Taku River Tlingit Fisheries

# 2019 King Salmon Creek Passage Assessment:

Prepared by:

TRT Fisheries, Atlin BC

August 29th, 2019

# Contents

## 1.0 Introduction:

King Salmon Creek is a left bank tributary of the Taku River that joins the Taku approximately 33.5 kilometers upstream of the Canada U.S. border and 63 kilometers from tidewater. The creek is a third order drainage underlain by sedimentary rocks of the Early Jurassic Laberge Group and the Late Triassic Stuhini Group (Mihalynuk et al, 2017). These rocks are predominantly layered argillite and limestone / wacke, respectively. A major fault, known as the King Salmon Fault bisects the watershed in a northwest direction. The combination of sedimentary rocks and faulting produces a high potential for fault and fracture derived groundwater that, in part, explains the high salmon productivity of King Salmon Lake. Similar to other high producing sockeye lakes in the region (i.e. Kuthai and Tahltan) the underlying limestone enhances the alkalinity of surface water bodies.

The King Salmon Watershed covers an area of 354 square kilometers of mountainous terrain with a climate that is transitional between the Coastal Ranges and the drier, less coastal Taku Plateau. Table 1 is a summary of hydrologic and physiographic features of the watershed;

| Table 1: King Salmon Creek Hydrology and Physiography | |
|---|---|
| **Elevation range (min, mean , max)** | **80-890-2291 (m)** |
| **Mean Annual discharge** | **3.93m $^3$/s** |
| **Coniferous forest coverage** | **260.3 km$^2$, 73.5%** |
| **Barren ground** | **44.4 km$^2$, 12.5%** |
| **Glacier / permanent snowfield coverage** | **4.6 km$^2$, 1.3%** |
| **Herb and mixed shrub forest cover** | **44.1 $^{km2}$, 12.5%** |

*Source: NW Water Tool (http://www.bcwatertool.ca/nwwt/#8/57.559/-128.941)*

The basin has a major headwater tributary to the south-west of King Salmon Lake that is un-named but has Lisadele Lake at the extreme headwater. The Lisadele Lake watershed has a mean annual discharge of 2.378 m$^3$/s that is a major source of flow to King Salmon Creek. This small basin has higher glacial coverage than the King Salmon basin as a whole owing to the large alpine glaciers of Mount Lester Jones. Above the Lisadele / King Salmon confluence King Salmon Creek has a less glacial hydrology and more stable groundwater / wetland and lake storage driven hydrology.

Telemetry and overflight data indicate that there is a migration delay at a debris jam (DJ4-2) on the lower reaches of King Salmon Creek. On April 21$^{st}$ and July 27$^{th}$, 2019 overflights were staged out of Nakina River to visit the site. During the July site visit the jam was accessed by foot to conduct a fish passage assessment. The creek was at low stage, water clarity was good with only slight turbidity. Reconnaissance level measurements were taken for the site including the debris width and depth, gradient and cross sectional widths. The jump height at the one passable spill point was measured as well as the staging depth immediately below the plunge. The last stop was at King Salmon Lake to recon a hydrometric gauging station site.

# 2.0 Results:

## 2.1 Overflight:

Photo 1 is an aerial view of the King Salmon Creek log jam taken on April 21st 2019. The red triangles are minor spill crests blocked with Large Woody Debris and the red arrow is the main spill, the only current passable spill point.

***Photo 1: The debris jam on King Salmon Creek, April 21st, 2019. The triangles mark the location of potential historic spill points, the red arrow is the only currently passable spill point and the red line is a historic by-pass channel.***

The geomorphic feature that forms the LWD jam is a dog-leg right channel alignment with a line of boulders acting as a debris catcher with very high LWD retention. High flows have strained LWD out of the flow and accumulated them across the channel spanning jam. There is a historic by-pass channel at river left (marked by the red line in photo 1) that may have been passable historically but the LWD at the inlet has collapsed and closed those passage options. The jam has keystone boulders that appear very stable under the current flow regime and are likely paleo-flood relicts from the ablation phase of the last glaciation. The channel is alluvial with a lag deposit of large to medium boulders moderately embedded in the cobble gravel matrix of instream sediment. Small sediment wedges are noted just upstream of the main spill point and the by-pass channel (river left) that show there is some weak backwatering at high flow. The small volume of upstream sediment storage indicates that the jam is relatively permeable since the degree of backwatering controls the amount of sediment stored in upstream wedges. Photo 2 (below) is an overview of the same location at summer migration period flows. The migration period stage is only moderately higher than the spring time stage based on a comparison of the photos.

