AECOM Environment

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November 27, 2012

Marsh Lake Run-up Analysis

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1.0 Introduction

The Yukon Energy Cooperation is proposing to increase full supply level of Marsh Lake in order to store additional water for winter power production at Whitehorse Rapids Generating Station. A numerical wave model was employed to investigate wind waves on Marsh Lake in order to establish pre-project wind- wave conditions and to simulate post-project wind-wave conditions. The details of this study are presented in the technical report titled "*Marsh Lake Fall-Winter Storage Concept: 2010 Geomorphology Study Report, May 2011*". Numerical wave modeling was conducted for the months of October and November as these months experience increasingly stormier conditions while the lake level is still relatively high, thus posing more risk to shorelines. Preliminary results from the numerical model suggest that post-project wind-wave conditions are marginally greater than pre-project conditions. The model does indicate that the extreme southern and northern ends of Marsh Lake may experience relatively higher wind-waves due to the shallows fronting these areas. The wave numerical model was run for return periods of 2,5,10 and 50 years.

The main purpose of this memorandum is to report on estimates of pre- and post-project run-up elevations at several locations around Marsh Lake (Figure 1). The run-up elevations are calculated based on the pre-project and post-project wave height and wave period data from the numerical model results. Most of the discussion in this memorandum will focus on the results for 2-year return period because any significant change in erosion potential will be largely indicated by the more frequent events represented by the 2-year return period. Figure 2 through Figure 5 show the shoreline transects investigated for the run-up estimates.

