AECOM Environment

Prepared for:
Yukon Energy
Whitehorse, Canada

Prepared by:
AECOM
Seattle, WA
60237818
December 6, 2012

Run-up Analysis – Tagish Lake Locations

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1.0 Introduction

The Yukon Energy Cooperation is proposing to increase the full supply level of Marsh Lake to store additional water for winter power production at the Whitehorse Rapids Generating Station. Tagish Lake and Marsh Lake are connected by the Tagish River, and the increase in lake levels of Marsh Lake will also increase the fall levels of Tagish Lake. The main purpose of this analysis is to report on estimates of significant run-up elevation due to wind waves at four sites that were identified as potential erosion-prone areas along the Tagish Lake shoreline. The calculations were performed for October and November, as these months experience increasingly stormier conditions while the lake level is still relatively high, thus posing more risk to the shoreline. Four locations on the northern end of Tagish Lake were investigated. Figures 1 through 4 indicate the location of the four sites and also show views of the beach and bank at each location where transects were surveyed for the run-up analysis presented here.

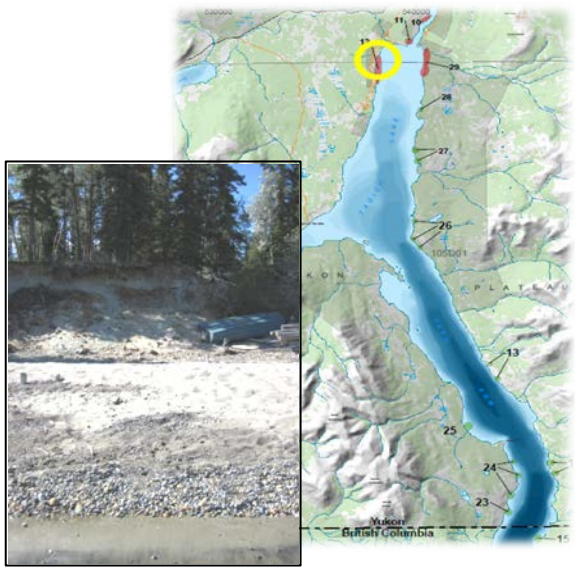

Figure 1 Tagish/Taku Subdivision-North

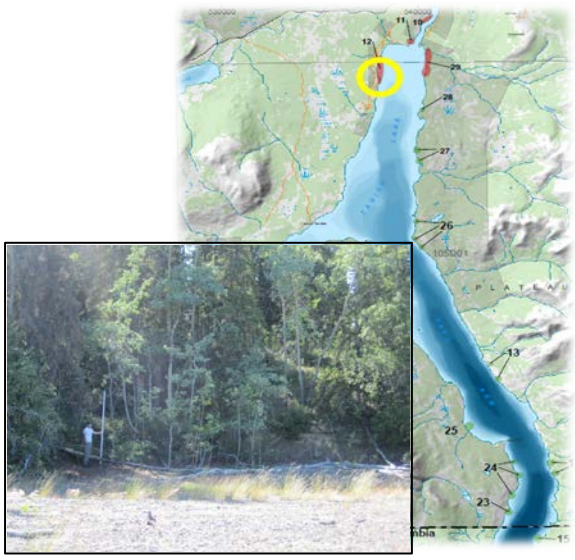

Figure 2 Tagish/Taku Subdivision-South

Figure 3 California Beach

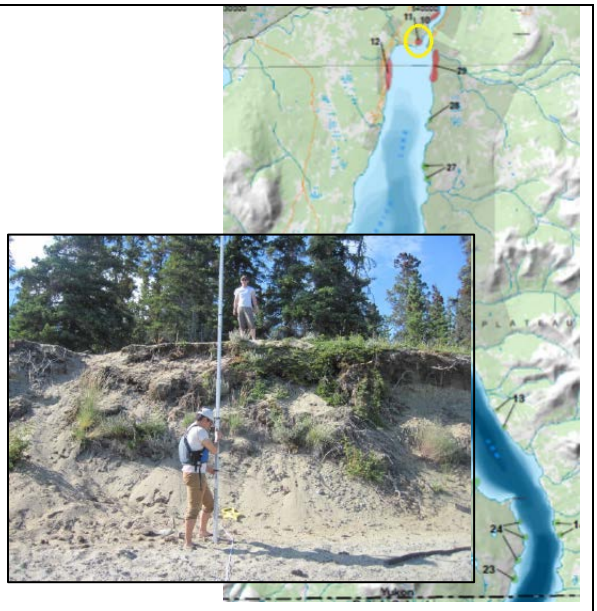

Figure 4 Tagish River Outlet

2.0 Methodology

Run-up elevations for the Tagish Lake shoreline were calculated using the procedures described in the Shore Protection Manual Volume 1 and Coastal Engineering Manual EM 1110-2-1100 Part II Chapter 4 (USACE 1984, 2006). From Whitehorse airport wind data, extreme return wind speeds were calculated based on a generalized extreme value approach. The extreme wind speeds were calculated for return periods of 2, 5, 10, and 50 years. In this report, results are presented for the run-up elevations primarily for the 2-year return period wind speed because any change in erosion potential should be indicated by the more frequent events represented by that return period. Data for the 5- and 10-year return periods are also presented for reference.

To calculate the run-up elevation, the deep water wave height and period were calculated. Since the only available data were for wind speed, calculations were performed to forecast the wave characteristics based on the wind stress factor and fetch.

The wind stress factor was calculated using:

$$U_A = 0.71U^{1.23}$$

Equation 1

In Equation 1, U_A is the wind stress factor and U is the wind speed in meters per second. For the fetch-limited situation that is the most likely case for Tagish Lake, the deep water wave height and wave period is given by:

$$H = 5.112 \times 10^{-4} U_A F^{\frac{1}{2}}$$

Equation 2

$$T = 6.238 \times 10^{-2} (U_A F)^{\frac{1}{3}}$$

Equation 3

In Equation 2 and Equation 3, U_A is the wind stress factor in metric units and F is the fetch in metric units. Once the deep water wave period is known, the deep water wave length can be calculated by:

$$L = \frac{gT^2}{2\pi}$$

Equation 4

To calculate the run-up, the surf similarity parameter was employed. The surf similarity parameter is defined as:

$$\xi = tan\beta \left(\frac{H_0}{L_0} \right)$$

Equation 5

In Equation 5, H_0 is the deep water wave height, L_0 is the deep water wave length, and tan β is the beach slope. The significant run-up based on the surf similarity parameter is given by:

$$\frac{R_{1/3}}{H_0} = 1.38\xi^{0.70}$$

Equation 6

In Equation 6, $R_{1/3}$ defines the significant run-up. The significant run-up elevation is used as the representative elevation in this analysis, as the significant run-up elevation represents the average of the highest 33% of the run-up elevations observed at a given site.

