

BABINE RIVER - SLIDE HAZARD ASSESSMENT

INTRODUCTION

In 1951, a rockslide into the Babine River obstructed the upstream progress of spawning salmon, resulting in severe mortality in 1951 and 1952. The debris from this rockslide was removed in 1952, but the possibility of further slides still remains. The writer was authorized under contract FP 93-5125 with the Department of Fisheries and Oceans to evaluate the Babine Slide in accordance with his letter to Mr. Wayne Peterson dated 13 August 1993, and to recommend a course of action.

Geological and topographic maps of the area were obtained and airphotos taken in 1952 at a scale of about 1:6000 were examined as were more recent but less detailed airphotos. Also, various reports, photos and miscellaneous information from Federal Archives pertaining to the 1951 Slide were examined. Several photographs taken in 1990 of a slide area a few kilometres upstream from the 1951 Slide were also available. The more important references and the airphotos are listed in Appendix A.

Following the examination of this information, September 21 and 22, 1993 were spent in a helicopter supported reconnaissance of the Babine River downstream from the Babine Fence. The first day was in the company of Mssrs. W. Peterson and A. Moore and the second with Mssrs. A. Moore and M. Jacobowski, all of the Department of Fisheries and Oceans. On 27 October 1993, a meeting was held with Mssrs. E. Woo, W. Peterson and I. Ross to discuss the preliminary findings of the study.

This report summarizes the results of the work and recommends a course of action.

LANDSLIDE DAMS - GENERAL

Damming of rivers by landslides is a common process in the mountainous areas of the world including the Cordillera of Western Canada, where at least 18 damming events are known to have occurred since 1880. Several of these slides have hindered salmon runs, for example the Thompson River slide of 1880, Hells Gate slides of 1913-14, the Babine slide of 1951 and the Inklin River Slide of 1979.

Geological evidence indicates there have been a great many landslide dams prehistorically along B.C.'s rivers. For example, the Fraser has been blocked at a number of locations including Lillooet, Katz and possibly Cheam. The effects of the prehistoric

slides on salmon runs are not known.

Most landslide dams survive only a few hours or days, especially those formed from unconsolidated materials such as the silts and clays along the Thompson River. The effects of these events on salmon runs could be to cause blockage and stranding followed by extreme floods of sediment-laden water which could damage fish and/or bury spawning beds.

Landslide dams formed by rockslides tend to last longer than those formed from unconsolidated materials and many become essentially permanent. Local examples are Silver Lake on Silverhope Creek, Lake of the Woods just East of Hope, Foley Lake on Foley Creek, Daisy Lake on the Cheakamus River and Nahatlatch Lake on the Nahatlatch River, to name just a few.

Case history information regarding landslide dams is plentiful but few generalizations have been made regarding their nature. Some evidence from New Zealand suggests that if the volume of water impounded is large relative to the volume of the landslide dam, it is likely to fail quickly. The evidence also indicates that large flood discharges are associated with shorter durations of blockages, as would be expected. Narrow gorges such as that at Babine tend to result in longer blockage durations even when the volume of ponded water is relatively large (i.e. similar to the 1951 Slide). Nothing was found in the literature regarding the relationship between the ease of erosion and the nature of the rockslide debris, but it is obvious that larger and stronger rock blocks would be more difficult for the river to remove.

GEOLOGICAL SETTING

Physiography

From the Babine Fence, the river flows north to northwest for about 25 km along a river valley moderately incised into the Nechako Plateau (Figure 1). A cursory inspection of this reach from a helicopter indicated that the river flows mainly on bedrock overlain by shallow fluvial deposits. The banks are either terraces of unconsolidated overburden deposits or moderately sloping bedrock.

Further downstream, the Babine River flows generally westward about 50 km to its junction with the Skeena River. The lower 25 km of this reach of the river has a steeper gradient and flows through a steep-sided canyon where it crosses the Babine Mountain range. The valley walls are generally 75 to 125 m high and often slope at 35 to 45 degrees. Some of the slopes are even steeper and approach vertical. The walls are usually formed by bedrock, covered by a veneer of colluvium but thick deposits of overburden form some

sections of the valley walls. Remnants of a bedrock terrace occur at many locations about half way down the canyon walls, indicating a period of valley widening as opposed to downcutting. The river flows over bedrock which is well exposed at river level and in the channel. Deposits of bedload (sand, gravel, boulders etc.) are scarce in the canyon.