***Photo 2: The King Salmon Creek debris jam as of July 27th, 2019. A comparison with photo 1 shows that the river stage is only moderately higher than the April stage based on a comparison of the two photos.***

Approximately 300 meters downstream of the main jam is a pair of debris jams (DJ4-1 (L&R)) with a fish passable by-pass on river right. The channel at that point bifurcates around a small island and there are small jams in both dis-tributaries. Photos A1 and A2 (in Appendix 2) are spring time views of the downstream jam. The river right distributary appears to have a passable side channel against the right bank so the site was not visited on the ground.

## 2.2 Ground Survey:

The upper jam was visited on foot to conduct a site survey / passage assessment Table 2 is a summary of the measurements taken;

| Field data: King Salmon Creek Passage Assessment | |
|---|---|
| **Approach channel gradient** | 3.0 % (1.7°) |
| **Downstream channel gradient** | 6.0 % (3.5°) |
| **Channel width across the debris jam** | 41 m |
| **Channel width upstream and downstream** | 18 m |
| **Jump height at main spill** | 1.7 m |
| **Staging depth below plunge** | 2.0 m |
| **Water temperature** | 11° C @ 1400hrs |
| **UTM Coordinates** | *V605717.6 E, 6515852 N |

The channel upstream gradient is approximately half of the downstream gradient indicating a long profile break point exists at that point. A long profile was estimated from the Google Earth DEM that also indicates the break point at the jam location. This suggests higher stream power in the downstream channel and potentially a more coarse textured bed matrix. The long profile is included as Appendix 1. The profile shows the position of the log jam in reference to the lake and the other reach breaks to give context.


***Figure 1: Google map of the lower King Salmon River showing the four reach breaks and two debris jam locations. DJ4-2 (bottom right of the map) is the jam location observed to be a migration delay.***

Figure 1 shows the lower reaches of the creek with interpreted reach breaks based on geomorphic characteristics. The debris of interest is in reach 4 (DJ4-2) That section of the creek is relatively steep and confined which results in the tendency to transport bedload out of the reach rather than promoting storage in bars and sediment wedges. There are braided sections both above and below this section with sediment stored in bars and overbank locations.

DJ4-2 is a channel spanning debris jam with a high debris trapping efficiency. Most of the individual pieces of LWD are in an advanced state of decay due to their long residence time. The jam is made up of a number of large key pieces with smaller pieces that have been strained out of the flow filling in the gaps between key pieces. At low flow this results in only one passable gap in the jam. Photo 3 (below) shows the top of jam DJ4-2 and the degree of decay in the key pieces. Key pieces are oriented perpendicular to the direction of flow which tends to optimize debris retention and the recruitment of smaller pieces.

***Photo 3: The view from the top of DJ4-2 showing the high degree of decay in the LWD making up the jam.***

Jump attempt monitoring was conducted for 30 minutes but the location made it difficult to determine the success rate. Fish were successfully navigating the jump but we estimate the success rate at only about 5%. The staging pool was highly aerated and turbulent which tends to reduce jump accuracy. The pool below the plunge was holding fish but it was difficult to estimate how many due to the aeration of the pool. Jump height and staging pool depth were measured with a survey rod. The jump height, at the stage of the day, was 1.65 meters with a staging depth of 2.0 meters. This gives a staging depth / jump height ratio of 1.21 which is low in comparison to published maximum passability estimates that range from 1.25 to 1.5. Although the spill point geometry is generally “U” shaped, which can produce good passage results the staging depth to jump height ratio is less than optimal.