3.0 Results and Discussion

3.1 Tagish/Taku Subdivision-North

Figure 5 shows the beach profile at Transect 10 at the Tagish/Taku Subdivision-North site. The toe of the bank is at an elevation of 656.6 m. The pre- and post-project lake levels at this site for October are 656.2 m and 656.6 m, respectively. For October, the significant run-up elevations were calculated as 657.1 m and 657.5 m for pre- and post-project conditions, respectively. Pre- and post-project significant run-up elevations for October are 0.5 m and 0.9 m above the toe of the bank, respectively. Figure 6 shows the graphical representation of the lake levels and significant run-up elevations for October, and the results are summarized in Table 1.

Significant run-up elevations for November were calculated as 657.0 m and 657.4 m for pre- and post-project conditions, respectively. Pre- and post-project run-up elevations for November are 0.4 m and 0.9 m above the toe of the bank, respectively. Lake levels and significant run-up elevations for November are summarized in Table 1, with the graphical representation shown in Figure 7.

Figure 5 Typical Beach Profile at Tagish/Taku Subdivision-North Transect 10

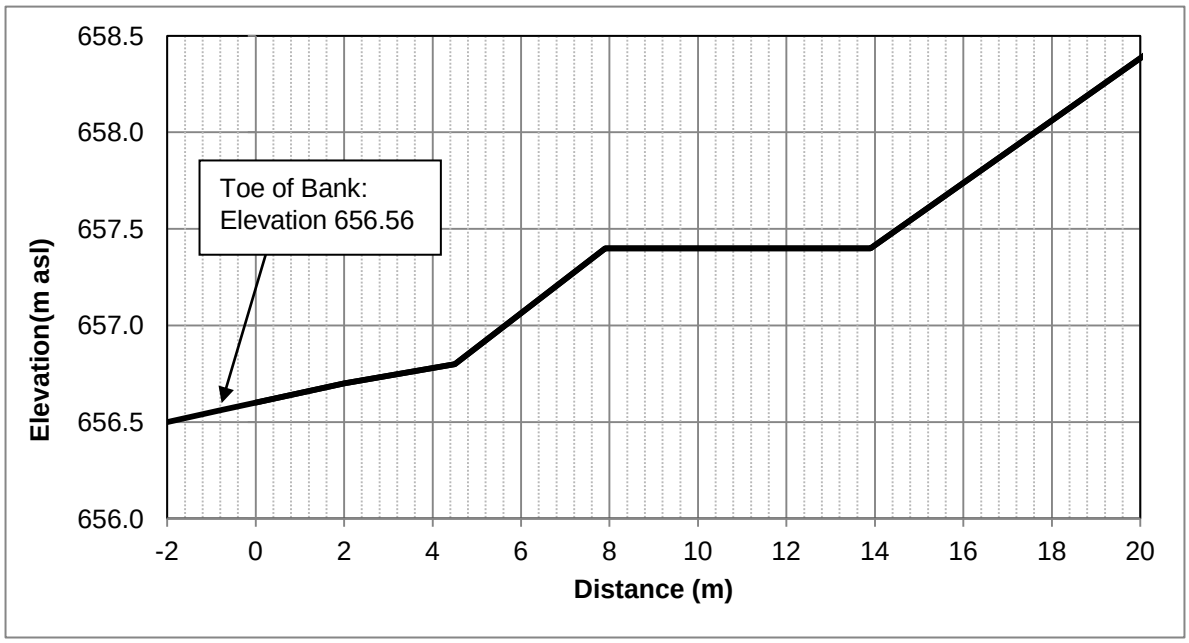

Figure 6 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for October at Tagish/Taku Subdivision-North Transect 10

