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Investigation of the Imja Glacial Lake Outburst Flood Risk and Potential Remediation Measures, Khumbu, Nepal: Summary Report

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During 2011 to 2013, the High Mountain Glacial Watershed Program (HMGWP) completed three field expeditions to Imja Lake in the Nepal Himalaya. The purpose of these expeditions and follow-on analyses has been to quantify the risk of a Glacial Lake Outburst Flood (GLOF) from Imja Lake, the potential risk to downstream communities, and possible remedial measures to reduce that risk to an acceptable level. The studies that were performed include Ground Penetrating Radar (GPR) surveys of the terminal moraine and the Imja Glacier; a sonar bathymetric survey of the lake; and computer modeling of a potential GLOF from Imja Lake and downstream flooding.

Detailed GPR surveys were conducted at Imja Lake to increase understanding of the internal structure of the terminal moraine of the former glacier tongue at Imja Lake, and the distribution of ice in the core of the moraine[1].

The GPR surveys were performed over most of the terminal moraine complex and around both sides of the outlet of the lake. The data obtained allowed for the mapping of the ice core of the moraine. The results of the GPR survey show that there is extensive ice present in the core of the terminal moraine complex at Imja Lake, with the thickest ice near the western end of the lake on the north side of the outlet. The ice in this region is several tens of meters thick and up to fifty meters thick in some places. Along the north and south sides of the outlet, the ice is between ten and twenty-five meters thick. In some portions of the moraine on the south side of the outlet the ice thickness is up to forty meters.

[1] Somos-Valenzuela, M. A., D. C. McKinney, A. C. Byers, K. Voss, J. Moss IV, and J. C. McKinney, Ground Penetrating Radar Survey for Risk Reduction at Imja Lake, Nepal, Submitted to Natural Hazards, December 2012

GPR survey, May and September 2012

Bathymetric survey, September 2012

A sonar bathymetric survey was conducted at Imja Lake in September 2012[2]. The results suggest that the maximum depth of the lake has increased from 98 m to 116 m during 2002 to 2012, and that the estimated volume has grown from 35 million m^3 to 63.8 million m^3 during this period. Most of the expansion of the lake in recent years has taken place in the glacier terminus/ lake interface to the east, now losing more than 200 m of glacial ice per year compared to previous estimates of 34 m/yr.

A hydraulic simulation model was developed to assess the impact of a potential GLOF from Imja Lake in Nepal and its impact on downstream communities[3]. Implications of proposed GLOF risk reduction alternatives, including one suggested by local community members, were assessed. Results of the modeling illustrate three alternatives that offer significant risk reduction for downstream communities: (1) lowering the lake 3 m and constructing a 60 m flood detention dam, resulting in risk reduction of 52 percent, (2) lowering the lake 10 m and constructing a 40 m dam, resulting in risk reduction of 48 percent, and (3) lowering the lake 20 m with no dam, resulting in risk reduction of 57 percent. An alternative to lower the lake by 3 m with no flood detention dam, as currently proposed in the UNDP Imja Lake ProDoc, would result in a 3 percent risk reduction. This option does not appear to offer significant risk reduction to downstream communities compared to lowering the lake by 20 m. Results indicate that either the lake must be lowered significantly more than 3 m (20 m is recommended) or that a downstream flood detention dam be included in the project. To lower the level of Imja Lake to a desired level, siphons could be used to drain lake water 3 m followed by excavation of the outlet channel to that that new water level. This process would be repeated until the desired level is achieved (again 20 m is recommended). This would require thirteen 350 mm-diameter siphon pipes.

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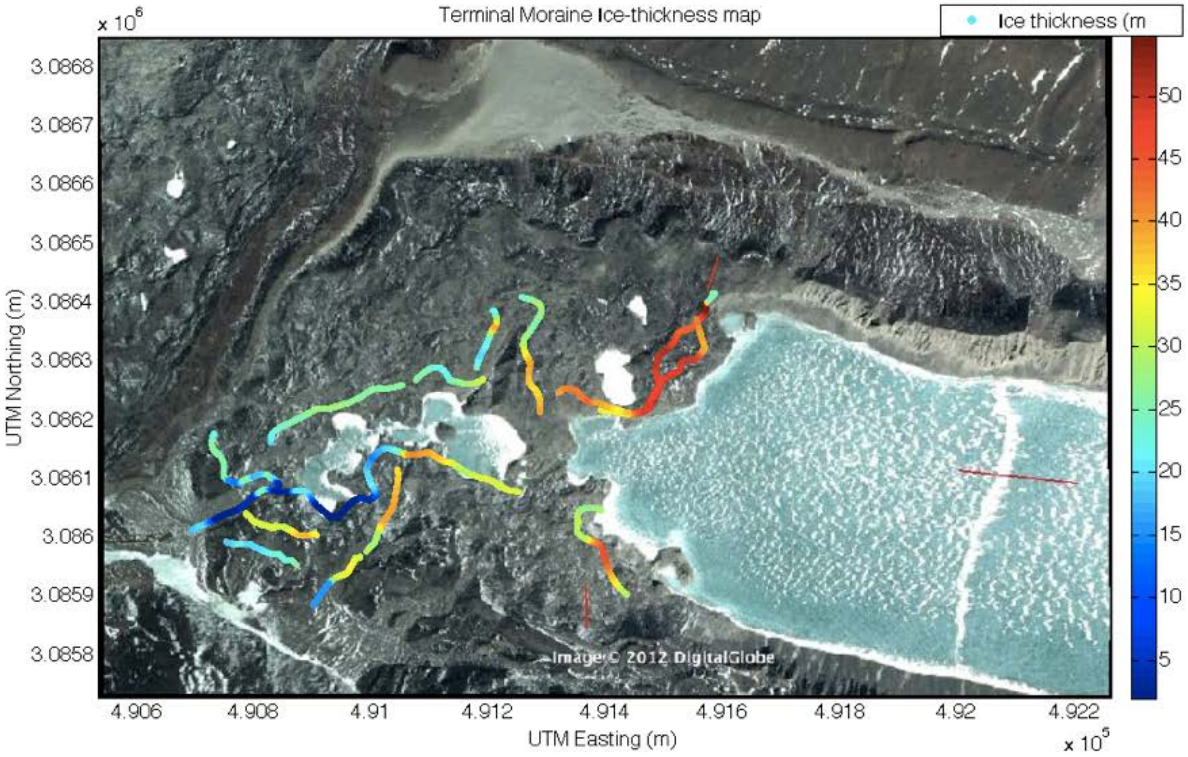
[2] Somos-Valenzuela, M. A., D. C. McKinney, A. C. Byers, and D, R. Rounce, Changes in a Potentially Dangerous Glacial Lake in the Mt. Everest Region of Nepal since 1992, submitted to Natural Hazards, June 2012

[3] Somos-Valenzuela, M. A., D. C. McKinney, A. C. Byers, D. R. Rounce, and C. Portocarrero, Modeling Mitigation Strategies for Risk Reduction at Imja lake, Nepal, in preparation.

Imja Lake glacier terminus, May 2012

Imja Lake glacier terminus, September 2012



GPR transects and ice thickness, September 2012