Master's degree course in Environmental and Land Engineering, specialist pathway in Natural Hazards and Civil Protection

Master's Thesis

Appendix

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TABLES WITH DATA USED FOR THE CONSTRUCTION OF THE VULNERABILITY CURVES

This chapter includes all tables used in the calculation of the resistance factor **Rs**. Tables will be divided on the basis of the 4 cases analysed (**A**, **B**, **C**, **D**), referring to the buildings' position on the landslide body.

▪ CASE A

Table 1: parameters used in the calculation of the resistance factor Rs, the key parameter being the depth of the sliding surface between 1.5 and 2 m

foundation depth	score	sliding surface depth	building construction material	score	Rs
WEIGHT 2		1.5/2m	WEIGHT 1		
Chalet 1m	0.7		Timber	0.6	0.9
Chalet >1m	0.4				0.7
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		1.5/2m	WEIGHT 1		
Villa 1m	0.7		Masonry	0.2	0.5
Villa >1m	0.4				0.4
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		1.5/2m	WEIGHT 1		
Villa 1m	0.7		Masonry + Concrete	0.3	0.7
Villa >1m	0.4				0.5
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		1.5/2m	WEIGHT 1		
Residential building <2m	0.5		Masonry	0.2	0.4
Residential building 2/10m	0.2				0.3
Residential building >10m	0.2				
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		1.5/2m	WEIGHT 1		
Residential building <2m	0.5		Reinforced Concrete	0.6	0.8
Residential building 2/10m	0.2				0.5
Residential building >10m	0.2				

Table 2: parameters used in the calculation of the resistance factor Rs, the key parameter being the depth of the sliding surface between 2 and 5 m

foundation depth	score	sliding surface depth	building construction material	score	Rs
WEIGHT 2		2-5m	WEIGHT 1		
Chalet 1m	1		Timber	0.6	1
Chalet >1m	0.5				0.8
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		2-5m	WEIGHT 1		
Villa 1m	1		Masonry	0.2	0.6
Villa >1m	0.5				0.4
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		2-5m	WEIGHT 1		
Villa 1m	1		Masonry + Concrete	0.3	0.8
Villa >1m	0.5				0.5
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		2-5m	WEIGHT 1		
Residential building <2m	1		Masonry	0.2	0.6
Residential building 2/10m	0.2				0.3
Residential building >10m	0.3				0.3
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		2-5m	WEIGHT 1		
Residential building <2m	1		Reinforced Concrete	0.6	1.1
Residential building 2/10m	0.2				0.5
Residential building >10m	0.3				0.6

▪ CASE C

Table 3: parameters used in the calculation of the resistance factor Rs, the key parameter being the depth of the sliding surface between 5 and 30 m

foundation depth	score	sliding surface depth	building construction material	score	Rs
WEIGHT 2		5-30m	WEIGHT 1		
Chalet 1m	1		Timber	0.6	1.1
Chalet >1m	0.8				1
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		5-30m	WEIGHT 1		
Villa 1m	1		Masonry	0.2	0.6
Villa >1m	0.8				0.6
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		5-30m	WEIGHT 1		
Villa 1m	1		Masonry + Concrete	0.3	0.8
Villa >1m	0.8				0.7
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		5-30m	WEIGHT 1		
Residential building <2m	1		Masonry	0.2	0.6
Residential building 2/10m	0.5				0.4
Residential building >10m	0.2				0.3
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		5-30m	WEIGHT 1		
Residential building <2m	1		Reinforced Concrete	0.6	1.1
Residential building 2/10m	0.5				0.8
Residential building >10m	0.2				0.5