## 3.0 Discussion:

Large woody debris dams grow by trapping debris from the channel and are therefore affected by the rate of recruitment from the surrounding forest. Wood is recruited to the channel in a chronic fashion as individual pieces along the riparian zone fall into the channel. Wood is also recruited in an event based, episodic fashion due to landslides and mass movements from upslope areas where adjacent topography is coupled to the channel. In this case most of the debris pieces in the jam appear to be similar aged so we assume the recruitment process was episodic from a landslide upstream in or near the canyon. These pieces are noted to be missing bark and branches and would classify as debris class 4 and 5 (highly decayed) in a 5 stage decay class system. There was a fire in 1930 (Fire # 83) on a left bank tributary upstream of DJ4-2 that may have contributed debris to the jam although there are also avalanche tracks and historic landslides upstream that could also be LWD sources. A few of the LWD pieces in the jam do appear to be younger (they have bark and branches) and are more likely derived from chronic riparian input. Looking at the watershed as a whole it appears that there are significant areas in the lower reaches and the canyon that were burned in 2015 (see fire # R90046 in the fire history map in Appendix 3) and may begin to generate episodic debris to the channel as the roots decay and soil strength is lost.

As a general rule of thumb LWD jams alone are rarely fish passage obstacles due to the degree of scouring that happens between the individual LWD pieces and the channel bed. In this case however decay of the pieces in the jam has caused the wood pile to collapse toward the bed and tighten up the gaps between the logs which has reduced the passage options to the one spill point. As the pile deforms downward the gaps decrease and the jam recruits progressively smaller pieces and further closes the passage options. Jam DJ4-2 is in an advanced state of decay which suggests that it may fail in the near future. Failure could be catastrophic (large sections of the dam fail) or it could fail gradually. The style of failure is largely determined by the magnitude of the spring freshet with high magnitude events favoring catastrophic failure.

## 4.0 Recommendations:

Given that the jam appears to be a migration delay it may be prudent to take actions that promote the gradual failure of the jam. The instability of the dam may block the last passage option and create a barrier at some point in the future. It may be prudent to clear some of the debris now as it appears that debris from the 2015 fire may begin to recruit LWD in the coming years further expanding the jam. With that in mind we recommend the following;

- Access the site in the early spring prior to freshet and remove some of the LWD to promote an avulsion into the historic by-pass channel on river left of the jam;
- Debris should be removed from the channel onto the bank to ensure that it does not travel down to DJ4-1 and simply move the passage issue there;
- Develop a helipad as close as possible to the site to allow for better access and egress;
- Establish a staff gauge and “C” grade hydrometric station to track flows in the future for passage assessment;
- Establish an upstream cross section and benchmarks on the keystone boulders of the jam to monitor for changes in channel elevation over time so as to understand the degree of down-cutting in the channel, if any, that is occurring.
- A more aggressive debris removal program may be possible but as a first step, given that the obstacle is not a complete barrier, opening up the river right by-pass and following up with monitoring of the upstream cross section would be the risk averse approach;
- The approach would be to remove (by winch) the top of the jam upstream of the by-pass channel without disturbing the sediment wedge at the leading upstream edge. In this way the failure mode may be more gradual as freshet flows will then be allowed to overtop the jam at river left, recruit sediment and infill and smooth the by-pass.

- Monitor the progress of the avulsion from overflights and site visits to determine if the river left by-pass has become a passage option after debris removal. Any changes to DJ4-1 should also be noted.

