Supplementary Materials

The 2020 glacial lake outburst flood at Jinwuco, Tibet: causes, impacts, and implications for hazard and risk assessment

Guoxiong Zheng[1,2,3], Martin Mergili[4,5], Adam Emmer[4], Simon Allen[2,6], Anming Bao[1,3], Hao Guo[7], Markus Stoffel[2,8,9]

[1]State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, 830011 Urumqi, China
[2]Climatic Change Impacts and Risks in the Anthropocene (C-CIA), Institute for Environmental Sciences, University of Geneva, 1205 Geneva, Switzerland
[3]University of Chinese Academy of Sciences, 100049 Beijing, China
[4]Institute of Geography and Regional Science, University of Graz, 8010 Graz, Austria
[5]Institute of Applied Geology, University of Natural Resources and Life Sciences (BOKU), 1190 Vienna, Austria
[6]Department of Geography, University of Zurich, 8057 Zurich, Switzerland
[7]School of Geography and Tourism, Qufu Normal University, 276800 Rizhao, China
[8]Dendrolab.ch, Department of Earth Sciences, University of Geneva, 1205 Geneva, Switzerland
[9]Department of F.A. Forel for Environmental and Aquatic Sciences, University of Geneva, 1205 Geneva, Switzerland

Correspondence to: G. Zheng (zhengguoxiong17@mails.ucas.edu.cn); A. Bao (baoam@ms.xjb.ac.cn)

Supplementary Table 1: Detailed description of empirical equations used to estimate V, t_b and Q_p. All variables are in metric units (m, m^2, m^3), time t_b in hours and peak discharge Q_p in m^3/s unless otherwise stated.

Equation	Description	Reference
Lake volume V:		
$V=0.035A^{1.5}$	A – lake area	Evans, 1986
$V=3.114A+0.01685A^2$	A – lake area	O'Connor et al., 2001
$V=0.104A^{1.42}$	A – lake area	Huggel et al., 2002
$V=0.0354A^{1.3742}$	A – lake area	Wang et al., 2012
$V=A \cdot D$, where $D=0.087A^{0.434}$	A – lake area; D – mean lake depth	Wang et al., 2012
$V=A \cdot D$, where $D=55A_{sqkm}^{0.25}$	A – lake area; A_{sqkm} - lake area in km^2; D – mean lake depth	Fujita et al., 2013
$V=0.2933A^{1.3324}$	A – lake area	Loriaux and Casassa, 2013
$V=0.054393A^{1.483009}$	A – lake area	Emmer and Vilímek, 2014
$V=A \cdot D$, where $D=0.1217A^{0.4129}$	A – lake area; D – mean lake depth (data replotted from Huggel et al. 2002)	Cook and Quincey, 2015
$V=A \cdot D$, where $D=0.5057A^{0.2884}$	A – lake area; D – mean lake depth (compilation including duplicate sites)	Cook and Quincey, 2015
$V=A \cdot D$, where $D=0.1746A^{0.3725}$	A – lake area; D – mean lake depth (compilation excluding duplicate sites)	Cook and Quincey, 2015
$V=A \cdot D$, where $D=0.3211A^{0.324}$	A – lake area; D – mean lake depth (compilation including duplicate sites and Huggel et al. 2002 data)	Cook and Quincey, 2015
$V=A \cdot D$, where $D=0.1697A^{0.3778}$	A – lake area; D – mean lake depth (compilation excluding duplicate sites and Huggel et al. 2002 data)	Cook and Quincey, 2015
$V=0.036A^{1.49}$	A – lake area	Kapista et al., 2017
$V=A(0.041L_w+2)$	A – lake area; L_w – lake width	Muñoz et al., 2020
Breach time t_b:		
$t_b=0.0179V_{er}^{0.364}$	V_{er} – volume of material eroded from the dam	MacDonald and Langridge-Monopolis, 1984
$t_b=1008\mathrm{A}/(B_d \cdot B_{w\_avg})^{0.5}$	A – lake area in acres; B_d – breach depth in feet; B_{w_avg} – average breach width in feet (calculated for both $B_{w\_avg\_v}$ and $B_{w\_avg\_t}$)	Costa, 1985
$t_b=0.011B_{w\_avg}$	B_{w_avg} – average breach width (calculated for both $B_{w\_avg\_v}$ and $B_{w\_avg\_t}$)	Bureau of Reclamation, 1988
$t_b=0.015B_d$	B_d – breach depth (for highly erodible dam)	Von Thun and Gillette, 1990
$t_b=0.020B_d + 0.25$	B_d – breach depth (for erosion resistant dam)	Von Thun and Gillette, 1990
$t_b=B_{w\_avg}/4B_d$	B_d – breach depth; B_{w_avg} – average breach width (for erosion resistant dam; calculated for both $B_{w\_avg\_v}$ and $B_{w\_avg\_t}$)	Von Thun and Gillette, 1990
$t_b=B_{w\_avg}/(4B_d + 61)$	B_d – breach depth; B_{w_avg} – average breach width (for highly erodible dam; calculated for both $B_{w\_avg\_v}$ and $B_{w\_avg\_t}$)	Von Thun and Gillette, 1990
$t_b=0.00254(V_{GLOF})^{0.53} \cdot B_d^{-0.9}$	V_{GLOF} – released volume; B_d – breach depth	Froehlich, 1995
Peak discharge Qp:		
$Q_p=1.268(B_d+0.3)^{2.5}$	B_d – breach depth	Kirkpatrick, 1977
$Q_p=8/27 \cdot g^{0.5} \cdot B_\mathrm{b}^{1.5} \cdot (0.4\ B_{w\_base\_t} + 0.6\ B_{w\_max})$	g – gravitational acceleration; B_d – breach depth; $B_{w\_base\_t}$ – breach width at the base; B_{w_max} – maximum breach width	Price et al., 1977
$Q_p=16.6B_d^{1.85}$	B_d – breach depth	Soil Conservation Service, 1981

