail. (no further information noted under the Maintenance section).

NRP: USGS began studying debris flows on Tahoma Creek

1989: General: Oct. 10 and 11, 1989 - high water from severe winter storms caused damage to Carbon River and West Side Roads, Tahoma Creek bridge, Sunshine Point Campground and Carbon Glacier Trail.

West Side Road was reopened for first time since the October 1988 debris flows. Closed again after the October 1989 debris flows.

NPS initiates an Interagency Agreement with USGS to study debris flows on Tahoma Creek.

1990: November, 1990 extensive damage from heavy rains that caused severe damage throughout most of western Washington. November 21-25, 14.38" rain at Paradise (the highest mean 24 hr. value was 5.72" on 11/24; the 40 yr. mean for Paradise for the entire month of November is 14.54").

Damaged facilities included Longmire dike, Kautz Creek Bridge, Tahoma Creek Bridge, West Side Road, washouts and rockslides on Stevens Canyon Road, general road shoulder/ditch washouts and pavement damage parkwide. Also Ohanapecosh campground access road, Cheunuis Falls parking area, numerous footlog bridges on trails throughout the park.

Summary of Environmental Compliance and Other records

Carbon River Road project (EA) 7/86
Repair Sunshine Point Dike (categorical exclusion) 1987
Nisqually River at Cougar Rock - Rip-rap (EA) 4/87
Ipsut Creek Trail Re-route (EA) 7/87
Amend EA for Cougar Rock work 8/6/87
Amend Carbon River Road work (EA) 8/87
Tahoma Creek Trail Re-route (EA) 7/88
West Side Road (EA) 7/88?
Carbon River DCP 9/30/88
Nisqually Entrance and Tahoma Creek ?? 11/88 final draft completed
Sunshine Dike EA 5/10/89
Tahoma Creek Bridge 5/10/89 final draft
West Side Road (categorical exclusion) 5/89
Ipsut Creek Trail 5/89 final draft
Carbon River Road 5/89 final draft
Flood Damage Package 1989-90: West Side Road, Sunshine Point Dike, Tahoma Creek Bridge, Carbon Road and Trail (categorical exclusions except WS Rd) 4/90
West Side Road (EA) 1/90
Tahoma Creek Bridge 12/90 (for Oct/Nov 1990 floods)
Nisqually River at Longmire 12/3/90
Cougar Rock Trail Bridge 1/11/91

References

Memorandum of 11/22/88. Storm Damage Request for Funds. Includes maps of damage, repairs needed and costs.

Memorandum of 1/19/90. Winter Storm Damage 1989-90. Includes same as 1988 memo.

Memorandum of 12/12/90. November 1990 storm damage. Includes same as 1988 and 1989 memos.

Memorandum of 7/29/91. Request for Technical Assistance in Floodplain Management: Tahoma Creek/West Side Road, Carbon, White River areas

Resource Management Plan. 1991. Project Statement on Water Resources
Water Resources Management Plan. 1989.

Erdmann, C.E. and A. Johnson. 1953. Preliminary Report Flood Problem on Nisqually River at Longmire, Washington. February 1953. USGS. Makes reference to a topographic map that accompanies this report.

A report prepared by Henry Lands and J. Hoover Mackin dated January 23, 1936, describes two flood surges on the Nisqually River, one of which occurred on October 14, 1932 and the other on October 25, 1934.

Giles, Gordon C. 1955. Longmire Flood. November 14, 1955.

Nelson, L. 1987. Flood Characteristics for the Nisqually River and Susceptibility of Sunshine Point and Longmire Facilities to Flooding in Mount Rainier National Park, Washington. U.S. Geological Survey Water-Resources Investigations Report 86-4179. Tacoma, Washington.