Bedrock Geology

The rocks of the canyon area are part of the Bowser Group of Upper Jurassic and Cretaceous age. They are mainly sandstone, siltstone and conglomerate with minor shale, coal and marl (a fine grained calcareous rock). Bedding generally strikes northwest and dips from about 20 degrees to vertical. These sedimentary rocks are folded and upturned but are essentially unmetamorphosed.

The rocks are generally weak and can be readily scratched or broken with a hammer. Large pieces tend to break when rolled or upon impact after a short fall. The more shaley beds tend to be thinner and break down to small fragments when exposed to the weather. No soft silty or clayey material or fault gouge was observed along the bedding.

The only igneous rock seen was the lamprophyre dyke at the site of the 1951 Slide. Dr. W.M White reported that there is a soft clay along the dyke and that it formed much of the base of the Slide. Lamprophyre is known to weather rapidly relative to most rocks; this particular dyke was no exception. Geological mapping would be required to determine if other lamprophyre dykes exist in the area.

Structural Geology

The predominant structural weaknesses in the rock are fractures along the sedimentary bedding. The spacing of these fractures is quite variable but is seldom greater than a metre or two. Two sets of fractures at right angles to the bedding surfaces were observed at several locations. One nearly vertical fault and several faults dipping shallowly northward were observed near the 1951 Slide. Geological mapping would be required to determine other locations of faults and their relationship to slope stability.

Seismicity

The Babine canyon is in an area of low seismicity with the nearest areas of significant activity being the Rocky Mountain Trench 200 km to the East and the Queen Charlotte Fault 400 km to the West.

PREVIOUS BLOCKAGES

During the reconnaissance flight and during the airphoto examination, evidence for previous river blockages other than the 1951 blockage was sought. This evidence could be: residual debris in the river, debris on the opposite bank from its source, rapids, ponding, constricted sections of the river, raised beaches, vegetation killed by inundation, boulder trains, depositional terraces or slide scars.

The river bottom is remarkably free of debris. This is probably more a result of the ability of the river to move and break down the weak rock than a result of infrequent slides. For example, most of the evidence for the 1951 Slide already has been removed. Although no evidence of previous blockages was found in the river bottom during this overview study, there are a number of obvious slide scars on the slopes where there is no debris at the toe. Therefore, it is likely that previous blockages have occurred but that the evidence is no longer obvious.

According to Dr. S. Evans of the Geological Survey of Canada, a second blockage of the Babine River was reported in the Victoria Times and the Victoria Colonist newspapers on 7 February, 1953 and on page 5 of the Vancouver Province on 6 February, 1953. No other information regarding this blockage was obtained.

SLOPE STABILITY

General

The first 50 km of the Babine River below the Fence flows in a valley that has far less evidence of slope instability than further downstream, as a result of the flatter slopes and less active river erosion. Some soil slopes (Photos 1 and 2) are actively sliding but the river appears to be able to keep pace with the rate of sediment inflow. Even large slides from these soil slopes would not result in prolonged blockages or steep gradients due to the erodible nature of the material, although sediment supply could increase sharply. The rock slopes along this reach generally are not high and there were no apparent rock instabilities of sufficient volume to block the River.

The lower section of the Babine River where it flows through the steep-sided canyon has been the area of greatest recent slide activity and it likely will remain that way. Within this section, the area of the 1951 Slide and the dipslope (a slope where the

bedding layers are parallel to the ground surface) a few kilometres upstream are clearly the most hazardous. These two areas will be discussed separately from the remainder of the canyon.

Rockslide Initiation

Rockslides along the Babine could be initiated by groundwater pressure increases, freeze/thaw cycles, earthquakes, mechanical deterioration or toe erosion. Groundwater pressure increases and toe erosion by the river would most likely occur as the weather warms and the snow melts, but heavy rains can result in similar high pressures and flows. Freeze/thaw cycles occur in the early spring as well as the fall. Consequently, spring is the most likely time for slides to occur. Slides can also be triggered by earthquakes, but these are not considered to be a major factor at this site. Mechanical deterioration resulting from creep movements could lead to sliding at any time.

Thus, rockslides at Babine are most likely to occur as the snow melts or during heavy rainfalls, but other times cannot be ruled out.