Q_p=0.54$(B_{w_base_t} \cdot B_{w_max})^{0.5}$	$B_{w\_base\_t}$ – breach width at the base; B_{w_max} – maximum breach width	Hagen, 1982
Q_p=19.1$B_d^{1.85}$	B_d – breach depth (envelope equation)	Bureau of Reclamation, 1982
Q_p=13.4$B_d^{1.89}$	B_d – breach depth	Singh and Snorrason, 1984
Q_p=1.776$V_{GLOF}^{0.47}$	V_{GLOF} – released volume	Singh and Snorrason, 1984
Q_p=1.122$V_{GLOF}^{0.57}$	V_{GLOF} – released volume	Costa, 1985
Q_p=0.981$(V_{GLOF} \cdot B_d)^{0.42}$	V_{GLOF} – released volume; B_d – breach depth	Costa, 1985
Q_p=2.634$(V_{GLOF} \cdot B_d)^{0.44}$	V_{GLOF} – released volume; B_d – breach depth	Costa, 1985
Q_p=44$B_d^{1.63}$	B_d – breach depth	Costa, 1985
Q_p=325$(B_d \cdot V_{GLOF} \cdot 10^{-6})^{0.44}$	B_d – breach depth; V_{GLOF} – released volume	Costa, 1985
Q_p=0.72$V_{GLOF}^{0.53}$	V_{GLOF} – released volume	Evans, 1986
Q_p=1.154$(B_d \cdot V_{GLOF})^{0.412}$	B_d – breach depth; V_{GLOF} – released volume	MacDonald and Langridge-Monopolis, 1984
Q_p=3.85$(B_d \cdot V_{GLOF})^{0.411}$	B_d – breach depth; V_{GLOF} – released volume (envelope equation)	MacDonald and Langridge-Monopolis, 1984
Q_p=0.607$(B_d^{1.24} \cdot V_{GLOF}^{0.295})$	B_d – breach depth; V_{GLOF} – released volume	Froehlich, 1995