Special Note: I have contacted Bill Sikonia, Chief of the Water Resources division and asked him to investigate the possibility that the 1959 Longmire flood was not included in the floodplain estimates and maps. We have located several photographs showing areas as far as the National Park Inn and adjacent road flooded. The 1959 Superintendent's Annual Research Report also references this flood event. Floodplain maps prepared by Leonard indicate 100 and 500 year floodplains to be located quite a distance (closer to the river) than flooding reached in the 1959 floods.

August, 1960: Letter from Richard S. Fiske to V.R. Bender, Chief Naturalist, MORA: Fiske spent a day at the "Cougar Flat Campground site" conducting field reconnaissance in the northeast part of this area which is in most danger of being encroached upon by the Nisqually River. Letter includes sketches.

Crandell, Dwight R. c. 1967. Mudflow and Flood At Tahoma Creek Campground, Mount Rainier National Park, Washington. U.S.G.S. report based on an interview with James Erskine, Park Ranger, and on field observations made by the author following the flood and mudflow.

Crandell, Dwight R. 1969. Surficial Geology of Mount Rainier National Park.

Fountain, A.G. 1985. The Effect of Glaciers on Streamflow Variations. Water Resources Research 21:579-586

Laird, L.B. 1965. Evaluation of potential water supplies at White River headquarters site and Tahoma Creek campground, Mount Rainier National Park, Washington. USGS, Water Resources Div., Tacoma, WA. letter to NPS 4/14/65. Copy available at USGS library, Tacoma, WA.

Weather Reports

Publicover, D.A. 1986. Water quality and associated characteristics of the Nisqually River basin, Mount Rainier National Park, Washington. M.S. Thesis. University of Vermont. 110 p.

Richardson, D. 1972. Effect of snow and ice on runoff at Mount Rainier, Washington. In: International Symposia on the Role of Snow and Ice in Hydrology.

Hobson, Frank D. 1976. Classification for the Soils of Mount Rainier National Park. M.S. Thesis. University of Washington.

Photographs. Collection of Kautz Creek aerial photographs

Collection of Kautz Creek flood photographs

Collection of Longmire Flood, November 1959

USGS. Longmire profiles of the Nisqually River. USGS. Tacoma Washington map files.

Crandell, D.R. 1973. Potential hazards from future eruptions of Mount Rainier, Washington. USGS, Misc. Geol. Invest. Map I-836, Denver, CO.

Grater, R.K. 1947. Report on Kautz Creek Flood: Memorandum for the Superintendent. In: Mount Rainier National Park Nature Notes.?

Grater, R.K. 1948. A report on the Kautz Creek flood studies. Unpubl. report, National Park Service, MORA. 18 p.

Meier, M.F. (ed.). 1963. The glaciers of Mount Rainier. IUGG Study Tour, Sept. 2-5, 1963. 21 p.

Patton, T.L. 1961. Report on aerial inspection of Kautz Creek following the surges which occurred August 23, 1961.

Richardson, D. 1968. Glacier outburst floods in the Pacific Northwest. U.S. Geological Survey, Prof. Pap. 600-D, pp. D79-D86.

Richardson, D. 1970. Nisqually glacier outburst of July 4, 1970. Unpubl. report, NPS, MORA. 3p.

Veatch, F.M. 1969. Analysis of a 24-year photographic record of Nisqually Glacier, Mount Rainier National Park. U.S. Geol. Surv. Prof. Pap. 631.,

Washington, D.C. 521 p.

Franklin, Jerry F, W. H. Moir, M.A. Hemstrom, S.E. Greene, B.G. Smith. 1988. The Forest Communities of Mount Rainier. Scientific Monograph Series, National Park Service, US Department of the Interior.

Driedger, Carolyn L. and A.G. Fountain. 1988. Glacier outburst floods at Mount Rainier, Washington State, U.S.A. In: Proceedings of the symposium on Snow and glacier research relating to human living conditions.

Jonientz-Trisler, C., C. Driedger, A. Qamar. 1989. Seismic signatures of debris flows on Mount Rainier, WA. In: American Geophysical Union 36th annual Pacific NW Regional Meeting.