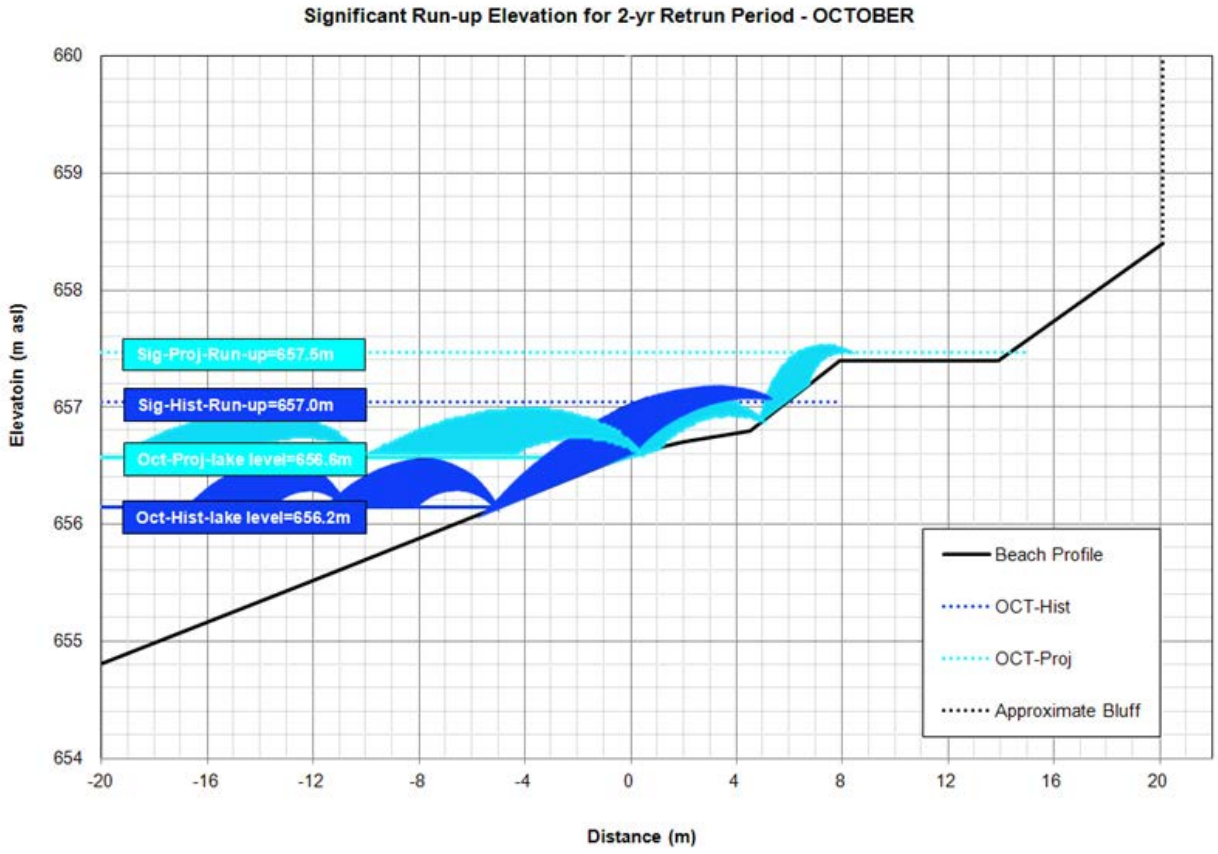

Figure 7 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for November at Tagish/Taku Subdivision-North Transect 10

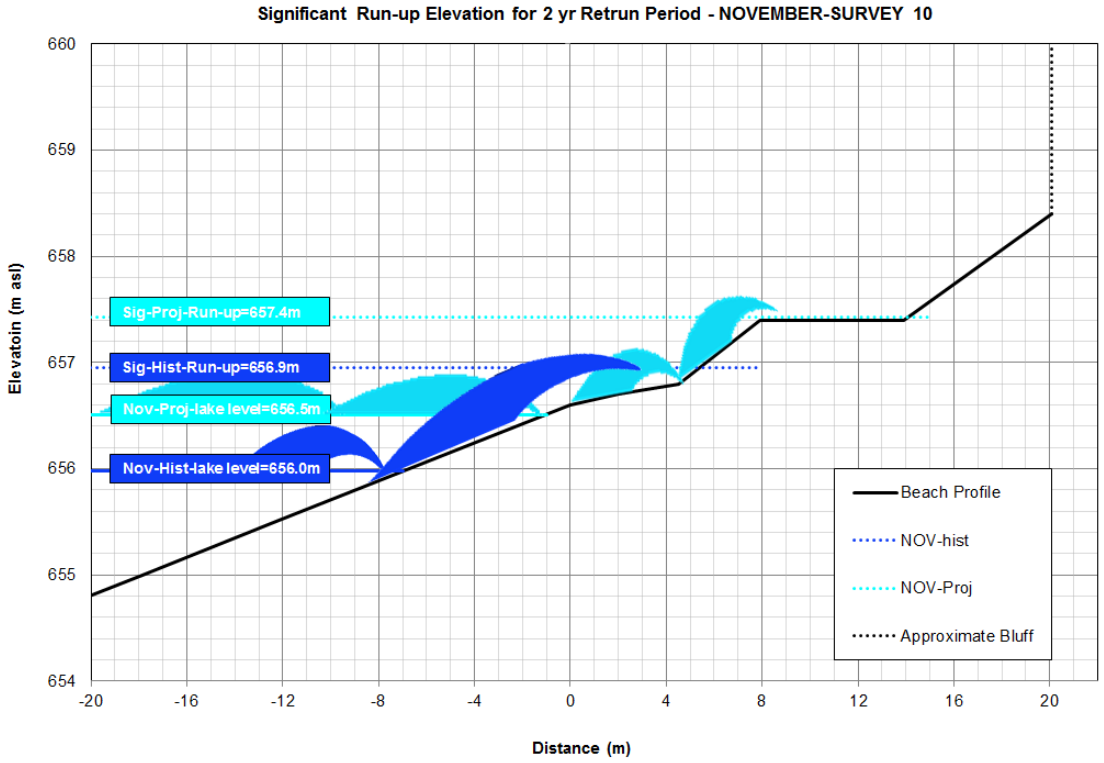

Table 1 Tagish/Taku Subdivision-North Run-up Elevations – Toe of Bank: 656.6 m asl

			Estimated Tagish Lake Level (m asl)	Wave Run-up $R_{1/3}$ (m)	Run-up Elevation based on $R_{1/3}$ (m asl)
2-yr Return Period	**Oct**	hist	656.15	0.90	657.05
		proj	656.56		657.46
	Nov	hist	655.98	0.97	656.95
		proj	656.46		657.43
5-yr Return Period	**Oct**	hist	656.15	1.09	657.24
		proj	656.56		657.65
	Nov	hist	655.98	1.16	657.14
		proj	656.46		657.62
10-yr Return Period	**Oct**	hist	656.15	1.21	657.36
		proj	656.56		657.77
	Nov	hist	655.98	1.28	657.26
		proj	656.46		657.74

Note:
Shading indicates that the lake level or run-up elevation is higher than the toe of the bank.

3.2 Tagish/Taku Subdivision-South

Figure 8 shows a typical beach profile at the shoreline of Tagish/Taku Subdivision-South. The toe of the bank at this transect location is at an elevation of 657.8 m. The pre- and post-project lake levels for October at the site are 656.2 m and 656.6 m, respectively. The significant run-up elevations for pre- and post-project conditions were calculated as 656.6 m and 657.0 m, respectively. Comparing the lake levels and the significant run-up elevation for October to the toe of the bank, it can be seen that the elevations never reach the toe of the bank. Figure 9 shows the graphic representation of the lake levels and significant run-up elevations for October with the results summarized in Table 2.

The pre- and post-project lake levels for November at the Tagish/Taku Subdivision-South transect are 656.0 m and 656.5 m, respectively. The significant run-up elevations for pre- and post-project condition at the site were calculated as 656.4 m and 656.9 m, respectively. Similar to the lake levels and significant run-up elevations observed for October, November results for lake levels and significant run-up elevations never reach the toe of the bank at the Tagish/Taku Subdivision-South. Graphical representations of the results are shown in Figure 10, and the summary is shown in Table 2.