## 5.0 Risk and Mitigation:

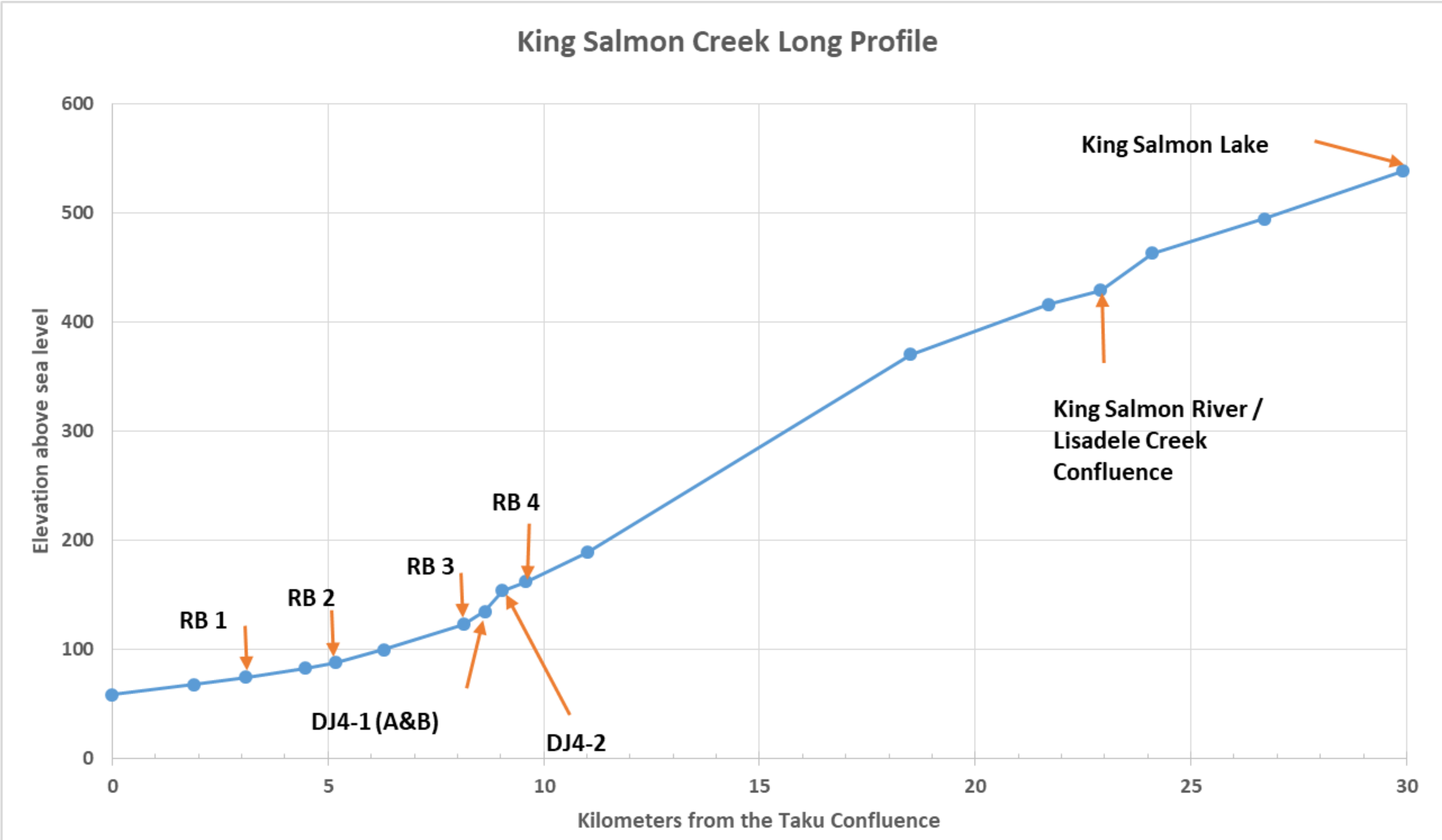
Any instream works carries some degree of risk. In this case the risks are related to channel response to debris removal. Risks that appear relevant include the following;

- **Risk 1**: Channel response, particularly erosional down-cutting. The risk here is that the debris removal will generate an erosional “nick point” that migrates upstream potentially creating other jump height or LWD recruitment issues. Mitigation is achieved by taking a cautious approach with debris removal by only opening the river left by-pass, removing only enough debris to support overtopping during freshet and following up with monitoring. The channel upstream is relatively coarse textured with a lag deposit of stable boulders that should reduce significant and support re-armoring should any down-cutting occur;
- **Risk 2**: Debris from the removal project travels down to DJ4-1 and creates a passage issue there. Mitigation of this risk may be achieved by carefully winching the debris to be removed and leave it above the high water mark and reduce the individual piece size. The channel between DJ4-2 and DJ4-1 is extremely rough with embedded boulders and will tend to grind the decayed debris so any debris that is transported downstream may be ground to a very small size by the time it arrives at DJ4-1 which may mitigate some of the risk here;
- **Risk 3**: Safety is always a risk consideration when working in remote locations. The mitigation here is to develop a helipad near the site, apply work safe protocols and plans, carry a satellite phone, and undertake the work at low flow;
- **Risk 4**: Further deformation of the jam may generate a more complete barrier. The mitigation here is to accelerate the imminent failure of the jam in a controlled manner.
- **Risk 5**: As episodic LWD input from the upslope areas burned in Fire R90046 makes its way to the DJ4-2 site this may aggravate the passage issues. Mitigation is to promote the gradual clearance of the debris currently in the jam to minimize the development of a more complex jam architecture that may be more difficult to mitigate. Starting with the river left debris removal may be advantageous given that it is located at the initial inflection in the dog-leg turn so it will preferentially accrue any newly recruited LWD without the historic collapsing debris. This may result in a more passable channel with the stabilizing influence of inlet

