Forest Sciences

Prince Rupert Forest Region

Extension Note # 43
December, 2000

Outburst floods at Tulsequah Glacier, northwestern British Columbia

Research Issue Groups:

Forest Biology

Forest Growth

Soils

Wildlife Habitat

Silviculture

Timber Harvesting

Ecosystem Inventory and Classification

Biodiversity

Ecosystem Management

Hydrology

Geomorphology

Extension

Forest Engineering

Forest Sciences
Prince Rupert Forest Region
Bag 5000, Smithers, BC V0J 2N0
847-7500 (FAX 847-7217)
www.for.gov.bc.ca/prupert/Research

INTRODUCTION

Catastrophic floods resulting from the breaching of temperate, glacier-dammed lakes (glacial outbursts) are relatively common in the Canadian Cordillera, particularly in the Coast Mountains. Some lakes drain and fill frequently whereas others remain empty for years after self-dumping (Clague & Evans 1994). The two lakes described in this paper are dammed by the Tulsequah Glacier and empty (often annually) through sub-glacial drainage channels.

This paper is based on information collected during a 1996 British Columbia Forest Service field trip, historic airphoto interpretation, discussions with eye witnesses (especially Norm Graham from Atlin, and Mitch Mihalynuk from the British Columbia Geological Survey), and on the work of others (Kerr 1936, 1948; Marcus 1960; Souther 1971; Clague & Evans 1994; Septer & Schwab 1995).

SETTING

Tulsequah Glacier is located on the eastern margin of the Juneau Icefield in the Boundary Ranges of the Coast Mountains (Holland 1976) near the British Columbia - Alaska border. This remote part of BC is a raw landscape, in large part only recently released from the grip of the Little Ice Age which occurred 150 to 300 years ago. Recent glacier advances (Motyka & Beget 1996), early 20th century glacier fluctuations in the general area (Cairnes et al. 1913; Marcus 1960), the presence of trees and forest floors beneath glaciers (Kerr 1948), fresh moraines covering forested slopes and the occurrence of at least four glacial outburst lakes in the area are essentially all lingering phenomena associated with deglaciation of the Little Ice Age.

Tulsequah Glacier impounds two lakes that have a long history of catastrophic drainage. Although much has been published about Tulsequah Lake, (Kerr 1948; Marcus 1960; Souther 1971; Clague & Evans 1994; Septer & Schwab 1995), nothing has hitherto been published about the larger Lake Nolake to the north.

GLACIAL OUTBURST LAKES

Hutchinson (1957; cited by Marcus 1960) describes seven types of glacier-dammed lakes: 1) supra-glacial (on glacier surface) lakes; 2) englacial (inside glacier) lakes; 3) lakes on ice sheets; 4) lakes in lateral stream valleys dammed by ice in the main valley; 5) lakes in main valleys dammed by ice from lateral valleys; 6) lakes between glacier and valley walls; and 7) lakes impounded by avalanches. Marcus (1960) describes an eighth type, where a lake is formed by the retreat of a tributary arm from a trunk glacier and he put Tulasequah Lake into this category. Lake Nolake fits none of these categories. It has formed along the margin of a tributary glacier and a valley wall, distally from the junction of a trunk glacier and its tributary arm.

Tulsequah Lake

Tulsequah Lake (Fig. 1), impounded by the Tulsequah Glacier, has been known to self-dump since the early 20th century (Kerr 1948; Marcus 1960; Souther 1971; Clague & Evans 1994). To date, Marcus (1960) has completed the most thorough analysis of Tulsequah Lake's jokulhlaups (glacial outburst flood: pronounced "yuk-ah-lup").

Figure 1. Westward view of Tulsequah Lake after draining - note the icebergs marking the highwater line.

In the mid-19th century, the entire bifurcating valley of Tulsequah Lake was occupied by two Little Ice Age glaciers flowing from Juneau Icefield, joining together, and then merging with Tulsequah Glacier. Sometime towards the close of that century, glaciers began to downwaste and recede. Separation of the glacier occupying Tulsequah Lake valley from the trunk Tulsequah Glacier resulted in the formation of an ice- dammed lake. The receding glacier snout must have been stable for some time because a large terminal moraine was constructed about 1.5 km into the valley (Fig. 2).