Figure 8 Typical Beach Profile at Tagish/Taku Subdivision-South Transect 11

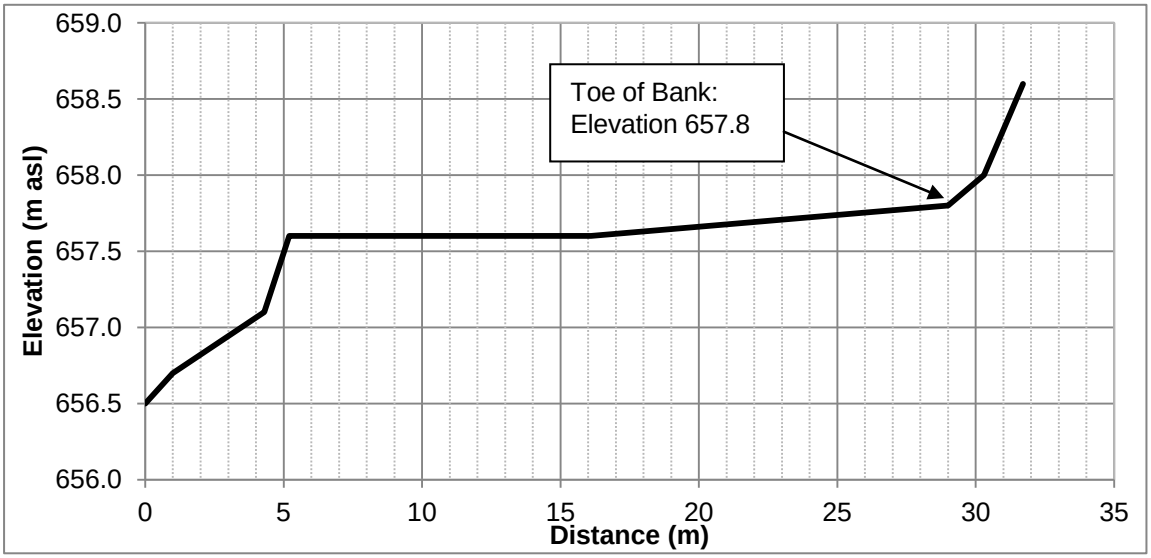

Figure 9 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for October at Tagish/Taku Subdivision-South Transect 11

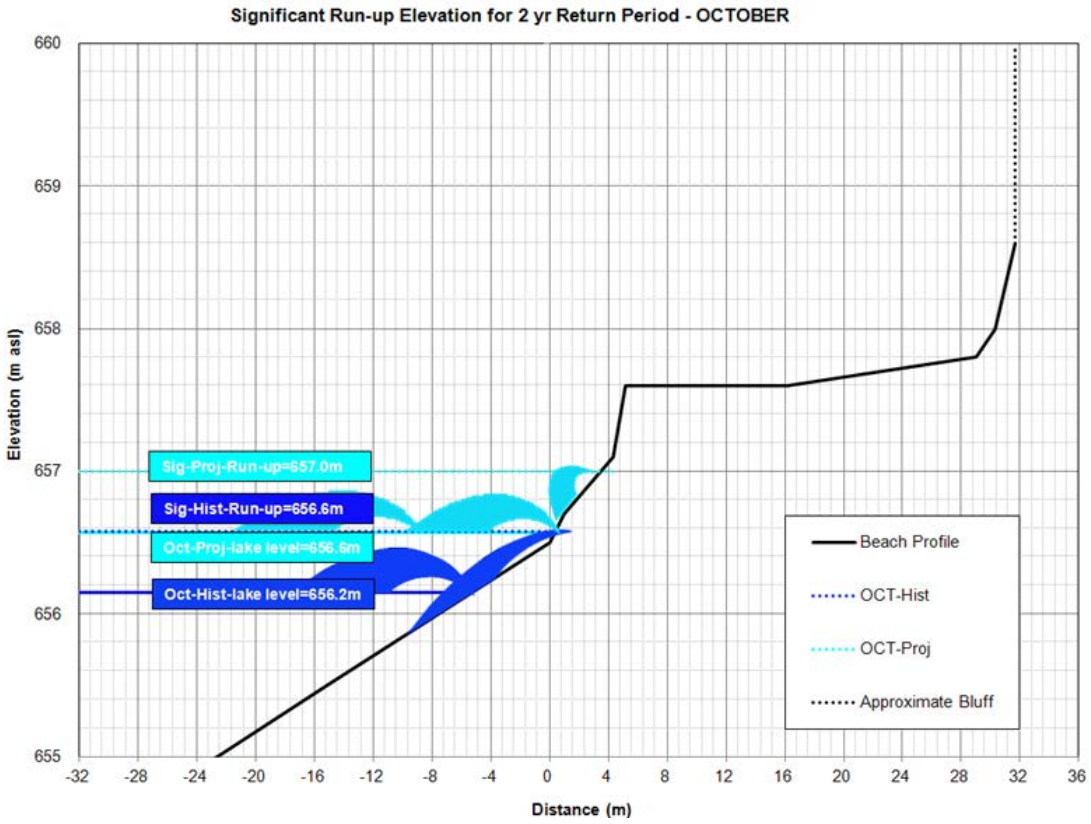

Figure 10 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for November at Tagish/Taku Subdivision-South Transect 11