The Canyon

The canyon has been eroded into the tilted and folded sediments of the Bowser Group and in a few locations especially toward the downstream, through thick overburden deposits. The River alternately follows the strike of the sedimentary bedding or cuts across it resulting in two distinct topographic profiles with differing slope stability characteristics.

Where the River follows the strike of the bedding and it is tilted greater than about 30 degrees, the topographic profile is asymmetric with one side of the canyon formed along bedding surfaces (dipslopes) and the opposite side formed along steep fracture surfaces (Photos 3 and 4). The Dipslope area discussed below is the best example of this situation. As the River erodes the toes of the dipslopes, successive layers of rock slide down the bedding surfaces. The nature of these slides depends on the steepness of the bedding, the stratigraphy, the geologic structure (faults etc.) and the rate and location of the river erosion. The canyon walls that are opposite from the dipslopes are often very steep. They appear to erode as a series of small rockfalls isolated by steep joints. Larger slides appear to have occurred where throughgoing joints or faults have been undercut.

Where the river crosses the sedimentary bedding, both sides of the canyon are often very steep. Small rockfalls appear to be the normal means by which these slopes erode as they are undercut by

the River (Photo 3). However, a few wedge-shaped hollows indicate larger slides also could have occurred (Photo 5). It is not known if these occurred as large, single-events which could block the river or as a series of small rockfalls.

Active sliding of overburden is common along the rim of the canyon and where overburden slopes are being actively undercut by the river. No evidence of recent, large, single-event slides was observed.

The 1951 Slide

The 1951 slide was unusual in that about 100,000 cubic metres of rock slid during a single event. This was a result of the isolation of a large mass of rock by a weak, lamprophyre dyke underlying the canyon wall and dipping towards the River. Contributing factors were the high, steep, canyon walls resulting from the river cutting across the steep bedding at this location and the isolation of the slide mass in a ridge formed by the River and a tributary creek. Also, the rock forming the slide mass was relatively massive which resulted in erosion-resistant slide debris. These exact circumstances no longer exist at the site of the 1951 Slide and are unlikely to exist elsewhere.

Nevertheless, the adjacent high, steep slopes provide opportunity for single event slides of similar magnitude. For example, a wedge of rock directly across from the 1951 slide which has a volume in the order of 50,000 cubic metres appears capable of sliding as a single event (Photo 5). This particular wedge would likely break up as it fell resulting in an erodible deposit but similar wedges lower on the slope or formed from more massive rocks could cause serious obstructions.

Thus, the high, steep slopes formed from the relatively massive rocks near the 1951 Slide still present a risk of blockage of this narrow portion of the canyon.

The Dipslope

The active slide described by Dr. White in 1964 and shown on the 1990 photos (Photos 6 and 7) is the most active slide along a 1 km section of the canyon about 1 km upstream from the 1951 Slide. At this location, the River flows parallel to the strike of bedding in the sedimentary rocks. The bedding dips 40-45 degrees southwest resulting in a dipslope on the right bank and a steep cliff on the left bank (Photo 7).

According to Dr. White, the active slide was about 8 m thick, 90 m long and 75 m along the river, corresponding to a volume of 54,000 cubic metres. Some of this material (6000 cubic metres+-)

has since been eroded away by the river. The crack at the top of the slide described as being about 5 m wide by Dr. White, now appears to be about 15 m wide, indicating about 10 m of downslope movement in the intervening 29 years.

Comparison of the 1990 photographs with the slope in 1993 indicates considerable activity during the last three years. The layer of rock has continued to slide along the undercut bedding surface as material is removed from the toe by the river. The layer breaks up into pieces around its toe and along its sides. The pieces roll and slide into the river creating a constriction. The largest pieces are in excess of 2 m on edge and, judging from the abrasion on the surface of some pieces at the waters edge, the River has difficulty moving these pieces even during high water.

It is likely that this slide mass will continue to slide in response to removal of material from the toe by the river. As a result of the accumulation of slide debris against the toe of the sliding mass, a sudden large movement creating a complete blockage or more severe constriction, presently is unlikely. This situation could worsen if the debris at the toe is eroded leaving the main mass unsupported. Under these circumstances, a large, sudden slide could occur.

Of more concern are the undercut slopes which have not yet slid significantly. Remnant scarps and slip surfaces along this section of the river clearly indicate a long history of sliding similar to that which is presently occurring. The two scarps shown on Photo 7 indicate previous slides of similar thickness but about twice the area of the current slide. Both slip surfaces appear to have been on a dark shale layer. It appears that the river undercuts the slope until a weak layer is daylighted and sliding follows. Large, single event slides would tend to occur where the spacing between weak layers is large.