Figure 1 Locations around Marsh Lake Investigated for Run-up

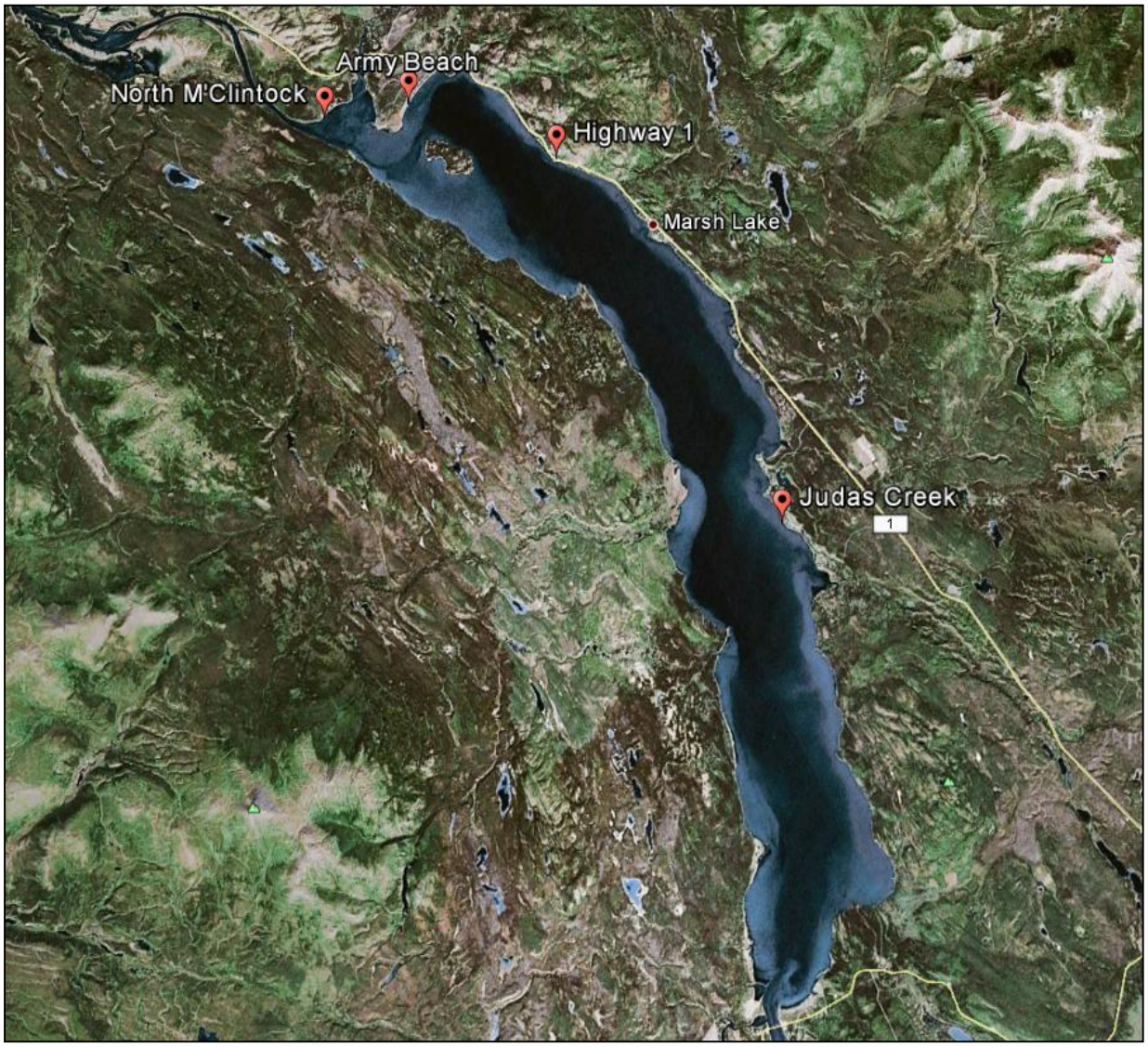

Figure 2 Location of North M'Clintock Shoreline Transect 3

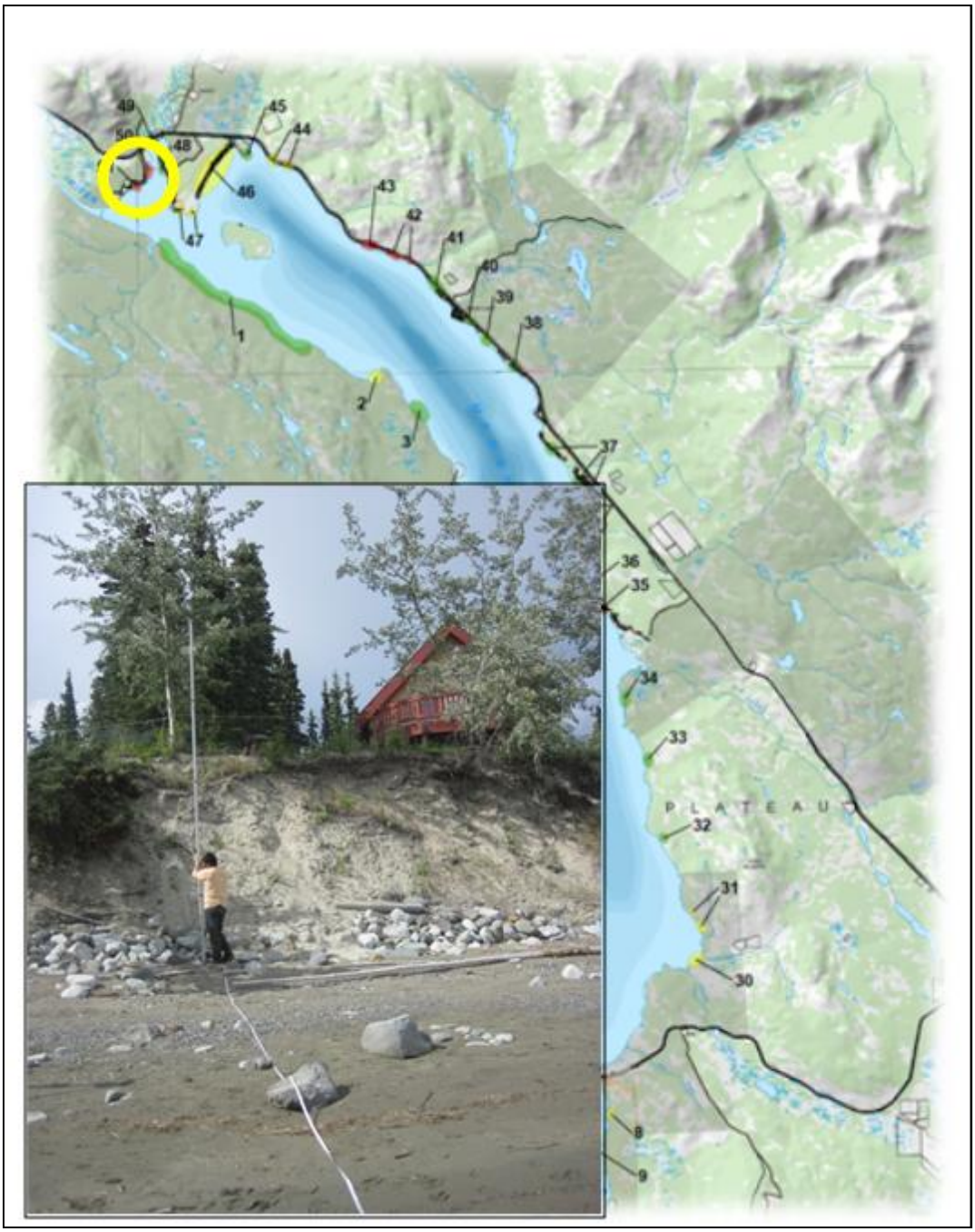

Figure 3 Location of Army Beach Shoreline Transect

Figure 4 Location of Highway 1 Transect

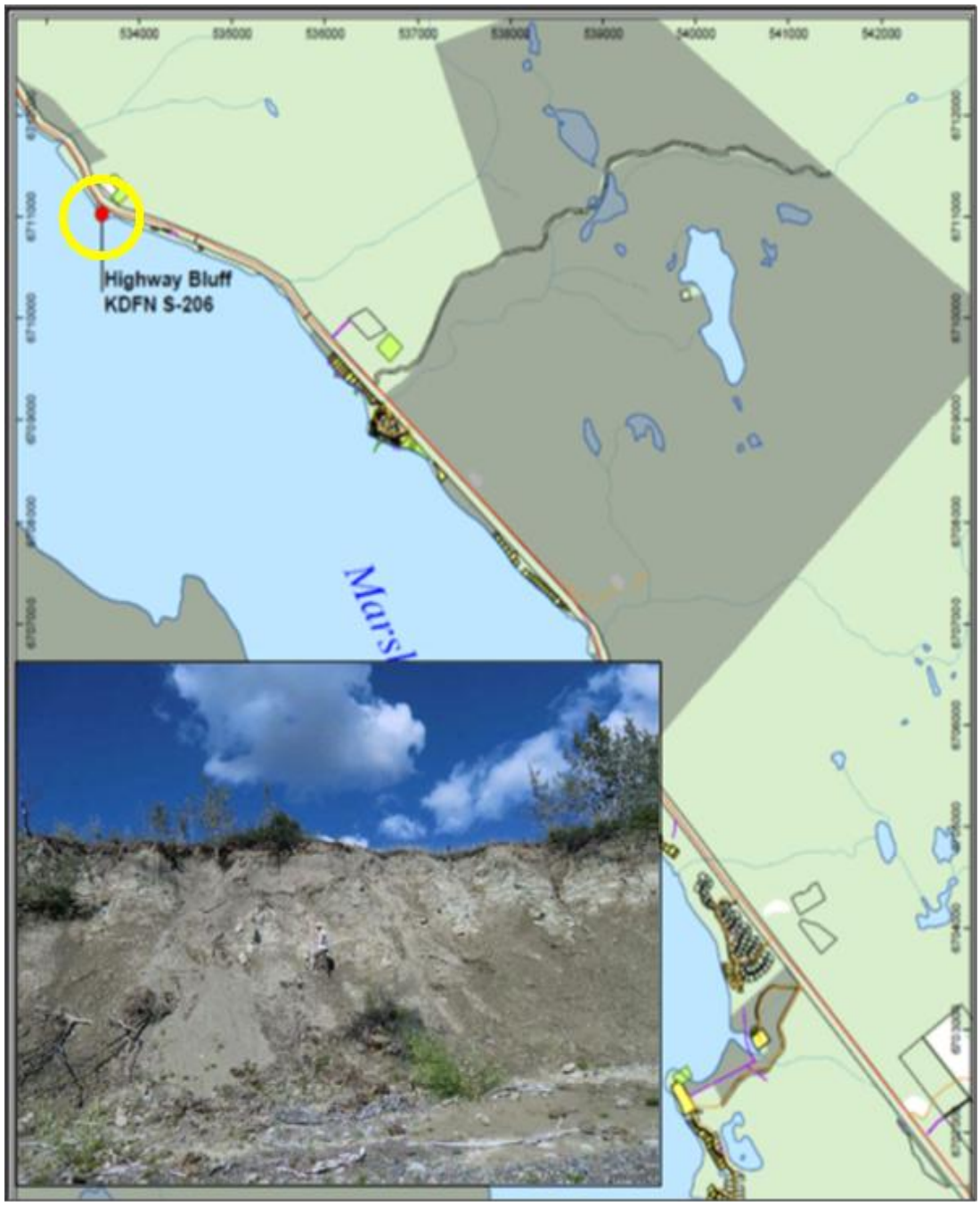

Figure 5 Location of Judas Creek Shoreline Transect 6

2.0 Methodology

The run-up elevations were calculated based on the guidance provided in the *Coastal Engineering Manual*, EM 1110-2-1100, chapters 1, 3, and 4. In order to calculate the run-up the Surf Similarity Parameter was employed. Surf Similarity Parameter is defined as:

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

Equation 1

In Equation 1, H_0 is the deep water wave height, L_0 is the deep water wave length and $tan\ \beta$ 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 2

In Equation 2, $R_{1/3}$ defines the significant run-up. The significant run-up elevation is chosen as the representative elevation for wind wave's run-up because it represents the average of the highest 33% of the run-elevations for a given site.

The locations where the wave heights were reported from the numerical modeling results are intermediate depths based on the water depth to the wave length ratio. Since the calculation of the surf similarity parameter requires the knowledge of the deep water wave height, a back calculation was performed to find the deep water wave height corresponding to the results obtained for wave heights and periods from the numerical wave model.