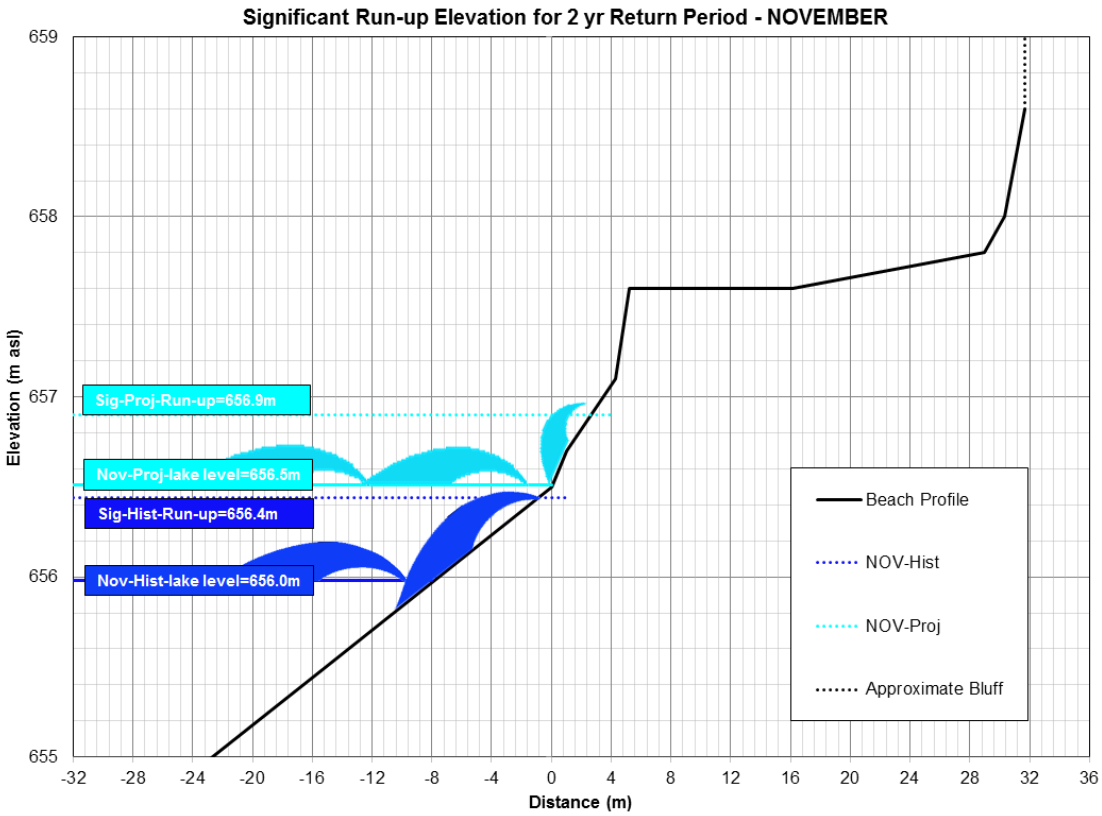

Table 2 Tagish/Taku Subdivision-South Run-up Elevations – Toe of Bank: 657.8 m asl

			Estimated Tagish Lake Level (m asl)	Wave Run-up $R_{1/3}$ (m)	Run-up Elevation based on $R_{1/3}$ (m asl)
2-yr Return Period	Oct	hist	656.15	0.43	656.58
		proj	656.56		656.99
	Nov	hist	655.98	0.46	656.44
		proj	656.46		656.92
5-yr Return Period	Oct	hist	656.15	0.52	656.67
		proj	656.56		657.08
	Nov	hist	655.98	0.55	656.53
		proj	656.46		657.01
10-yr Return Period	Oct	hist	656.15	0.58	656.73
		proj	656.56		657.14
	Nov	hist	655.98	0.61	656.59
		proj	656.46		657.07

Note:
Shading indicates that the lake level or run-up elevation is higher than the toe of the bank.

3.3 California Beach

Figure 11 shows a typical beach profile at the shoreline of California Beach. The toe of the bank at this transect location is at an elevation of 658.6 m. The pre- and post-project lake levels for October at the site are 656.2 m and 656.6 m, respectively. The significant run-up elevations for pre- and post-project conditions were calculated as 656.9 m and 657.3 m, respectively. Comparing the lake levels and the significant run-up elevation for October to the toe of the bank, it can be seen that the elevations do not reach the toe of the bank.

Figure 12 shows the graphic representation of the lake levels and significant run-up elevations for October with the results summarized in Table 3.

The pre- and post-project lake levels for November at California Beach transect are 656.0 m and 656.5 m, respectively. The significant run-up elevations for pre- and post-project condition at the site were calculated as 656.8 m and 657.3 m, respectively. Similar to the lake levels and significant run-up elevations observed for October, November results for lake levels and significant run-up elevations do not reach the toe of the bank at the California Beach site. Graphical representations of the results are shown in Figure 13 and the summary is shown in Table 3.

Figure 11 Typical Beach Profile at California Beach Transect 9

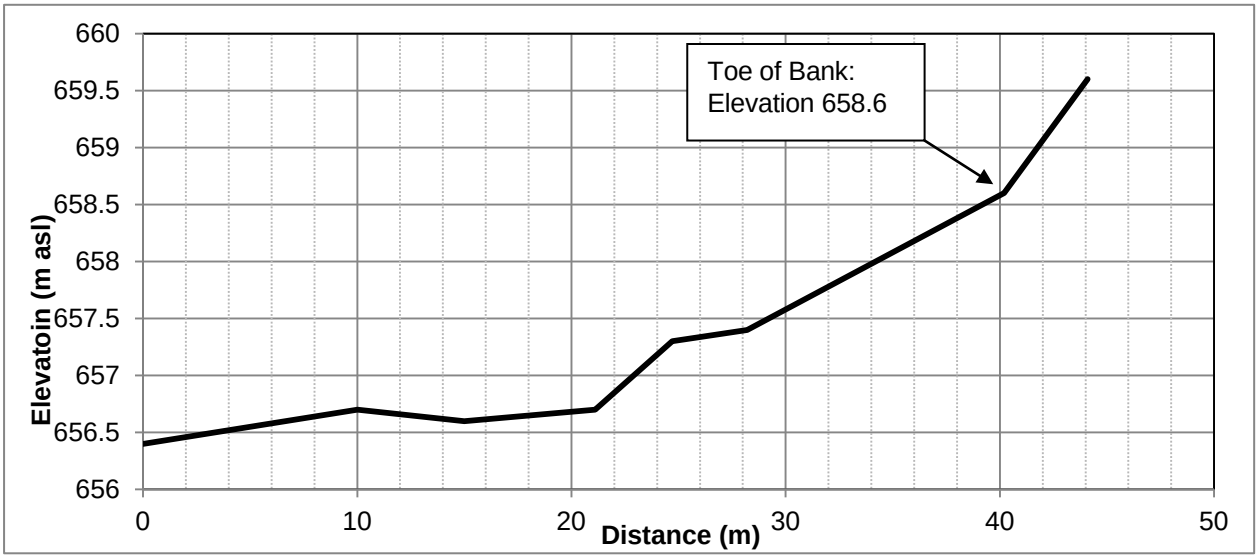

Figure 12 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for October at California Beach Transect 9