Table 4: parameters used in the calculation of the resistance factor Rs, the key parameter being the depth of the sliding surface higher than 30 m

foundation depth	score	sliding surface depth	building construction material	score	Rs
WEIGHT 2		>30m	WEIGHT 1		
Chalet 1m	1		Timber	0.6	1.1
Chalet >1m	1				
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		>30m	WEIGHT 1		
Villa 1m	1		Masonry	0.2	0.6
Villa >1m	1				
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		>30m	WEIGHT 1		
Villa 1m	1		Masonry + Concrete	0.3	0.8
Villa >1m	1				
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		>30m	WEIGHT 1		
Residential building <2m	1		Masonry	0.2	0.6
Residential building 2/10m	1				
Residential building >10m	0.8				0.6
foundation depth	score	sliding surface depth	building construction material	score	
WEIGHT 2		>30m	WEIGHT 1		
Residential building <2m	1		Reinforced Concrete	0.6	1.1
Residential building 2/10m	1				
Residential building >10m	0.8				1

▪ CASE B

Table 5: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to structure inclination and rotation, in this case defined as very low

number of floors	score	structure inclination and rotation	score	building construction material	score	Rs
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	very low	1.2	Timber	0.6	0.7
Chalet 2, >2	0.3					1.1
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	very low	1.2	Timber + concrete	0.4	0.7
Chalet 2, >2	0.3					0.9
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	very low	1.2	Masonry	0.2	0.7
Villa 3	0.9					1.1
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	very low	1.2	Concrete and masonry	0.3	0.9
Villa 3	0.9					1.2
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building 4	0.9	very low	1.2	Masonry	0.2	1.1
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building >4	1	very low	1.2	Reinforced Concrete	0.6	1.6

Table 6: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to structure inclination and rotation, in this case defined as medium

number of floors	score	structure inclination and rotation	score	building construction material	score	Rs
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	medium	0.7	Timber	0.6	0.6
Chalet 2, >2	0.3					0.9
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	medium	0.7	Timber + concrete	0.4	0.5
Chalet 2, >2	0.3					0.8
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	medium	0.7	Masonry	0.2	0.6
Villa 3	0.9					0.9
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	medium	0.7	Concrete and masonry	0.3	0.7
Villa 3	0.9					1
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building 4	0.9	medium	0.7	Masonry	0.2	0.9
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building >4	1	medium	0.7	Reinforced Concrete	0.6	1.3

Table 7: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to structure inclination and rotation, in this case defined as very high

number of floors	score	structure inclination and rotation	score	building construction material	score	Rs
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	very high	0.1	Timber	0.6	0.3
Chalet 2, >2	0.3					0.5
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Chalet 1	0.1	very high	0.1	Timber + concrete	0.4	0.3
Chalet 2, >2	0.3					0.4
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	very high	0.1	Masonry	0.2	0.3
Villa 3	0.9					0.5
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
Villa 2	0.3	very high	0.1	Concrete and masonry	0.3	0.4
Villa 3	0.9					0.5
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building 4	0.9	very high	0.1	Masonry	0.2	0.5
number of floors	score	structure inclination and rotation	score	building construction material	score	
WEIGHT 1		WEIGHT 2		WEIGHT 3		
residential building >4	1	very high	0.1	Reinforced Concrete	0.6	0.7

▪ CASE D

Table 8: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to maintenance state, in this case defined as very poor

number of floors	score	maintenance state	score	building construction material	score	Rs
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	very poor	0.1	Timber	0.2	0.2
Chalet 2,>2	0.3					0.3
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	very poor	0.1	Timber + concrete	0.6	0.3
Chalet 2,>2	0.3					0.5
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	very poor	0.1	Masonry	0.8	0.5
Villa 3	0.9					0.75
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	very poor	0.1	Concrete and masonry	1.2	0.6
Villa 3	0.9					0.9
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building 4	0.9	very poor	0.1	Masonry	0.8	0.75
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building >4	1	very poor	0.1	Reinforced Concrete	1.5	1

Table 9: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to maintenance state, in this case defined as medium

number of floors	score	maintenance state	score	building construction material	score	Rs
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	medium	0.8	Timber	0.2	0.4
Chalet 2,>2	0.3					0.7
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	medium	0.8	Timber + concrete	0.6	0.7
Chalet 2,>2	0.3					0.9
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	medium	0.8	Masonry	0.8	1
Villa 3	0.9					1.5
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	medium	0.8	Concrete and masonry	1.2	1.2
Villa 3	0.9					1.7
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building 4	0.9	medium	0.8	Masonry	0.8	1.5
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building >4	1	medium	0.8	Reinforced Concrete	1.5	1.9