3.0 Results and Discussion

3.1 North M'Clintock

Figure 6 indicates the location of North M'Clintock and a view of the beach and bluff where the beach transect (Transect 3 shown in Figure 2) was surveyed for the run-up analysis discussed here. The toe of the bank at Transect 3 is located at 656.42 m. The pre- and post-project lake levels for October are 656.14 m and 656.53 m, respectively. Pre-project lake level for October is below the toe of the bank but the post-project lake level is 0.11 m above the toe of the bank. The pre- and post-project run-up elevations for October are 656.39 m and 656.79 m respectively (see Section 2.0 for description of significant run-up). This indicates that the pre-project significant run-up elevations do not reach the toe of the bank, while the post-project significant run-up elevations reach an elevation 0.37 m above the toe of the bank. Figure 7 shows the graphical representation of the results discussed above. The results of the significant run-up for North M'Clintock are summarized in Table 1.

For November, the pre- and post-project lake levels are 656.04 m and 656.45 m respectively. Pre-project lake level does not reach the toe of the bank and the post-project lake level is barely above the toe of the bank with an elevation of 0.03 m above the toe. The pre- and post-project run-up elevations for November are 656.29 m and 656.71 m, respectively. The pre-project significant run-up elevation does not reach the toe of the bank but the post-project significant run-up is 0.29 m above the toe of the bank. A graphical representation of the November pre- and post-significant run-up elevations is shown in Figure 8 and the results are summarized in Table 1.

Figure 6 Typical Beach Profile at North M'Clintock

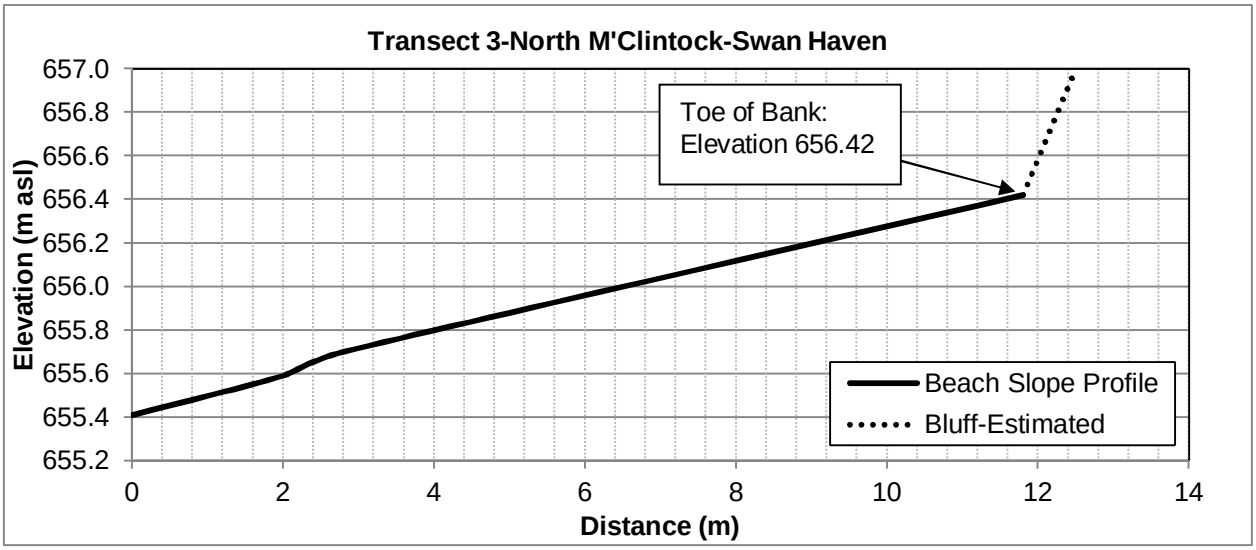

Figure 7 Pre- and Post-Project Lake Levels together with the Significant Run-up Elevation for October at North M'Clintock Transect 3

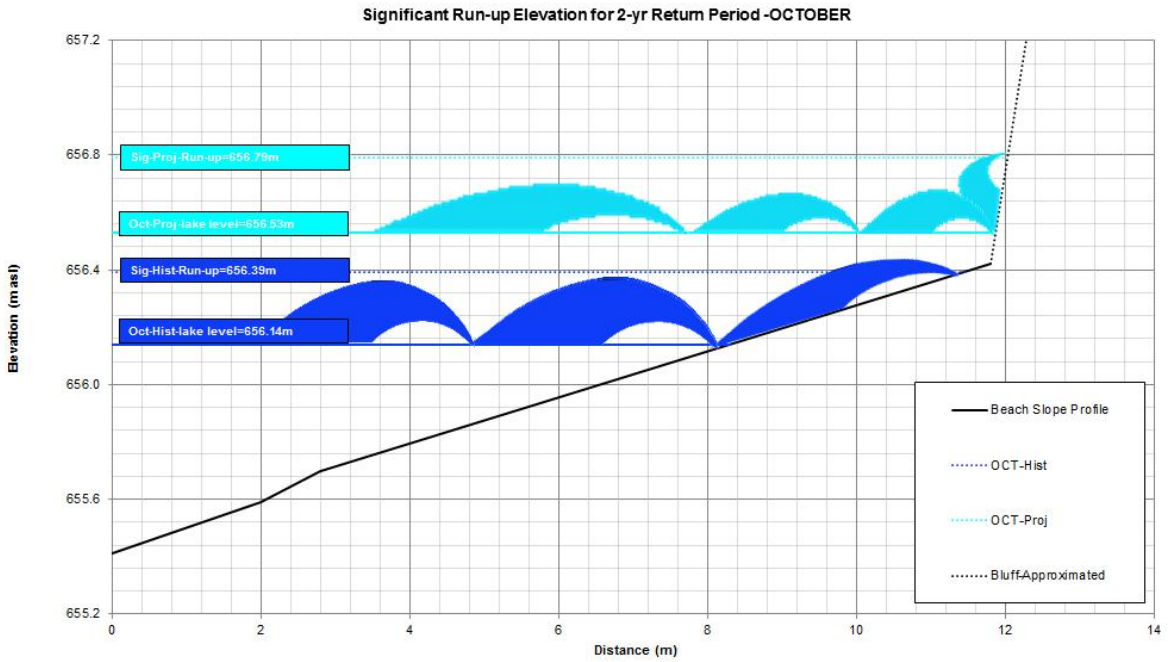

Figure 8 Pre- and Post-Project Lake Levels together with the Significant Run-up Elevation for November at North M'Clintock Transect 3