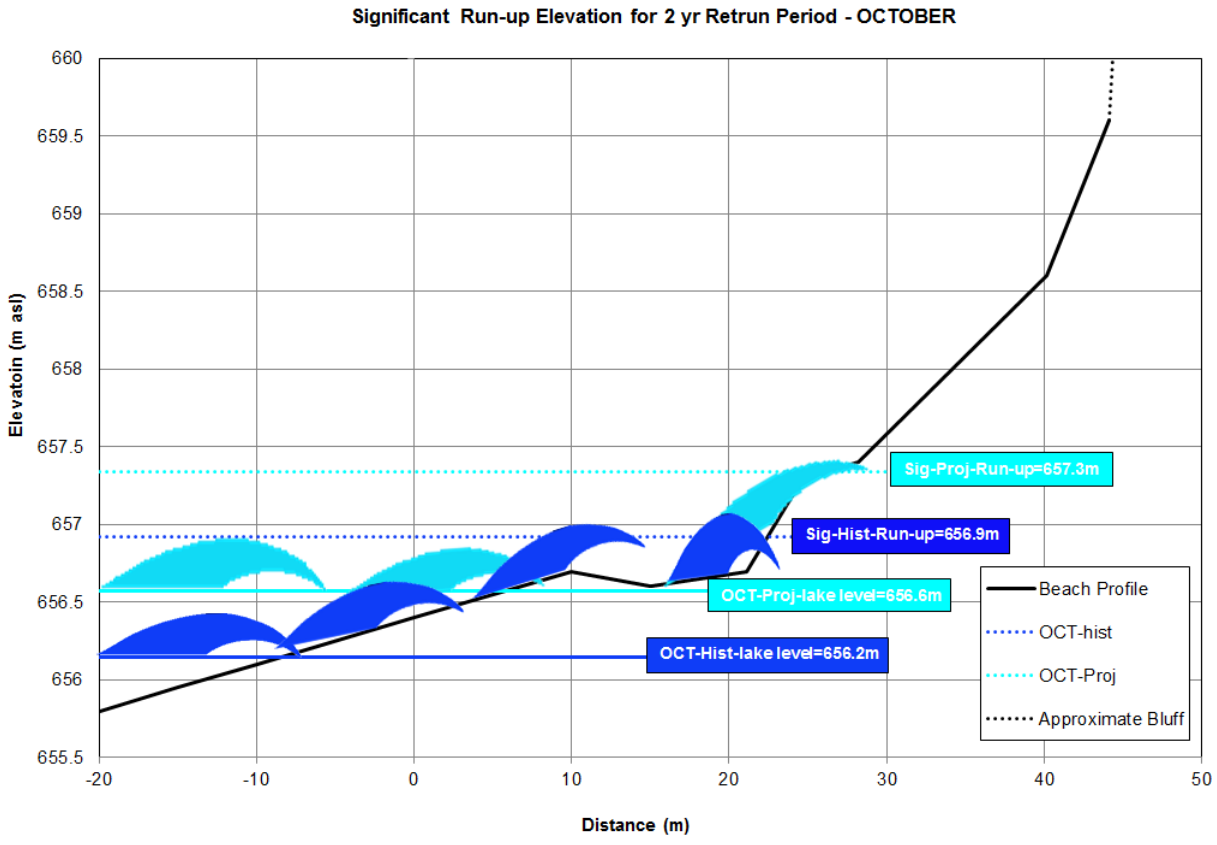

Figure 13 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for November at California Beach Transect 9

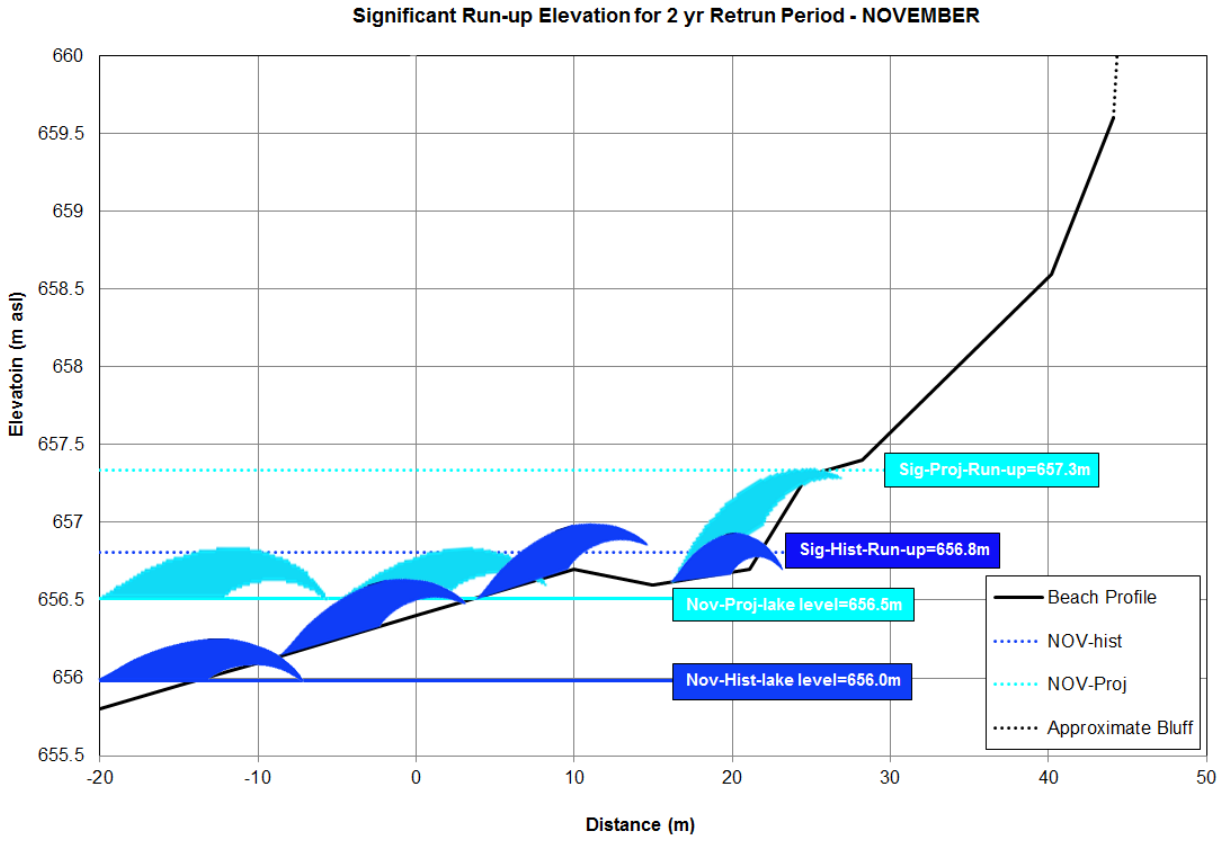

Table 3 California Beach Run-up Elevations – Toe of Bank: 658.6 m asl

			Estimated Tagish Lake Level (m asl)	Wave Run-up $R_{1/3}$ (m)	Run-up Elevation based on $R_{1/3}$ (m asl)
2-yr Return Period	Oct	hist	656.15	0.77	656.92
		proj	656.56		657.33
	Nov	hist	655.98	0.83	656.81
		proj	656.46		657.29
5-yr Return Period	Oct	hist	656.15	0.93	657.08
		proj	656.56		657.49
	Nov	hist	655.98	0.99	656.97
		proj	656.46		657.45
10-yr Return Period	Oct	hist	656.15	1.04	657.19
		proj	656.56		657.60
	Nov	hist	655.98	1.09	657.07
		proj	656.46		657.55

3.4 Tagish River Outlet

Figure 14 shows a typical beach profile at the shoreline of Tagish River Outlet. The toe of the bank at this transect location is at an elevation of 656.7 m. The pre- and post-project lake levels for October at the site are 656.2 m and 656.6 m, respectively. The significant run-up elevations for pre- and post-project conditions were calculated as 657.1 m and 657.5 m, respectively. Pre- and post-project significant run-up elevations for October are 0.4 m and 0.8 m above the toe of the bank, respectively. Figure 15 shows the graphic representation of the lake levels and significant run-up elevations for October with the results summarized in Table 4.