Table 10: parameters used in the calculation of the resistance factor Rs, the key parameter being the one referring to maintenance state, in this case defined as very good

number of floors	score	maintenance state	score	building construction material	score	Rs
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	very good	1.5	Timber	0.2	0.6
Chalet 2,>2	0.3					0.8
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Chalet 1	0.1	very good	1.5	Timber + concrete	0.6	0.8
Chalet 2,>2	0.3					1.1
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	very good	1.5	Masonry	0.8	1.3
Villa 3	0.9					1.9
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
Villa 2	0.3	very good	1.5	Concrete and masonry	1.2	1.5
Villa 3	0.9					2.1
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building 4	0.9	very good	1.5	Masonry	0.8	1.9
number of floors	score	maintenance state	score	building construction material	score	
WEIGHT 2		WEIGHT 1		WEIGHT 3		
residential building >4	1	very good	1.5	Reinforced Concrete	1.5	2.3

GRAPHS CONCERNING VULNERABILITY CURVES AND CASE STUDIES

This chapter contains all the graphs, related to the implementation of case studies on vulnerability curves, which are not reported in *Chapter 6* of the thesis. Plots will be divided on the basis of the 4 case studies analysed.

- **Hohberg Landslide (case D)**

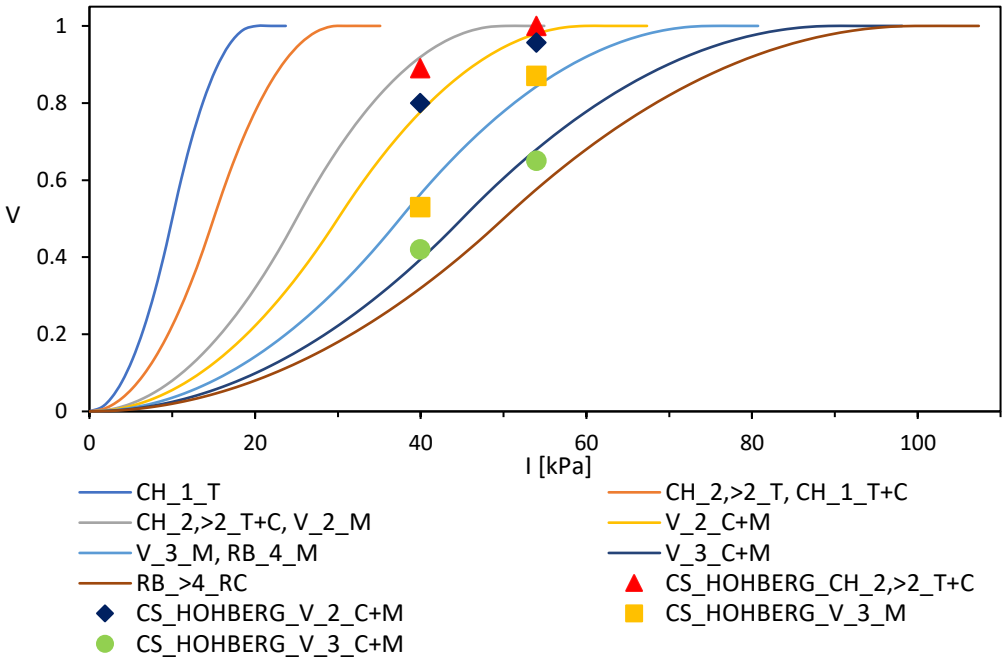

*Figure 1: Vulnerability curves obtained for case **D** when the maintenance state is very poor*