References:

Mihalynuk , MG., Zagorevski, A., English, J.M., Orchard, M.J., Bidgood, A.K., Joyce, N., and Friedman, R.M., 2017. Geology of the Sinwa Creek area, northwest BC. (104K/14). In *Geological Fieldwork 2016, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2017-1, pp 153-178.*

**Appendix 1: King Salmon River Long Profile**



# Appendix 2: Site Photographs:

***Photo A1: The two debris jams (DJ4-1 L&R) located approximately 300 meters downstream of the main obstructing jam.***

*Photo A2: The lower jam (DJ4-1R) river right side distributary showing a passable side channel.*

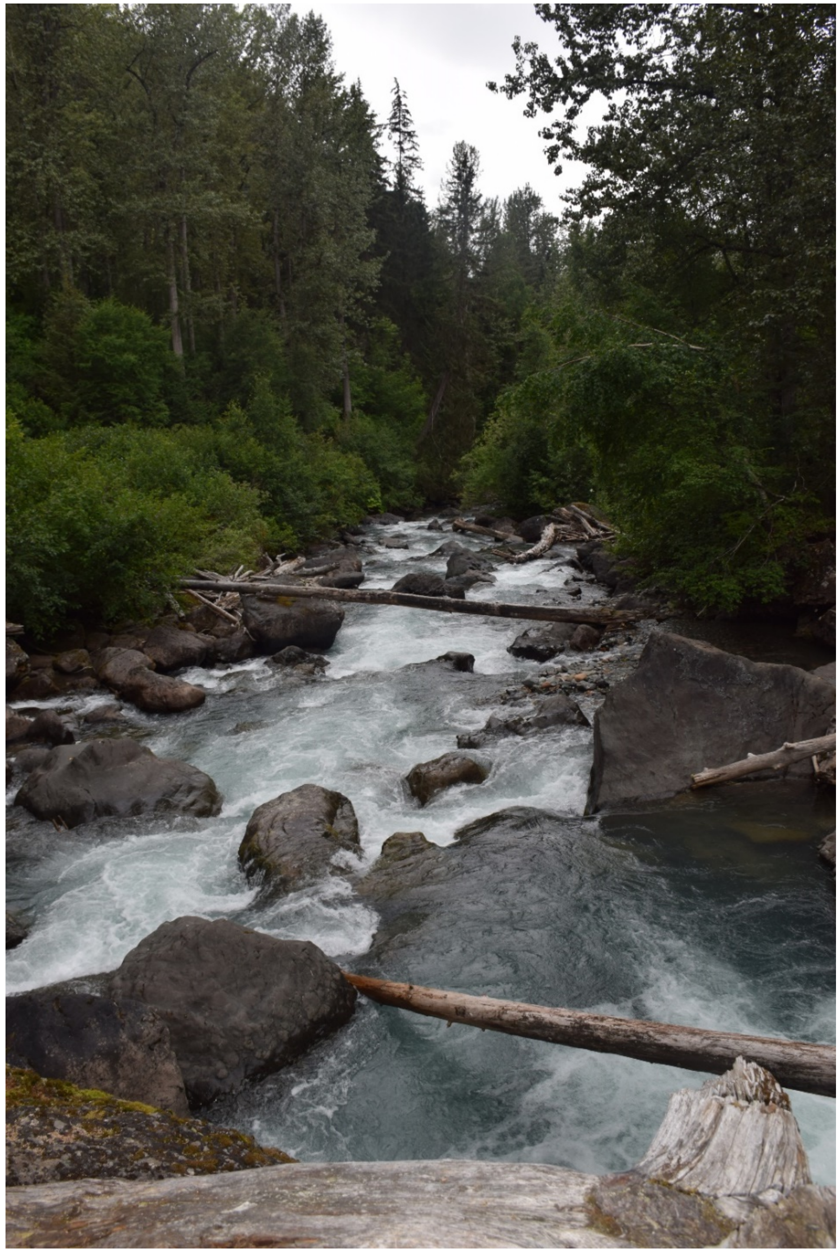


*Photo A 3: Downstream view from the top of the debris jam.*