The pre- and post-project lake levels for November at the Tagish River Outlet transect are 656.0 m and 656.5 m, respectively. The significant run-up elevations for pre- and post-project condition at the site were calculated as 657.0 m and 657.5 m, respectively. Pre- and post-project significant run-up elevations for November are 0.3 m and 0.8 m above the toe of the bank, respectively. Graphical representations of the results are shown in Figure 16 and the summary is shown in Table 4.

Figure 14 Typical Beach Profile at Tagish River Outlet Transect 8

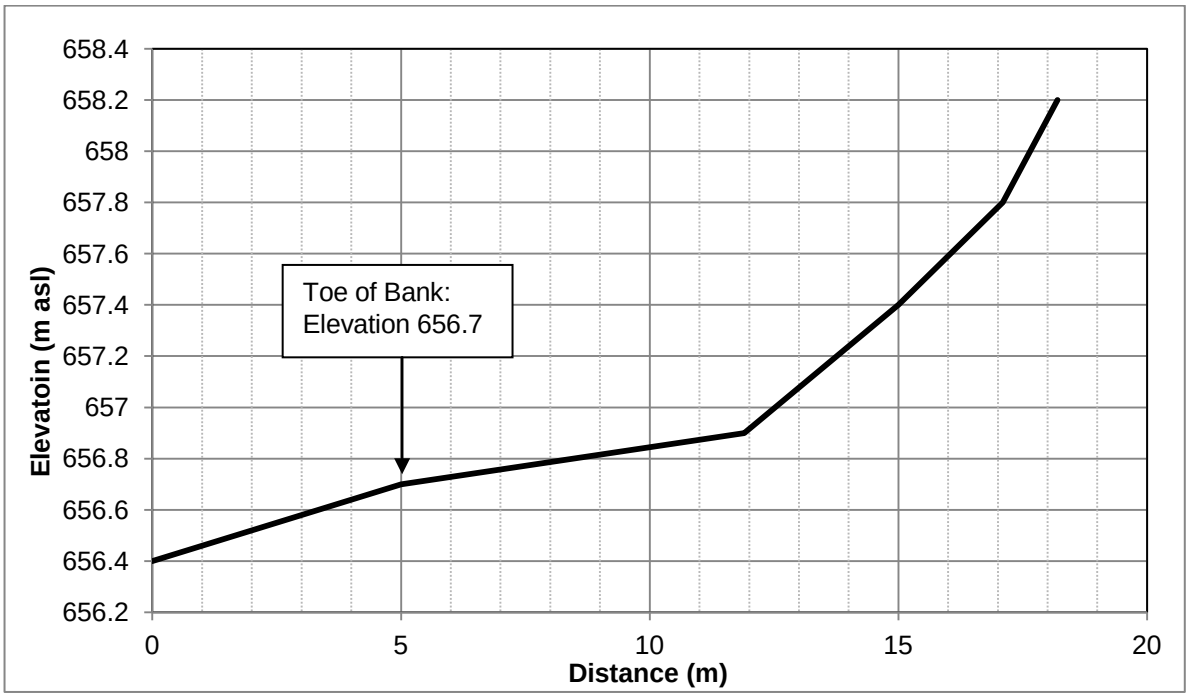

Figure 15 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for October at Tagish River Outlet Transect 8

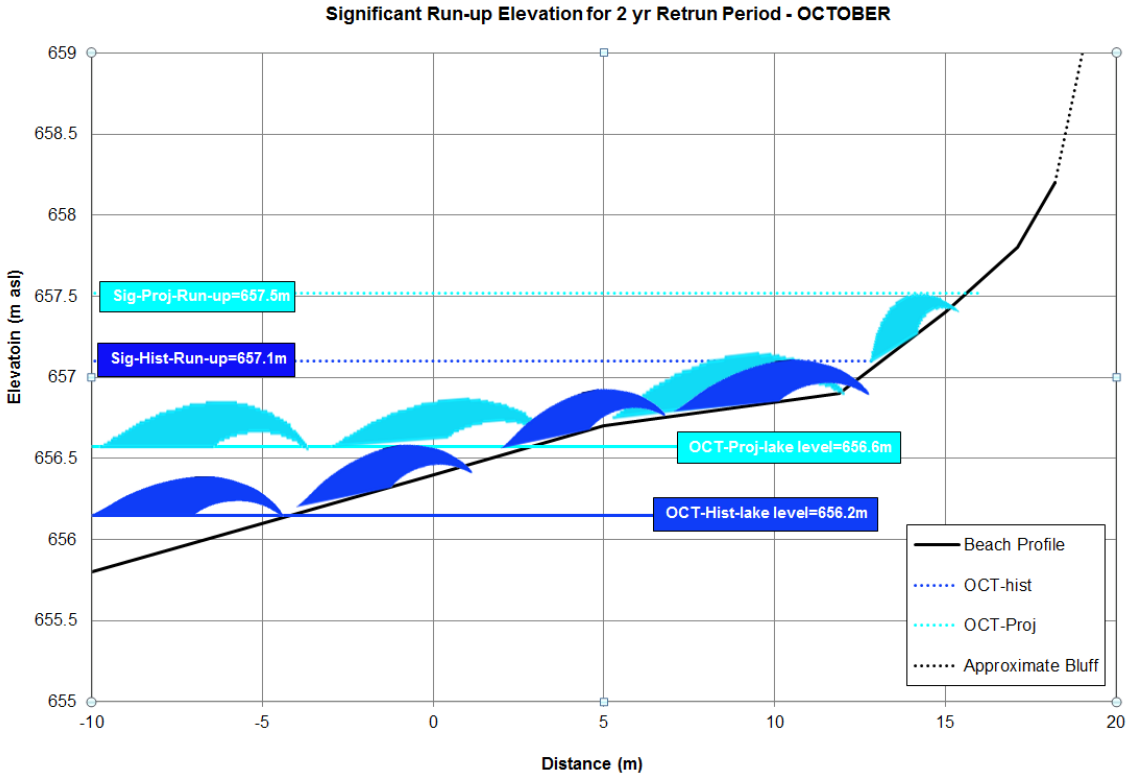

Figure 16 Pre- and Post-Project Lake Levels with the Significant Run-up Elevation for November at Tagish River Outlet Transect 8