By about 1920, the tributary glaciers had receded several kilometers, thereby increasing the size of Tulsequah Lake substantially. It is quite conceivable that both these tributary glaciers had floating ice tongues (as opposed to glacier beds in contact with the ground surface) during this early phase. At this time, lake levels were deeper, and outburst floods of greater magnitude than in later years.

By 1958 the level of Tulsequah Lake had dropped sufficiently to create an upper moraine dammed lake, named Upper Tulsequah Lake (this newer lake,dammed by the moraine, does not drain catastrophically) (Kerr 1948). Today, this upper lake is almost cut in two by two colluvial fans, coalescing from opposite sides of the valley. Falling lake levels probably coincided with downwasting of Tulsequah Glacier and sub-glacial drainage development.

Further changes to Tulsequah Lake have occurred during the last few decades (Norm Graham, pers. com., May 1999). High water levels have

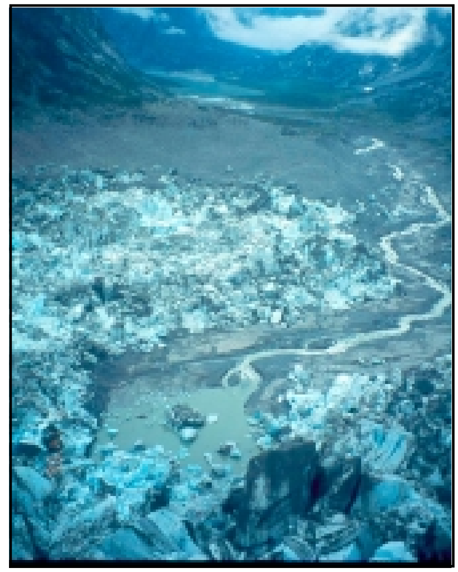

Figure 2. Large terminal moraine (upper 1/3 of photo) was formed by a standstill of a glacier in the early 20th century.

continued to decline, and the lake often drains twice a year. In addition, Graham has noticed a linear depression on the west margin of Tulsequah Glacier, along the valley wall. Perhaps this depression represents a collapsing conduit. This could represent the creation of a permanent open channel. The years of Tulsequah Lake's existence may truly be numbered.

Lake Nolake

While Tulsequah Lake was being studied, Lake Nolake (Figure 3) appears to have remained unknown as a glacial outburst or self-dumping lake, and appears on topographic maps as a small glacial lake. It was not until about the late 1970's or early 80's that people started referring to the floods of the "big lake" (Norm Graham, pers. com., May 1999).

Perhaps this lack of attention relates to the recent growth of Lake Nolake, which has lagged behind Tulsequah Lake in development. Based on aerial photo assessment, the lake has grown dramatically since 1958. Measurements made

Figure 3. Lake Nolake in the process of draining (Aug. '94). Note the stranded ice bergs marking the high water level.

over the last 40 years show a surface area increase from 0.43 to 4.8 km^2. A recent measurement of Lake Nolake puts its depth at 150 meters (calculated as the difference between the elevation of the high water mark and the bottom of the drained lake - Norm Graham, pers. com., May 1999). This gives the lake a volume of approximately 720 million m^3.

The largest known increase in lake area occurred in the summer of 1993 when a large portion of Tulsequah Glacier separated from the main glacier. A large slab, estimated to be 500 by 700 m in area and 170 m thick (almost 60 million m^3), calved into Lake Nolake (Mitch Mihalynuk, pers. com., May 1999). The glacier separated near a broad dark band trending perpendicular to the axis of the glacier. It is possible that this band represented a hinge, separating grounded ice from an ice tongue floating on, and rising and falling with the fluctuating levels of Lake Nolake. If this is the case, future flood volume calculations should include a sub-glacial lake component, however, there are currently insufficient data to do more than speculate.

As was the case for Tulsequah Lake, Lake Nolake's maximum water levels are decreasing over time, but because of its increased area the lake is taking longer to fill (Norm Graham, pers. com., May 1999). Graham has also pointed out that it is not uncommon for Lake Nolake to empty and fill twice in one year. One year, he found that the lake drained about half its water, stopped draining for approximately one month, and then resumed to drain the rest of the water. This latter observation has important implications for sub-glacial drainage mechanics.