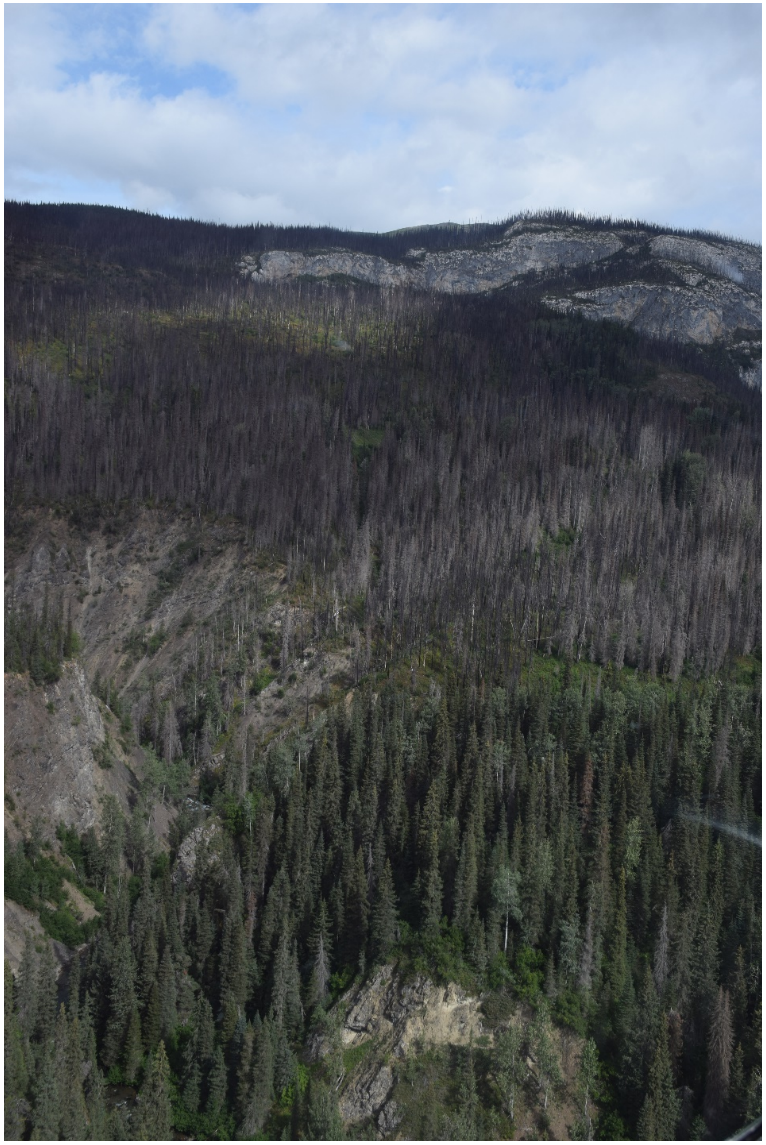


***Photo A4: A view of burned over area (Fire # R90046) in the mid King Salmon Creek canyon with side slopes coupled to the channel. This is an example of where future debris recruitment may occur.***

*Photo A5: An overhead view of DJ4-2 during the migration period (July 27th, 2019).*

*Photo A6: Upstream view from the top of DJ4-2.*

*Photo A7: Close up view of the river left historic by-pass channel and the accumulated debris proposed for removal.*

*Photo A8: Downstream view toward DJ4-2. The proposed debris removal is at the left.*

*Photo A9: Overhead view of DJ4-2 during the spring site visit (April, 27, 2019).*