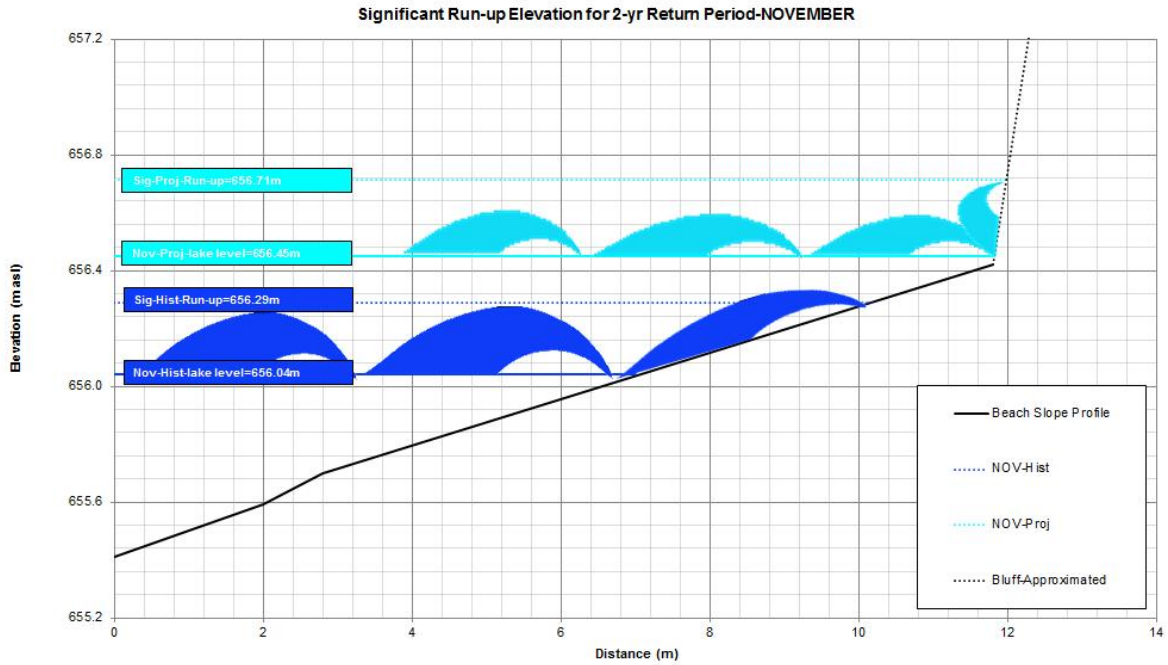

Table 1 North M'Clintock Run-up Elevations for 2, 5, and 10-yr Return Period – Toe of Bank: 656.42

			Monthly Average Lake Levels (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	656.14	0.25	656.39
		proj	656.53	0.26	656.79
	Nov	hist	656.04	0.25	656.29
		proj	656.45	0.26	656.71
5-yr Return Period	**Oct**	hist	656.14	0.28	656.42
		proj	656.53	0.32	656.85
	Nov	hist	656.04	0.29	656.33
		proj	656.45	0.35	656.80
10-yr Return Period	**Oct**	hist	656.14	0.32	656.46
		proj	656.53	0.30	656.83
	Nov	hist	656.04	0.31	656.35
		proj	656.45	0.33	656.78

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

3.2 Army Beach

Figure 9 indicates the location of Army Beach and a view of the beach and bluff where the beach transect (shown in Figure 3) was surveyed for the run-up analysis discussed here (Note that Figure 9, Figure 10 and Figure 11 have significant vertical exaggeration). The toe of the riprap structure at the transect shown in Figure 3 is located at elevation 656.83 m. For October, pre- and post-project lake levels at Army beach are 656.14 m and 656.53 m, respectively. The pre- and post-project lake levels reported for October at the transect location at Army Beach do not reach the toe of the riprap structure. Pre- and post-project significant run-up elevations for October at Army Beach are 656.45 m and 656.85 m, respectively. The pre-project significant run-up elevation does not reach the toe of the riprap structure but the post-project significant run-up elevation is 0.02 m above the toe of the riprap structure. Figure 10 shows the graphical representation of the results discussed above. The results of the significant run-up for Army Beach are summarized in Table 2.

Pre- and post-project significant run-up levels for November are 656.35 m and 656.77 m, respectively. Comparing the significant run-up elevations to the toe elevation of the riprap structure at the Army Beach transect, it can be seen that the significant run-up elevations do not reach the toe of the riprap structure. However, the post-project significant run-up elevation is close to the toe elevation of the riprap structure being only 0.06 m below the toe. Graphical representation of the November pre- and post-significant run-up elevations are shown in Figure 11 and the results are summarized in Table 2.

Figure 9 Typical Beach Profile at Army Beach

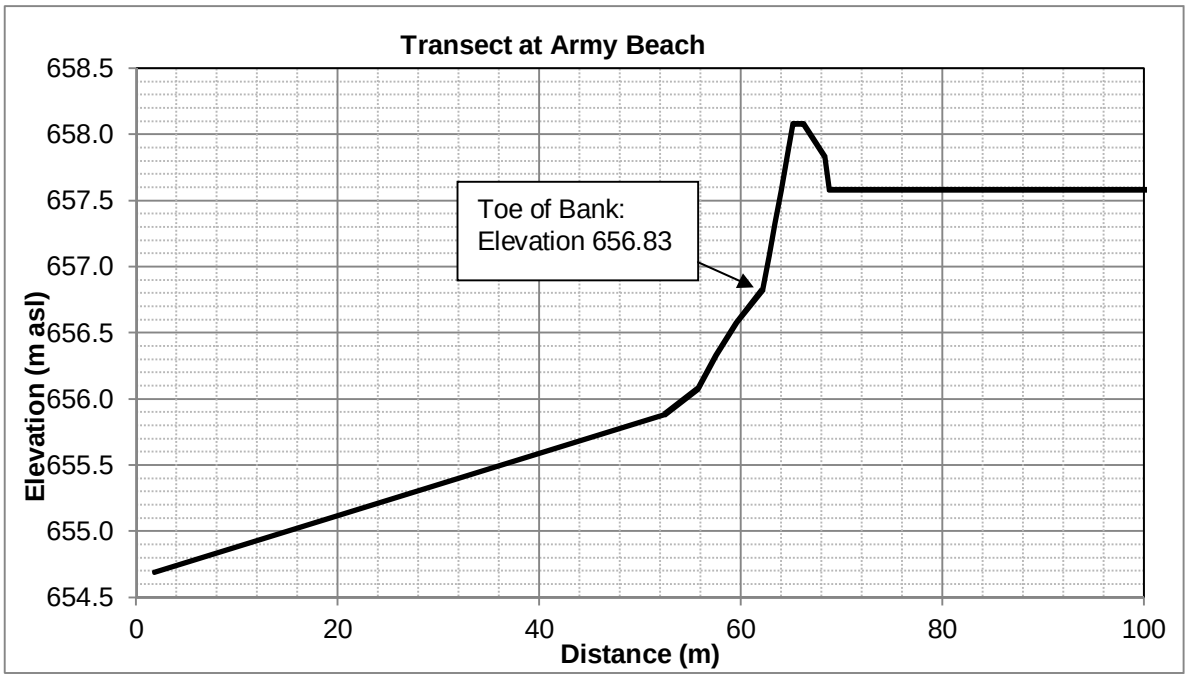

Figure 10 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for October at Army Beach Transect