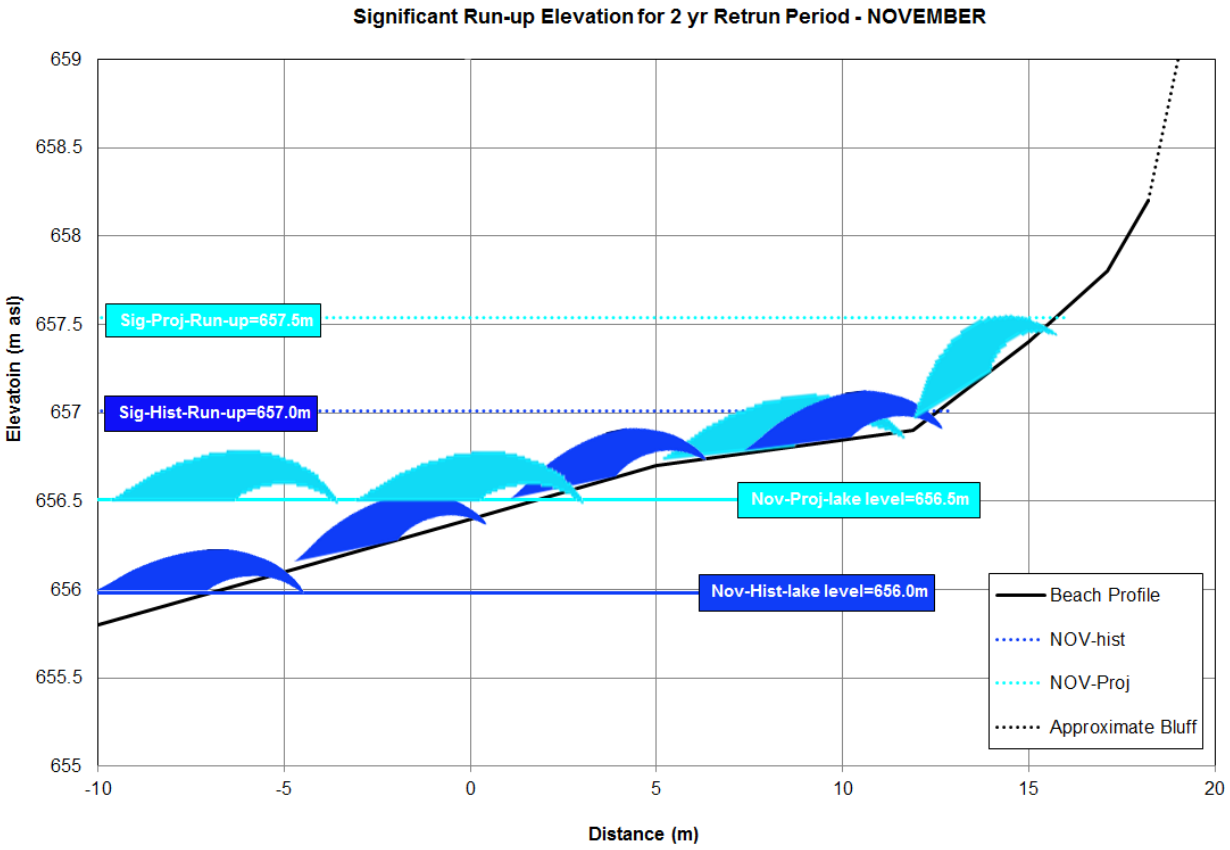

Table 4 Tagish River Outlet Run-up Elevations – Toe of Bank: 656.7 m asl

			Estimated Tagish Lake Level (m asl)	Wave Run-up $R_{1/3}$ (m)	Run-up Elevation based on $R_{1/3}$ (m asl)
2-yr Return Period	Oct	hist	656.15	0.95	657.10
		proj	656.56		657.51
	Nov	hist	655.98	1.03	657.01
		proj	656.46		657.49
5-yr Return Period	Oct	hist	656.15	1.15	657.30
		proj	656.56		657.71
	Nov	hist	655.98	1.23	657.21
		proj	656.46		657.69
10-yr Return Period	Oct	hist	656.15	1.29	657.44
		proj	656.56		657.85
	Nov	hist	655.98	1.36	657.34
		proj	656.46		657.82

Note:
Shading indicates that the lake level or run-up elevation is higher than the toe of the bank.

4.0 Conclusion

The proposal for an increase in the full supply level for hydropower generation could impact the Tagish Lake shoreline. As such, four erosion-prone sites were investigated to gauge the effect that an increase in the fall lake levels could have on toe erosion at the north end of Tagish Lake. The investigation was performed for the months of October and November as these months experience stormier conditions with higher water levels in the lake. Results of this analysis indicate that the 2-year return significant run-up elevations are above the toe of the bank at two of the sites studied: the Tagish/Taku Subdivision-North transect, and the Tagish River Outlet transect. This has the potential to induce erosion. The 2-year significant run-up elevations at the Tagish/Taku Subdivision-South transect do not reach the toe of bank for either pre- or post-project conditions, indicating that the post-project conditions are not likely to induce any more toe erosion than what the site has been experiencing with pre-project conditions. Similarly, for the transect investigated at the California Beach site, the 2-year significant run-up elevation does not reach the toe of the bank.

It should be noted that the transects chosen for this analysis were limited to those surveyed. It is recommended that additional transects be surveyed to better understand the erosion effects along the Tagish Lake shoreline.

5.0 References

Environment Canada. 2010. National Climate Data and Information Archive, http://www.climate.weatheroffice.gc.ca.

USACE (U.S. Army Corps of Engineers).1984. Shore Protection Manual. Volume 1. Coastal Engineering Research Center, Vicksburg, Mississippi.

USACE. 2006. Coastal Engineering Manual. Engineering Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.