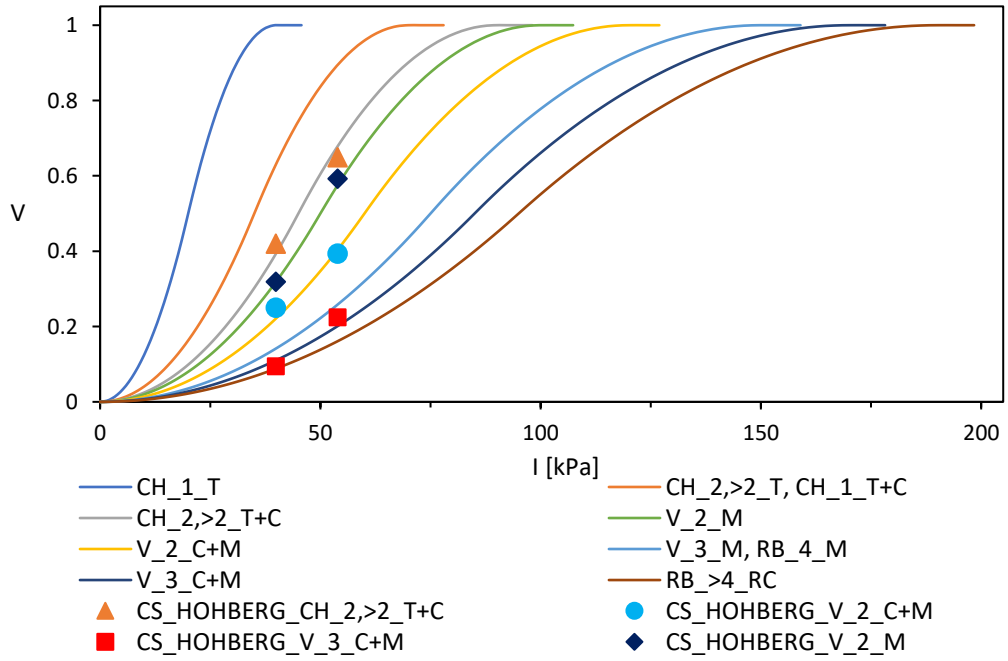

*Figure 2: Vulnerability curves obtained for case **D** when the maintenance state is medium*

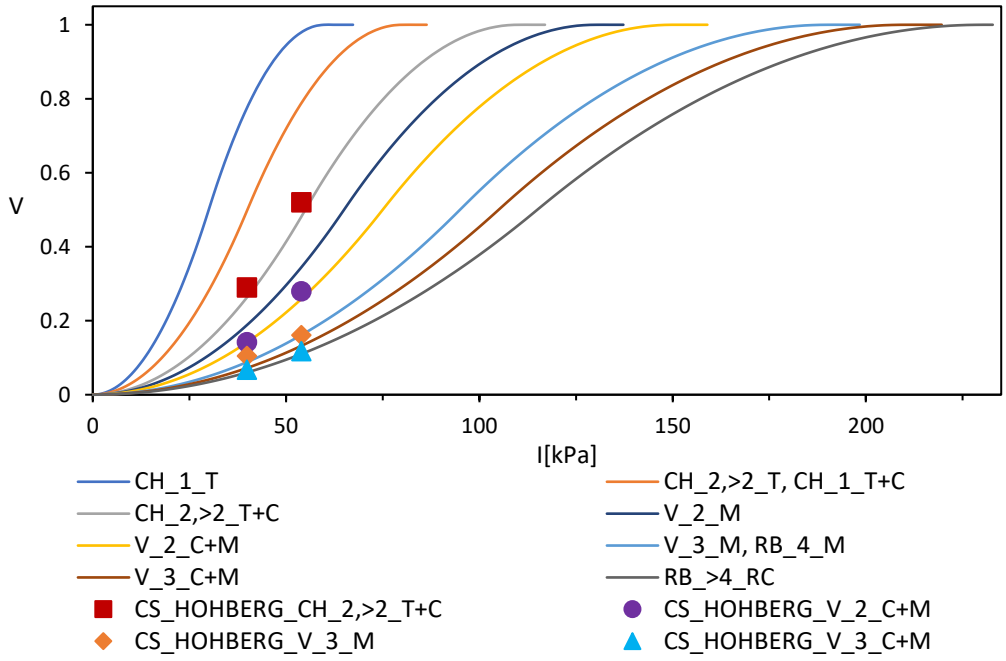

*Figure 3: Vulnerability curves obtained for case **D** when the maintenance state is very high*