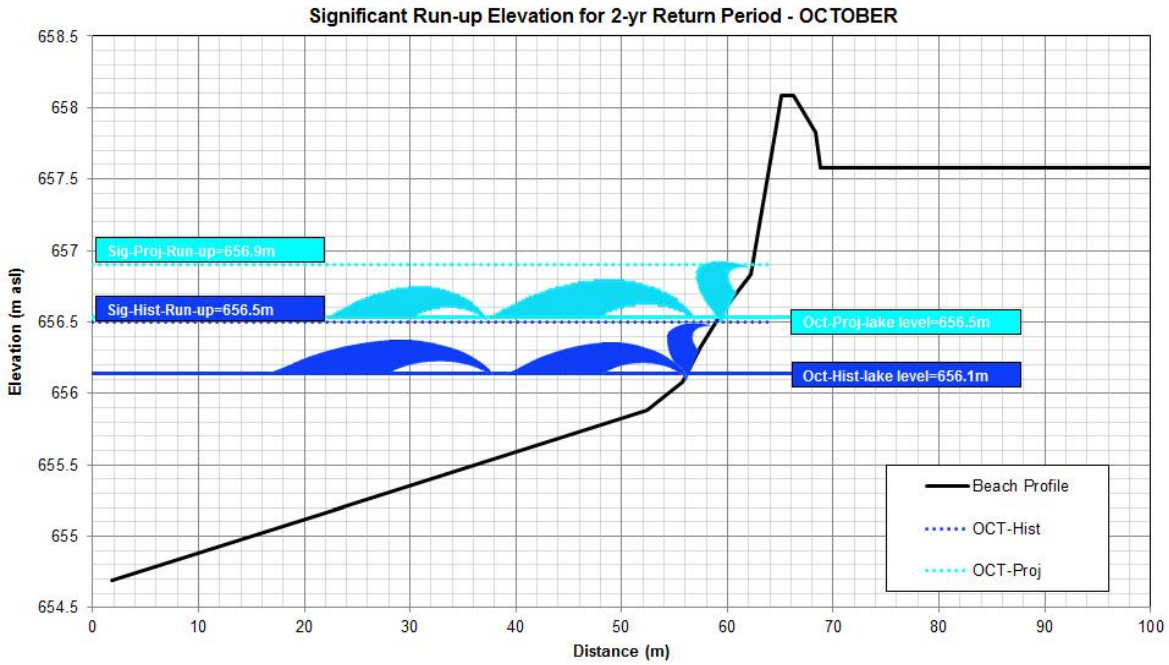

Figure 11 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for November at Army Beach Transect

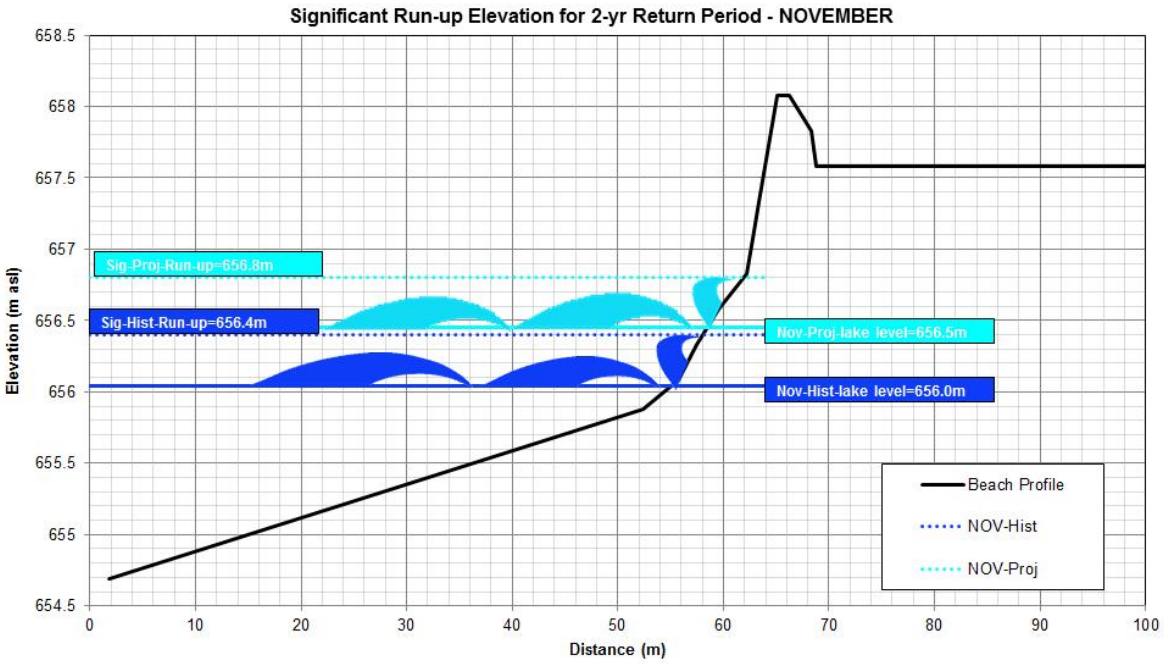

Table 2 Army Beach Run-up Elevations for 2, 5, and 10-yr Return Period – Toe of Bank: 656.83

			Monthly Average Lake Levels (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	656.14	0.31	656.45
		proj	656.53	0.32	656.85
	Nov	hist	656.04	0.31	656.35
		proj	656.45	0.32	656.77
5-yr Return Period	**Oct**	hist	656.14	0.39	656.53
		proj	656.53	0.40	656.93
	Nov	hist	656.04	0.40	656.44
		proj	656.45	0.41	656.86
10-yr Return Period	**Oct**	hist	656.14	0.43	656.57
		proj	656.53	0.43	656.96
	Nov	hist	656.04	0.43	656.47
		proj	656.45	0.43	665.88

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

3.3 Alaska Highway Bluff

Figure 12 indicates the location of the Alaska Highway transect and a view of the beach and bluff where the beach transect (transect shown in Figure 4) was surveyed for the run-up analysis discussed here. The toe of the bluff for the Alaska Highway transect is at 656.68 m. The pre- and post-project lake levels for October are 656.14 m and 656.53 m, respectively. These lake levels are below the toe of the bluff. The pre-project run-up elevation is 656.71 m, indicating that the significant run-up is 0.03 m above the toe of the bluff. The post-project significant run-up elevation is 657.10 m, which is 0.42 m above the toe of the bluff at Alaska Highway. Figure 13 shows the graphical representation of the significant run-up elevations and the lake levels for October. These results are summarized Table 3.

The pre- and post-project lake levels for November at the Alaska Highway transect are 656.04 m and 656.45 m respectively. These lake levels do not reach the toe of the bluff at Alaska Highway. The pre-project significant run-up elevation is 656.64 m and the post project run-up elevation is 657.06 m. The pre-project run-up elevation is 0.04 m below the toe of the bluff while the post-project run-up elevation is 0.38 m above the toe of the bluff. Graphical representations of the significant run-up elevations and lake levels for November are shown in Figure 14 with the results summarized in Table 3.