Presently, the greatest apparent slide hazard exists just downstream from the existing slide (Photo 8). At this location the river has already undercut the bedding 5 or 10 metres and rock is actively sliding from the toe (Photo 9). Whether this slide develops as a series of small rockfalls which can be removed by the river or as a single large slide that creates an obstruction remains to be seen.

Debris Torrents

Several of the creeks tributary to the Babine River show evidence of periodic mudflows or debris torrents. Tomlinson and Shenismike Creeks appear to be particularly susceptible. There is also a possibility of mobilization of the debris from the 1951 Slide where it has been placed alongside Camp Creek. The material from such flows is likely to be readily eroded by the Babine River at least when it is in flood. There is little concern of a

persistent blockage but sudden increases in sediment supply should be anticipated.

Summary of Slope Stability

Potential for rock and/or soil slides exists throughout the lower 50 km of the Babine River valley but by far the greatest risk is within the 25 km from Shed in Creek to a few kilometres downstream from Tomlinson Creek.

The soil slides and debris torrents are relatively small in volume and would likely be readily eroded by the river especially during the spring. These would result in a sudden increase in sediment load but are very unlikely to cause a prolonged obstruction to fish passage.

Rock slides are a serious potential problem. At this level of investigation few if any of the high, steep, rock slopes can be considered completely free of the possibility of sliding. Minor recent activity could indicate more deep-seated problems and should be viewed with caution (Photo 10). Nevertheless, it is readily apparent from the current activity that most of the risk lies within the 3 km stretch from the 1951 Slide upstream, as previously identified by Fisheries personnel. Within this section of the canyon it is almost certain that additional rock slides will take place sometime during the next few decades. The risk of these slides seriously obstructing the river is more difficult to predict. Geological mapping would help to determine the likely modes of failure and risk of blockage.

POSSIBLE REMEDIAL MEASURES

The risk of damage to the Salmon runs from a rockslide obstruction along the Babine River can be reduced either by undertaking a program of pre-slide remediation or by planning for a rapid and effective response to slides after they have occurred.

Pre-slide remediation is impractical because there are a large number of locations where potentially serious rockslides could occur. Stabilization would be extremely costly. For example, the cost to excavate or to anchor the marginally stable material along the worst 250 m length along the Dipslope area could cost in the order of \$10 million. Such a program would only remove the rockslide risk from this particular slope, leaving a considerable risk of slides elsewhere in the canyon.

Contingency planning has the advantage of being capable of

reducing the damage from a slide anywhere along the river. To be most effective an early warning of slide movement or at least an early indication of an obstruction would be necessary. Monitoring could be very effective in providing this early information.

Effective rockslide monitoring can be as simple as a periodic visual inspection and photographic comparison of key areas by a trained observer or as sophisticated as an automatic data acquisition and telemetry system. The latter system is well within existing technology even for a remote area such as Babine River. The installation cost of such systems varies widely depending on the number and location of the monitoring stations, the number and type of instruments being monitored and the requirements for telemetry and data acquisition. Installation costs could easily exceed hundreds of thousands of dollars. Maintenance of these systems can be onerous especially in remote locations with hostile climates and can result in very significant costs.

Design, installation and maintenance require a team of personnel with technical expertise in instrumentation, computer science, telecommunications, electronics, monitoring and a detailed understanding of the rockslopes and the river and the relation of the instruments to them. Long term commitment of human and financial resources to the task is essential if an effective monitoring system is to be maintained. Given these resources a monitoring system could be established which would provide warning of deteriorating slope conditions and/or blockage of the river.

More detailed geological mapping and hazard assessment followed by periodic visual monitoring, possibly combined with simple instrumentation, would provide a good benefit relative to its cost at Babine River. Following a better understanding of the hazard, routine visual monitoring by a trained observer could provide a warning of any deteriorating condition and if carried out at appropriate times could identify obstructions in time to limit the damage. Better access and modern equipment would allow remedial work to be undertaken in far shorter time than was the case in 1951.

Contingency planning to identify access routes and possible bridge locations, available equipment and materials including bridges and pre-emergency consultation with other authorities would help enable a rapid response to a serious existing or threatened obstruction.