- **Converney-Taillepied Landslide (cases C, D)**

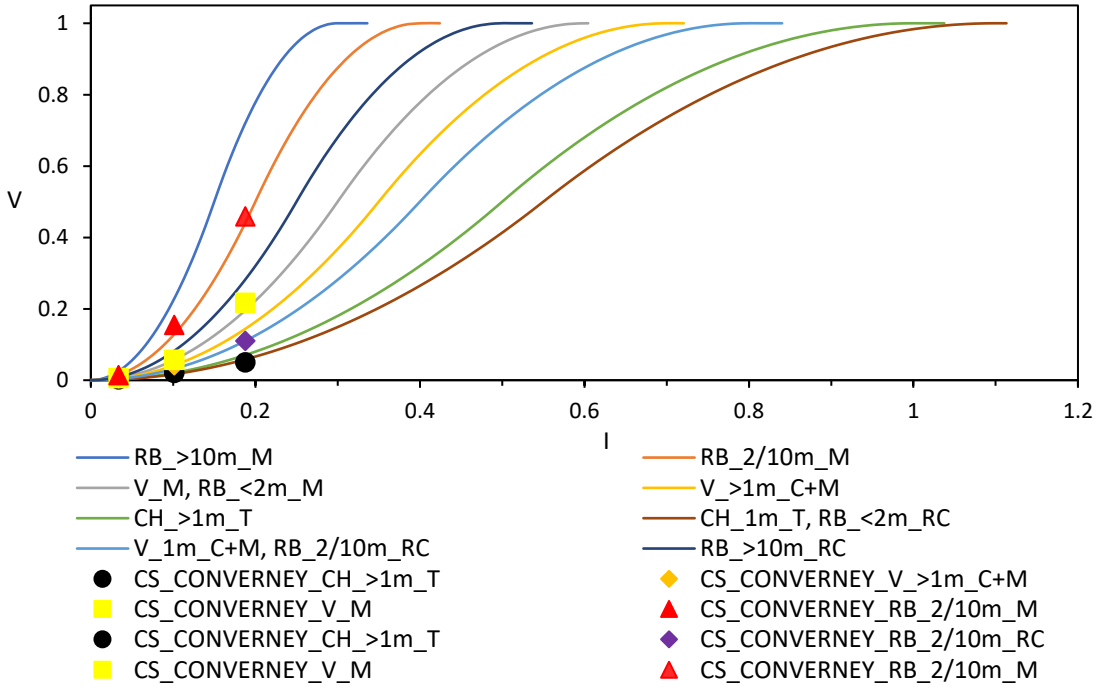

*Figure 4: Vulnerability curves and indicators obtained for case **C** when the depth of the sliding surface is assumed to be between 5 and 30 metres*