Figure 12 Typical Beach Profile at transect Alaska Highway Bluff

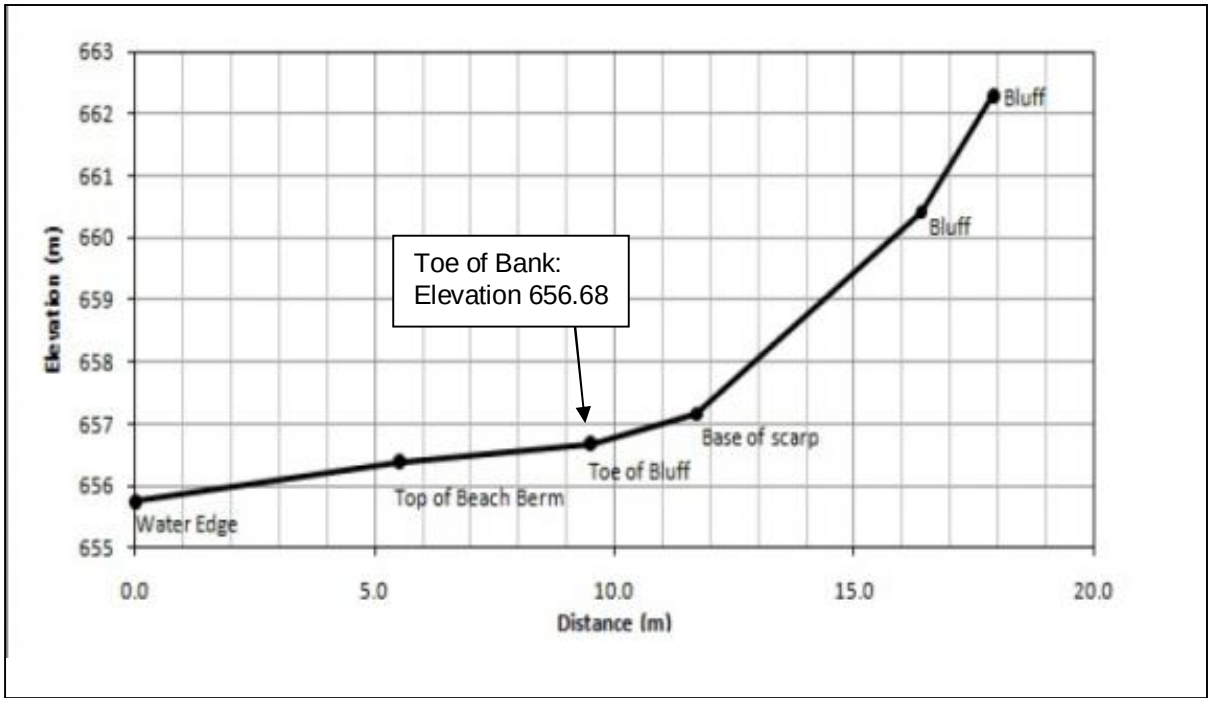

Figure 13 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for October at Alaska Highway Transect

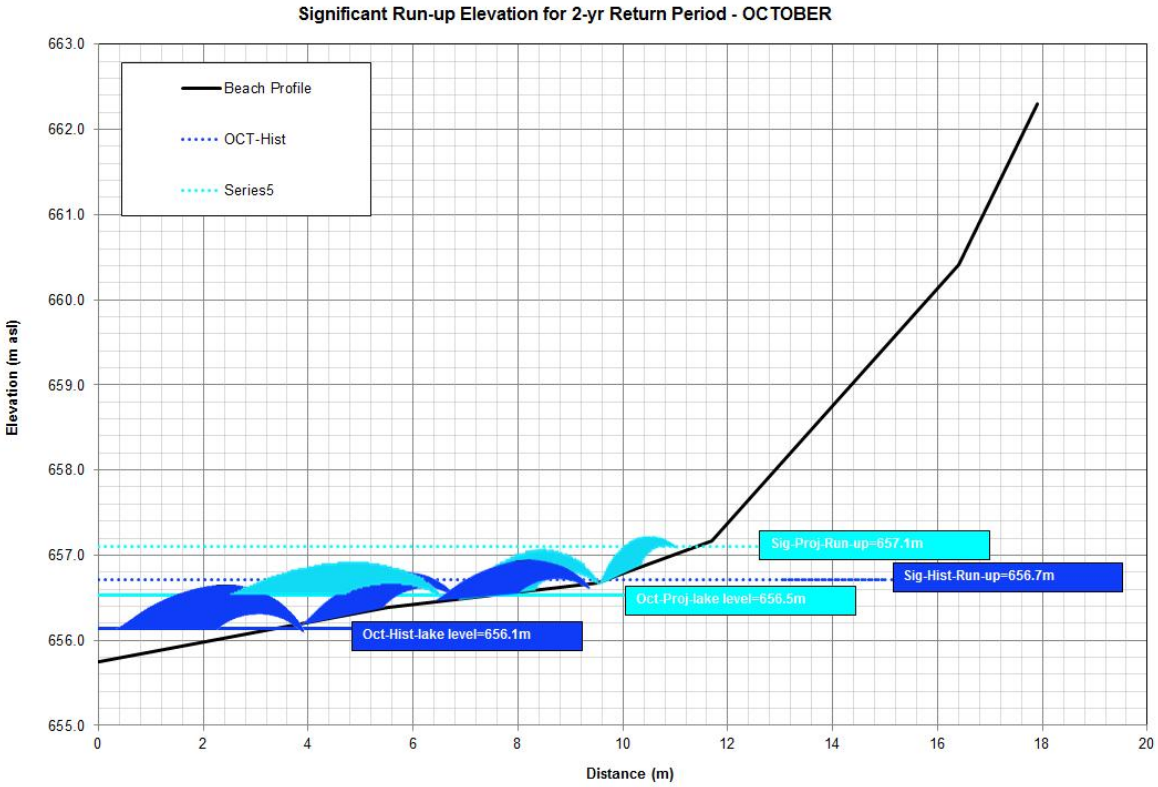

Figure 14 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for November at Alaska Highway Transect