DOWN STREAM IMPACTS

Glacial outburst flood waters have emanated from the snout of Tulsequah Glacier for approximately one century. As a result, the Tulsequah River has a broad gravel bed floodplain which is mostly dry (Fig. 4), except at times of outburst floods (Fig. 5). There is evidence that flood levels have been higher in the past than they are at present. Beside the main floodplain there is a sparsely vegetated, elevated terrace that has channels that were carved by high magnitude floods from Tulsequah Lake and / or Lake Nolake. Synchronous discharge of the lakes would undoubtedly have increased flood magnitude.

The repeated outburst floods of Tulsequah River has meant the regular replacement of mining bridges across the active and unstable floodplain throughout the 1950's and 60's (Mitch Mihalynuk, pers. com., May 1999). Flooding of the local airstrip was also a common occurrence.

Figure 4. Tulsequah River at normal, low-water level.

Figure 5. Tulsequah River in the early stages of flooding during the drainage of Lake Nolake in Sept. '96.

and river crossing structures will remain temporary. Nonetheless, if the glaciers continue to downwaste and recede, eventually the ice dams will vanish, and flow regimes on Tulsequah River will return to that of a more typical Holocene gravel bed river.

ACKNOWLEDGEMENTS

Norm Graham and Mitch Mihalynuk have provided valuable accounts of the outburst floods and lakes described in this paper. Norm Graham, Will Mackenzie, and Jim Pojar provided some of the photos.

CONTACT:

Marten Geertsema
Research Geomorphologist
Prince George Forest Region
Marten.Geertsema@gems3.gov.bc.ca

SUMMARY

The physical signature of the Little Ice Age lies strong upon northwestern British Columbia. The self-dumping, ice-dammed lakes described in this paper are just one of its lingering effects.

The lakes appear to be at different stages of development. Tulsequah Lake has increased in area earlier this century, and is now diminishing because of falling maximum lake levels. In contrast, the now larger Lake Nolake is still expanding in area because of ice ablation and calving, but its peak levels are also declining. Although the two lakes are similar, Lake Nolake may lag about 80 years behind Tulsequah Lake in evolutionary phase.

As long as the outburst floods continue, the active floodplain of Tulsequah River will remain bare

REFERENCES

Cairnes, D.D., Wright, F.E. & Martin, L. 1913. Yukon and Malsapina -Excursion C 8. In: Excursions in Northern British Columbia and Yukon Territory and along the North Pacific Coast. Guide Book 10. Geological Survey, Ottawa, Canada. pp. 39-168.

Clague, J.J., & Evans, S.G. 1994. Formation and failure of natural dams in the Canadian Cordillera. Geological Survey of Canada, Bulletin 464.

Holland, S.S. 1976. Landforms of British Columbia. B.C. Dept.of Mines and Petr. Resources. Bulletin 48. 138 p.

Kerr, F.A. 1948. Taku River Map-area, British Columbia. Can. Dept. Mines and Resources, Ottawa. Geolog. Surv. Memoir 248. Hutchinson, G.E. 1957. A treatise on limnology. Vol 1. Geography, Physics, and Chemisitry. NewYork.

Marcus, M.G. 1960. Periodic drainage of glacier-dammed Tulsequah Lake, British Columbia. The Amer. Geograph. Soc. Geograph. Review 55: 46-52. British Columbia. Canadaian Journal of Earth Sciences 30: 499-508.

Mihalynuk, M., Smith, M.T. Hancock, K.D., & Dudka S. 1994. Regional and economic geology of the Tulsequah River and Glacier areas (104K 12 and 13). In Current Research: Geological Fieldwork 1993. Paper 1994-1: 171-197.

Motyka, R.J. & Beget, J.E. 1996. Taku Glacier, southeast Alaska, U.S.A.: late Holocene history of a tidewater glacier. Arctic and Alpine Research 28: 42-51.

Septer, D. & Schwab, J.W. 1995. Rainstorm and flood damage: Northwest British Columbia 1891 - 1991. B.C. Min. For., Victoria, B.C. Land Manage. Rep. 31, 196 p.

Souther, J.G. 1971. Geology and mineral deposits of Tulsequah map-area, British Columbia (104K). Memoir 362. Geol. Survey of Canada.