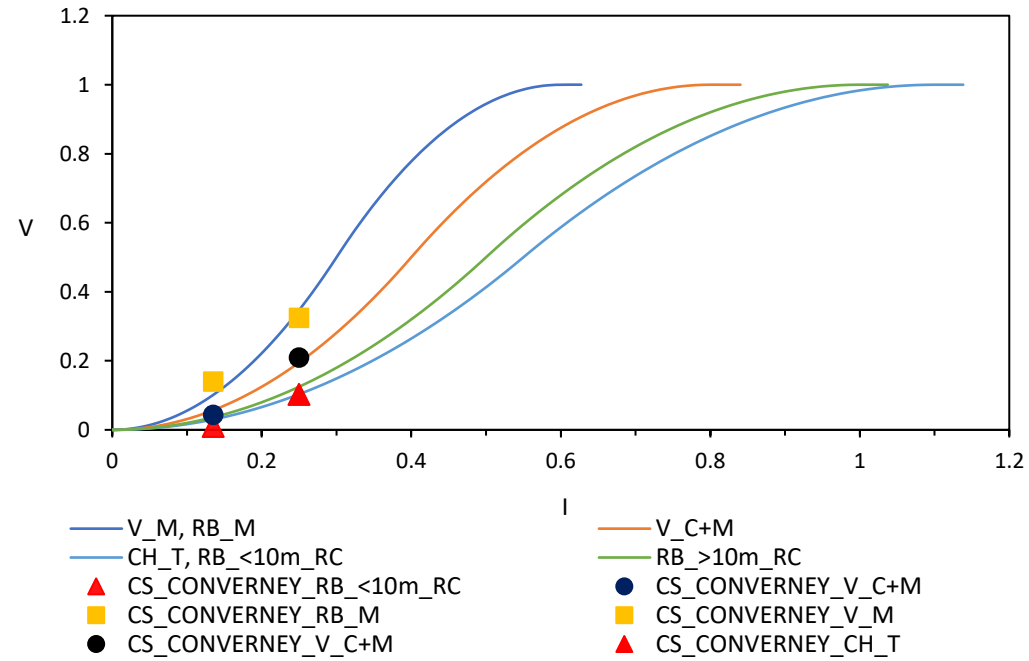

*Figure 5: Vulnerability curves and indicators obtained for case **C** when the depth of the sliding surface is assumed to be higher than 30 metres*

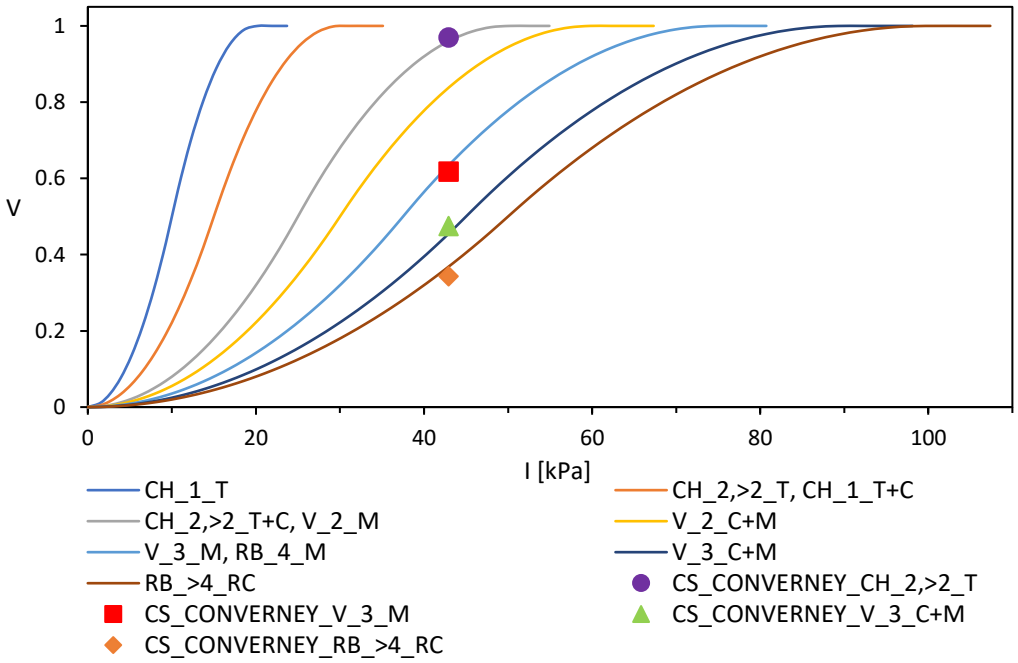

*Figure 6: Vulnerability curves obtained for case **D** when the maintenance state is very poor*