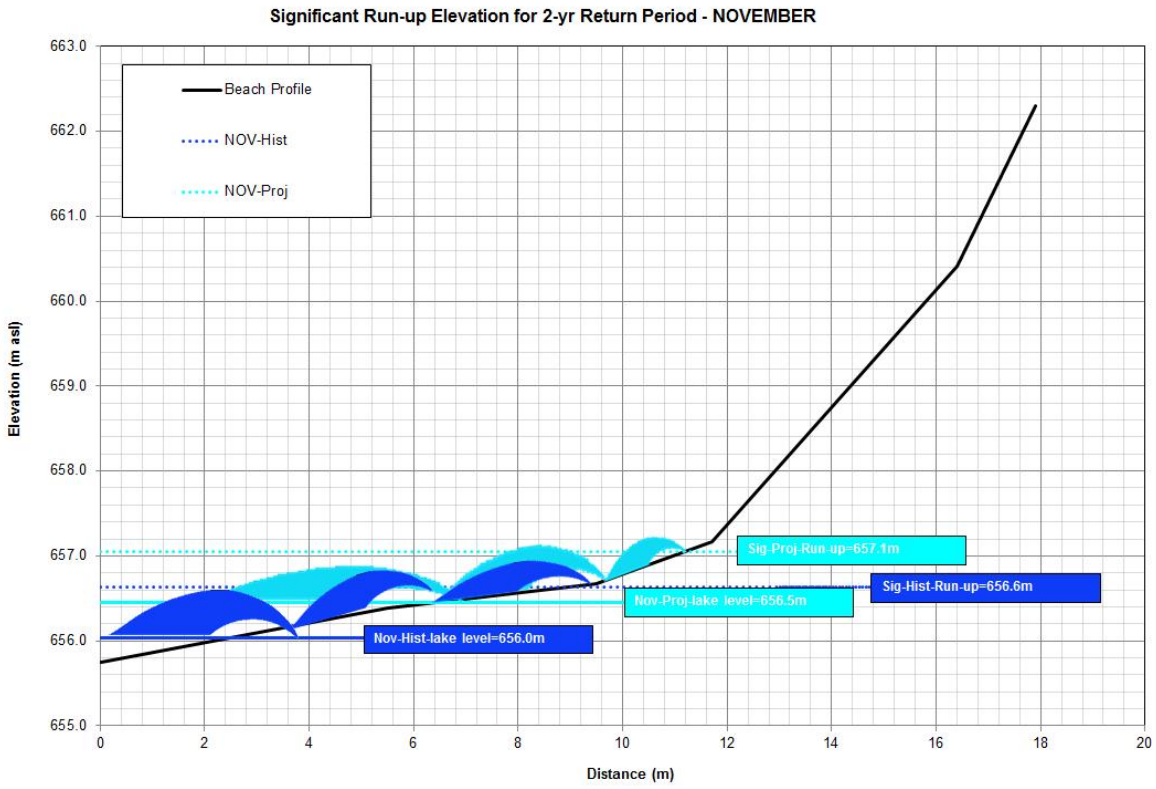

Table 3 Alaska Highway Run-up Elevations for 2, 5, and 10-yr Return Period – Toe of Bank: 656.68

			Monthly Average Lake Levels (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	656.14	0.57	656.71
		proj	656.53	0.57	657.10
	Nov	hist	656.04	0.60	656.64
		proj	656.45	0.61	657.06
5-yr Return Period	**Oct**	hist	656.14	0.70	656.84
		proj	656.53	0.70	657.23
	Nov	hist	656.04	0.72	656.76
		proj	656.45	0.73	657.18
10-yr Return Period	**Oct**	hist	656.14	0.74	656.88
		proj	656.53	0.75	657.28
	Nov	hist	656.04	0.76	656.80
		proj	656.45	0.77	657.22

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

3.4 Judas Creek

Figure 15 indicates the location of Judas Creek and a view of the beach and bank where the beach transect (Transect 6 shown in Figure 5) was surveyed for the run-up analysis discussed here. The toe of the bank for the Judas Creek transect is at 657.1 m. The pre- and post-project lake levels for October at Judas Creek are 656.14 m and 656.53 m, respectively. Significant run-up elevations for the Judas Creek transect are found to be 656.95 m and 657.34 m for pre- and post-project conditions, respectively. Pre- and post-project lake levels for October do not reach the toe of the bluff at Judas creek. Pre-project significant run-up elevation for October does not reach the toe of the bluff but the post-project significant run-up elevation is 0.24 m above the toe of the bluff. Figure 16 shows the graphical representation of the lake levels together with the significant run-up elevations for October. These results are summarized in Table 4.

Pre- and post-project lake levels for November are 656.04 m and 656.45 m, respectively. The pre- and post-project significant run-up elevations for November are 656.89 m and 657.31 m, respectively. This indicates that the significant run-ups are 0.85 m and 0.86 m, respectively, for pre- and post-project conditions. Figure 17 shows the lake levels and significant run-up elevations for November at Judas Creek, with the result summary shown in Table 4.

Figure 15 Typical Beach Profile at Judas Creek

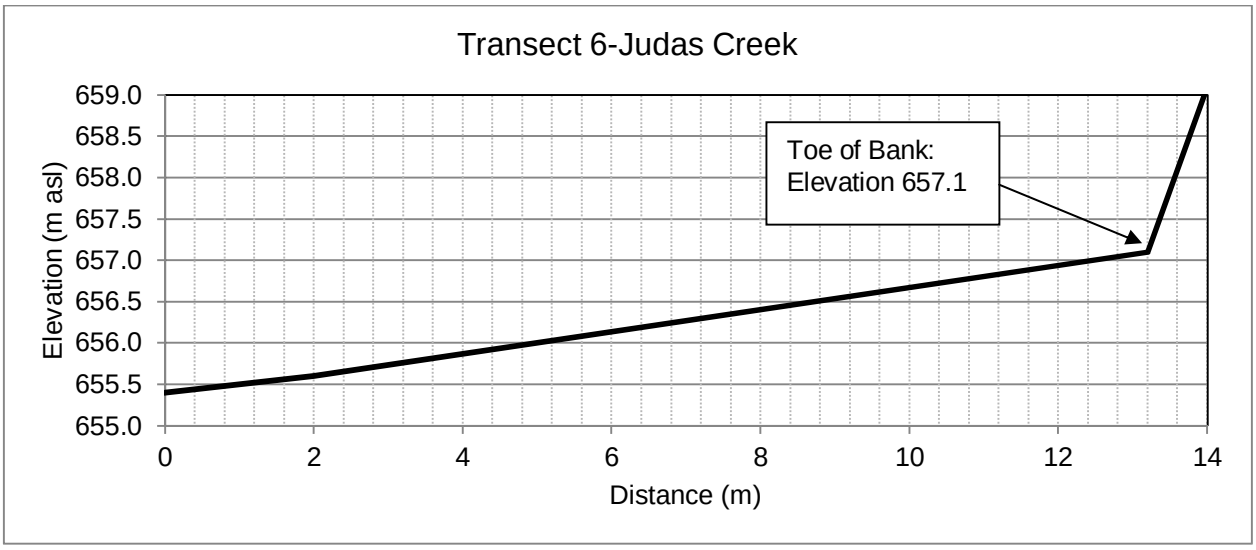

Figure 16 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for October at Judas Creek Transect 6