RECOMMENDATIONS

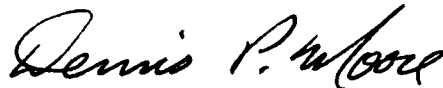
The following work is recommended:

1. Gather geological data and prepare a comprehensive slide hazard assessment, for all slopes between Shedin and Tomlinson Creeks with an emphasis on those slopes along the 3 km length of river upstream from the 1951 Slide. This would involve detailed airphoto interpretation and compilation of data on a base map, followed by geological mapping of selected areas.

2. Develop and implement an ongoing monitoring program following the comprehensive hazard assessment. Based on the present information, only photography and photo comparison of key locations to identify deteriorating conditions once or twice a year is warranted. During the geological mapping, simple, manually-read, surface instrumentation should be installed, if appropriate locations can be identified.

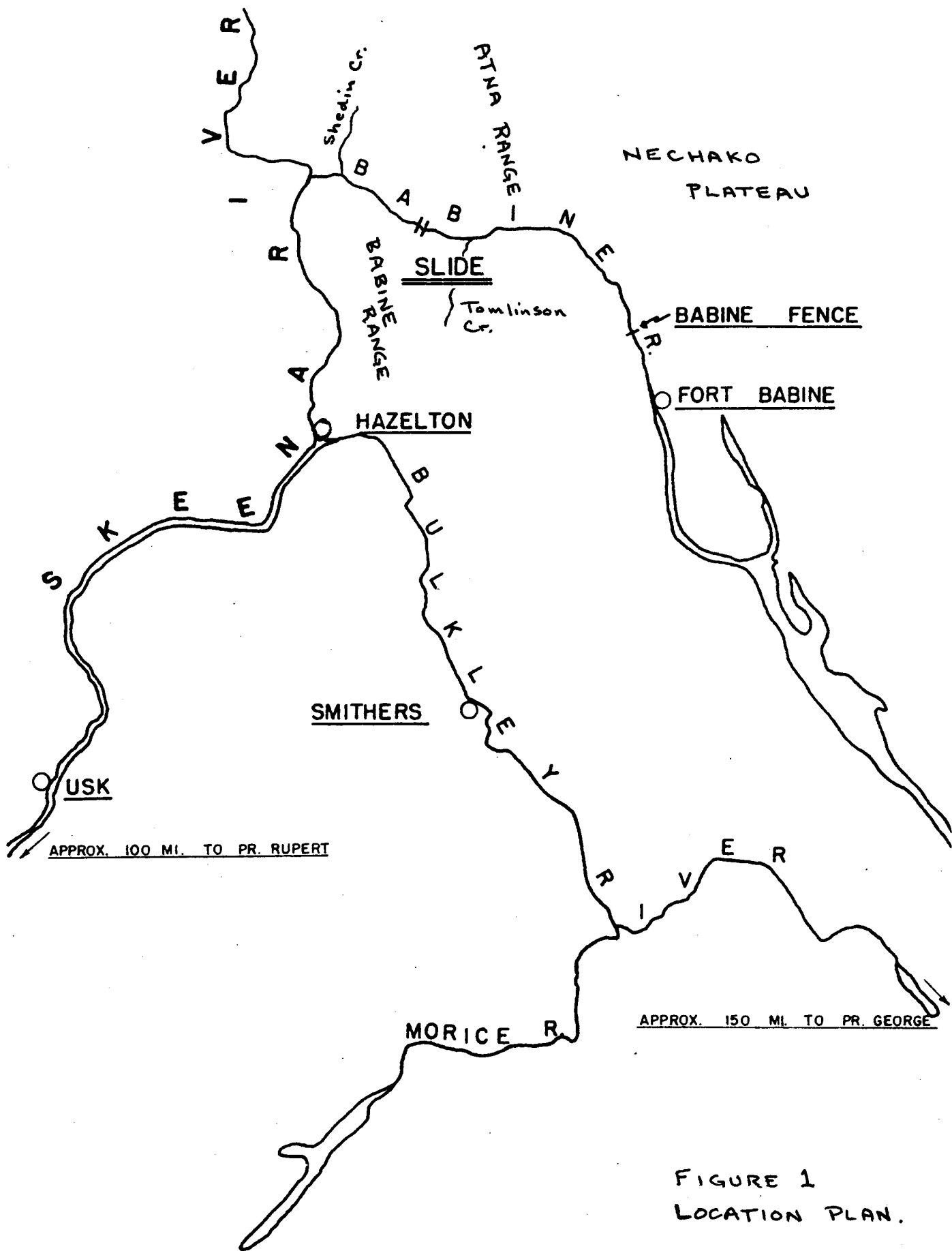
3. Develop a contingency plan for the implementation of remedial measures should they become necessary.