Jonientz-Trisler, C. and C. Driedger. 1990 Seismic evidence of historic debris flows and dry-season floods on Mount Rainier, Washington, 1961-1990.

Pringle, P.T. 1990. Hazards from volcanic debris flows in the Puyallup Valley, west of Mount Rainier, Washington. Washington Department of Natural Resources, Division of Geological and Earth Resources, Olympia, WA.

Hemstrom, M.A. 1982. Fire and other disturbances of the forests in Mount Rainier National Park. PhD Thesis. Oregon State University, Corvallis, OR.

Crandell, D.R. and R.K. Fahnestock. Rockfalls, debris flows and eruptions at Mount Rainier, Washington. USGS Professional Paper no. 525A p. A57-A58.

Crandell, D.R. 1970. Postglacial lahars from Mount Rainier Volcano, Washington. Professional Paper

Crandell, D.R. and D.R. Mullineaux. 1967. Volcanic hazards at Mount Rainier, Washington.

Crandell, D.R. 1963. Paradise debris flow at Mount Rainier, Washington. USGS Research 1963. Professional Paper p. B135-B139.

Sigafoos, R.S., and E.L. Hendricks. Recent activity of glaciers of Mount Rainier, Washington.

Heliker, C.C., A. Johnson, and S.M. Hodge. 1983. The Nisqually Glacier, Mount Rainier, Washington, 1857-1979: A Summary of The Long-term Observations and a Comprehensive Bibliography. U.S. Geological Survey. Tacoma, Washington. 20 p.

Driedger, C. L. 1986. A Visitor's Guide to Mount Rainier Glaciers. U.S. Geological Survey and Pacific Northwest National Parks and Forests. 80 p.

Russell, Israel Cook. 1898. Glaciers of Mount Rainier, with a paper on The Rocks of Mount Rainier, by George Otis Smith: U.S. Geological Survey 18th Annual Report, 1896-97, Part II, p. 349-423.

- Brockman, C. Frank. 1938. The recession of glaciers in Mount Rainier National Park, Washington: *The Journal of Geology*, vol. XLVI, no. 5, p. 764-781.
- Johnson, Arthur. 1960. Variation in surface elevation of the Nisqually Glacier, Mt. Rainier, Washington: *International Association of Scientific Hydrology, Bulletin* 19, p. 54-60.
- Veatch, Fred M. 1969. Analysis of a 24-year photographic record of Nisqually Glacier, Mount Rainier National Park, Washington, 52 p.
- Miller, Maynard M. 1970. Wind, sky and ice: *Explorers Journal*, vol. XLVIII, No. 3, p. 192-197.
- Hodge, Steven M. 1974. Variations in the sliding of a temperate glacier; *Journal of Glaciology*, vol. 13, no. 69, p. 349-369.
- Driedger, C.L. and P.M. Kennard. 1984. Ice volumes on Cascade volcanoes: Mount Rainier, Mount Hood, Three Sisters and Mount Shasta: U.S. Geological Survey Open File Report 84-581, 55p.
- Crandell, D.R. and R.D. Miller. 1964. Posthypothermal glacier advances at Mount Rainier, Washington: U.S. Geological Survey Professional Paper 501-D, p. 110-114.
- Sigafoos, Robert S. and E.L. Hendricks. 1972. Recent activity of glaciers of Mount Rainier, Washington: U.S. Geological Survey Professional Paper 387-B, 24 p.
- Burbank, Douglas W. 1981. A chronology of late holocene glacier fluctuations on Mount Rainier, Washington: *Arctic and Alpine Research*, vol. 13, no. 4, p. 369-386.
- National Park Service. 1941-1959. Glacier Surveys and Studies In Mount Rainier National Park (19 reports). National Park Service. Mount Rainier National Park.
- Brockman, C. Frank. 1940. Progressive Summary of Glacier Recession in Mount Rainier National Park, Washington (1904-1940). National Park Service, Department of the Interior. Mount Rainier National Park, Ashford, Washington.