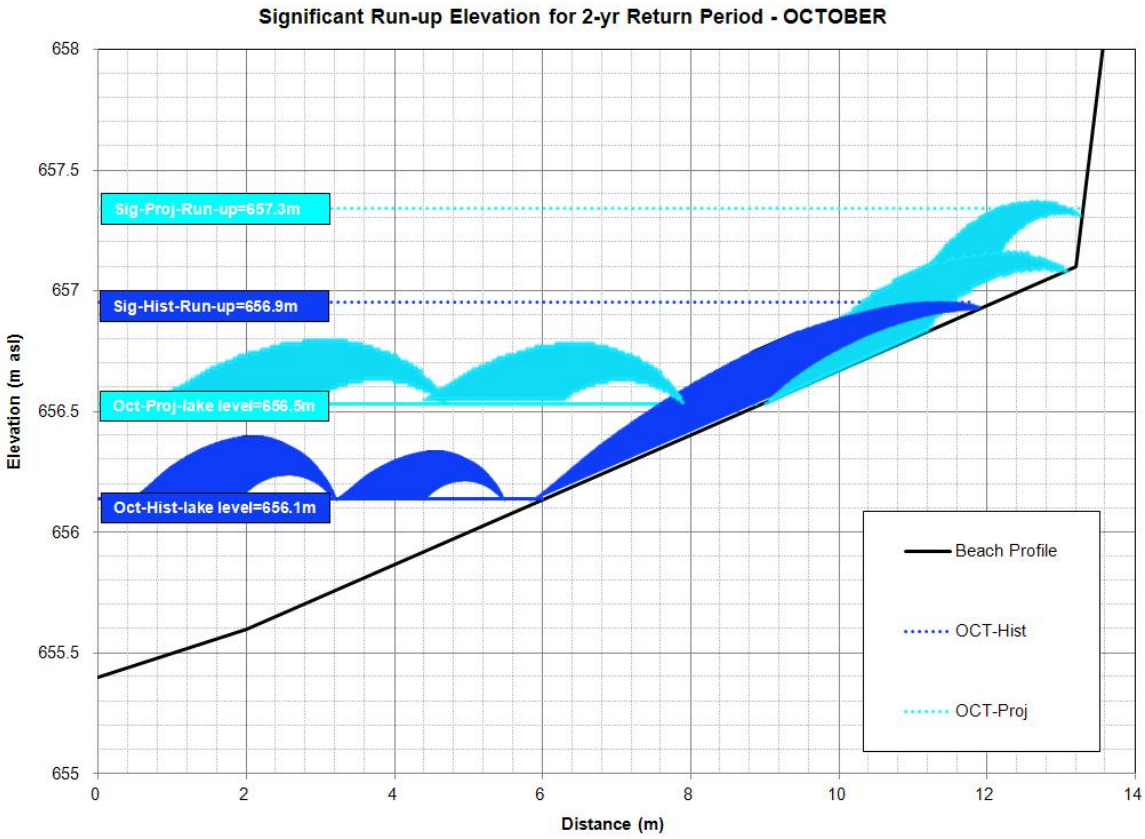

Figure 17 Pre- and Post-Project Lake Levels Together with the Significant Run-up Elevation for November at Judas Creek Transect 6

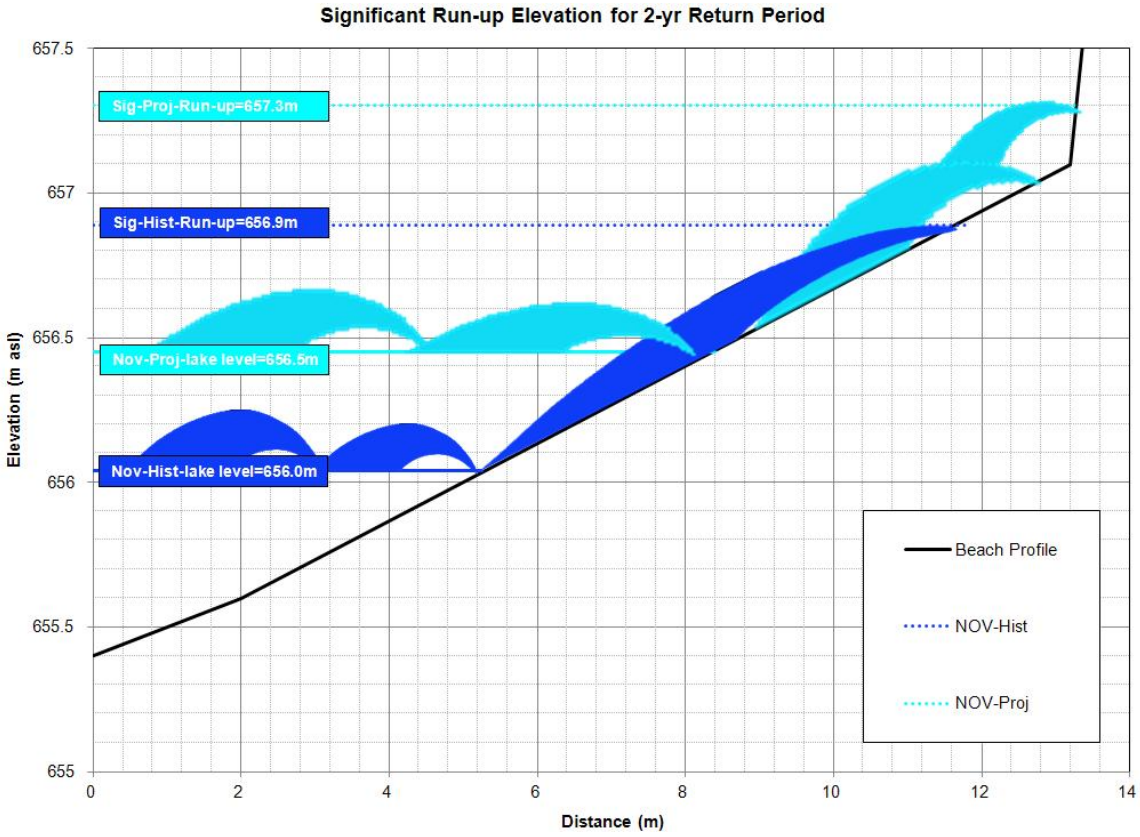

Table 4 Judas Creek Run-up Elevations for 2, 5, and 10-yr Return Period – Toe of Bank: 657.10

			Monthly Average Lake Levels (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	656.14	0.81	656.95
		proj	656.53	0.81	657.34
	Nov	hist	656.04	0.85	656.89
		proj	656.45	0.86	657.31
5-yr Return Period	**Oct**	hist	656.14	1.00	657.14
		proj	656.53	1.01	657.54
	Nov	hist	656.04	1.04	657.08
		proj	656.45	1.05	657.50
10-yr Return Period	**Oct**	hist	656.14	1.08	657.22
		proj	656.53	1.08	657.61
	Nov	hist	656.04	1.11	657.15
		proj	656.45	1.11	657.56

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

4.0 Conclusion

Most of the transect sites investigated in this analysis for the current conditions had 2-year return period significant run-up elevations exceeding the elevation of the toe of the bluff. This indicates that these sites are probably experiencing erosion under current conditions. Increasing the full storage level in late fall may increase the existing erosion due to wave run-up from storms. The site that might experience the least impact due to the increase in lake level is the Army Beach transect. At Army Beach the significant run-up elevations barely reach the toe of the existing riprap structure. The post-project condition for October at the Army Beach transect shows that the significant run-up elevation is above the toe elevation of the riprap structure by 0.02 m and the post-project condition for November shows that the significant run-up elevation is below the toe elevation by 0.06 m. The remainder of the sites investigated showed higher post-project significant run-up elevations when compared with the toe-of-bluff elevations at their respective sites.