4. Review the results annually to determine whether or not changes to the ongoing program are required.



Dennis P. Moore, P.Eng., P.Geo.

November 25, 1993



DRAWN:
 CHECK:
 APPROVED:

DEPARTMENT OF FISHERIES, CANADA
 MAP SHOWING THE LOCATION OF
 STREAM GAUGING STATIONS

DATE:
 SCALE: 1"=15.78 MI.
 DWS. NO.:



PHOTO 1: Undercutting and slumping of glacial deposits. Slumped material is readily removed by the River.



PHOTO 2: Sliding in silty sediments. Recent slide debris protrudes slightly into the River.



PHOTOS 3 AND 4: Typical bedrock canyon. Steep ravelling slopes in the upper photo occur where the river cuts across the strike of the bedding. In the lower photo, resistant beds protrude into the river and form rapids.



PHOTO 5: A potential wedge failure opposite from the 1951 Slide. Scars of previous failures are apparent adjacent to the wedge.



PHOTO 6: The active slide along the Dipslope area. Crack at top of slide was described as 15 feet wide in 1964.



PHOTO 7: The Dipslope area with active slide and river constriction in centre of photo. Scars of previous slides further upstream.



PHOTO 8: Undercut slopes just downstream from the active slide and scarps from earlier slides.



PHOTO 9: Small slides from the toe of the slope seen in Photo 8. Scarp is 5-10 m high.



PHOTO 10: A recent small rock and soil slide just upstream from Kisgegas could indicate larger instabilities.

APPENDIX A - REFERENCE MATERIALS

AIRPHOTOS:

B.C. Government

BC 4350 No. 222-224 1:15,840

30BC92074 No. 038-042 1:15000, 1992.

BC 7487 No. 115-118 1:15,840, July 27, 1973.

15BC81044 No. 69-70 1:40,000, July 12, 1981.

Aero Surveys Limited for Department of Fisheries

Flight S89, Lines 1 to 31, 1:6000, 8-9 May 1952.

TOPOGRAPHIC MAPS:

Department of Energy, Mines and Resources, 1:50,000, Maps 93
M/7, M/10, M/11, M12.

GEOLOGICAL MAPS AND REPORTS:

Geology of Hazelton (93M) Map Area, by T.A. Richards,
Open File 720, Geological Survey of Canada.

Babine Slide, Description of the Obstruction, by J.B. Dyson,
Inspection of Slide, August 23-31, 1951.

The Babine Rock and Earth Slide,
Thesis by J.B. Dyson, June 30, 1955.

Geological Report on the Babine Slide, by William H. White,
February 1, 1953.

Supplementary Geological Report on the Babine Slide, by Wm. H.
White, March 31, 1953.

Re-examination of Babine Slide, by Wm. H. White, June 2, 1964.
Landslide Damming in the Cordillera of Western Canada, by S.G.
Evans, Landslide Dams: Processes Risks and Mitigation,
ed. R.L. Schuster, ASCE, Geot. Spec. Pub. No.3, 1986.

CONCLUSIONS

The 1951 Rockslide, the numerous slide scars, the active sliding and the adverse geology and topography indicate that there is a substantial risk of future obstruction of the Babine River by rockslides.

The existing geological information is inadequate to carry out a thorough assessment of all slopes along the river, but most of the risk appears to be in the 3 km section upstream from the 1951 Slide. Considerable risk also exists elsewhere along the river.

The cost of stabilization of even a short section of the canyon would be in the order of \$10 million, which is probably not warranted considering that it would only address part of the problem.

Sophisticated monitoring is feasible but requires a serious long term commitment of human and financial resources and would only result in an early warning of an impending slide or recent obstruction of the river. Remediation would still be necessary.

Additional geological data gathering and hazard assessment followed by periodic visual monitoring by a trained observer would be an effective way of detecting deteriorating slope conditions. If carried out at appropriate times it could provide an early indication of imminent sliding or a recent obstruction.

Contingency planning for obstruction removal or for assisting the spawning salmon would help ensure a rapid and appropriate response to a blockage.