# Appendix 3: King Salmon Watershed Fire History

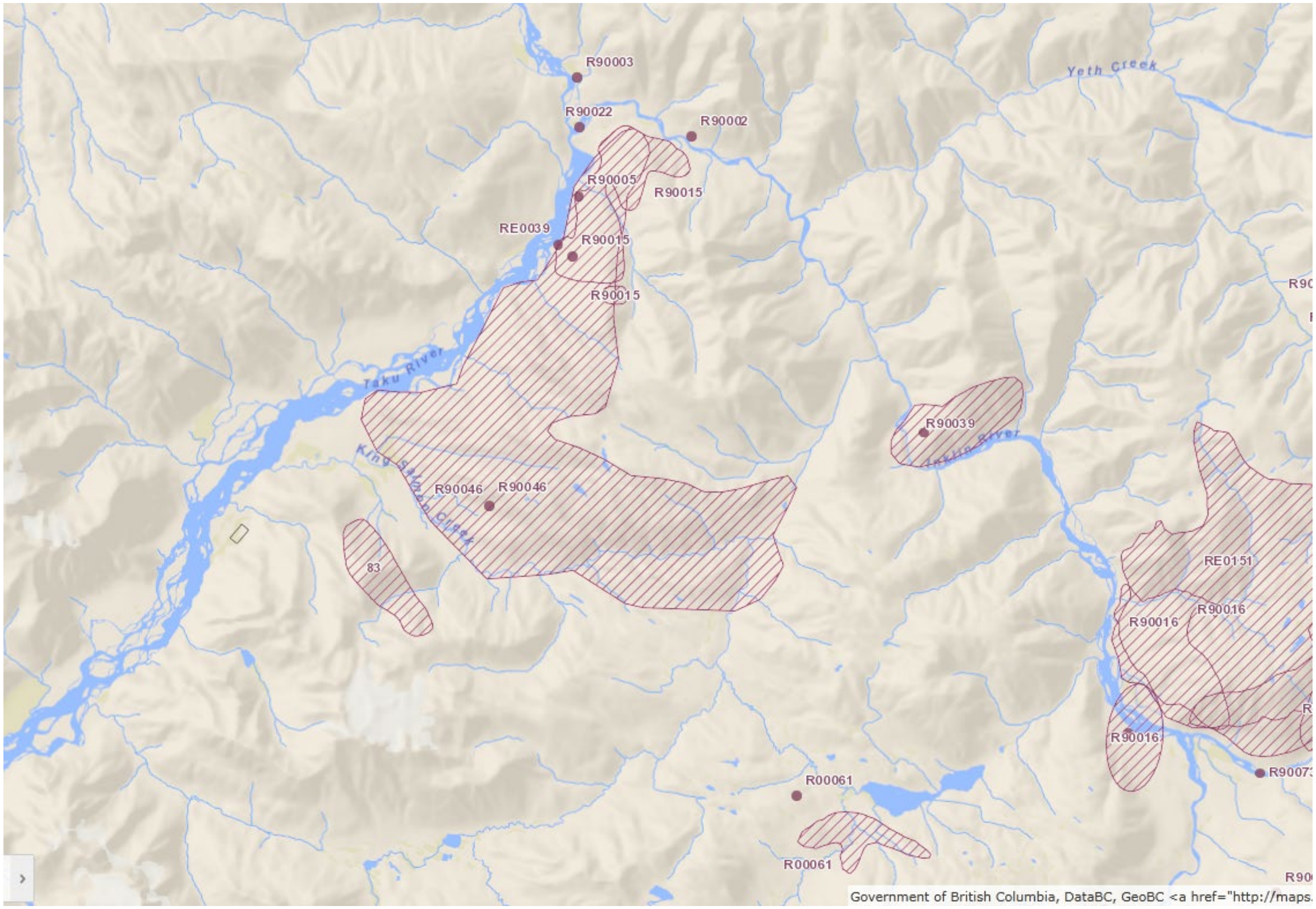



***Figure A1: A fire history map for the King Salmon watershed. Fire number dates as follows; 2015-R90046, 1992-R90015, 1951-R00061 (Southwest of King Salmon Lake), 1930-83.***