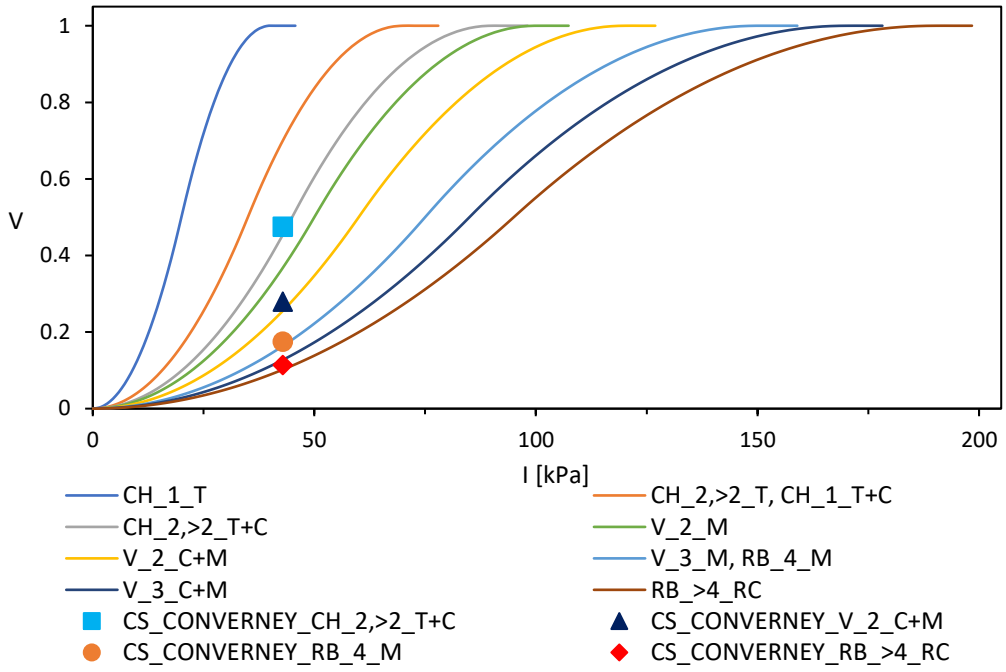

*Figure 7: Vulnerability curves obtained for case **D** when the maintenance state is medium*

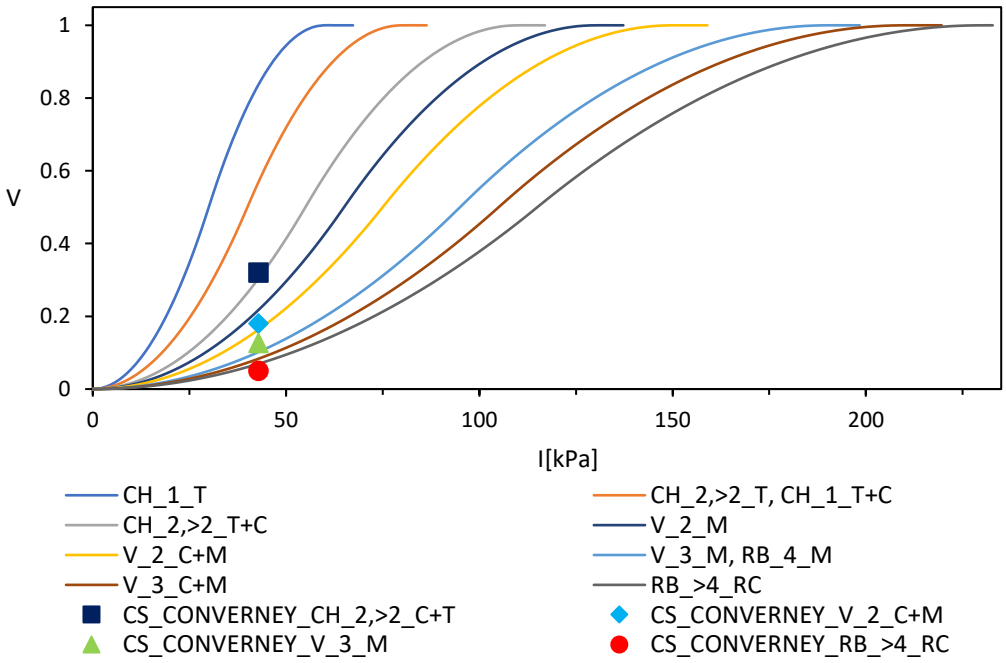

*Figure 8: Vulnerability curves obtained for case **D** when the maintenance state is very high*

- **La Frasse landslide (case D)**

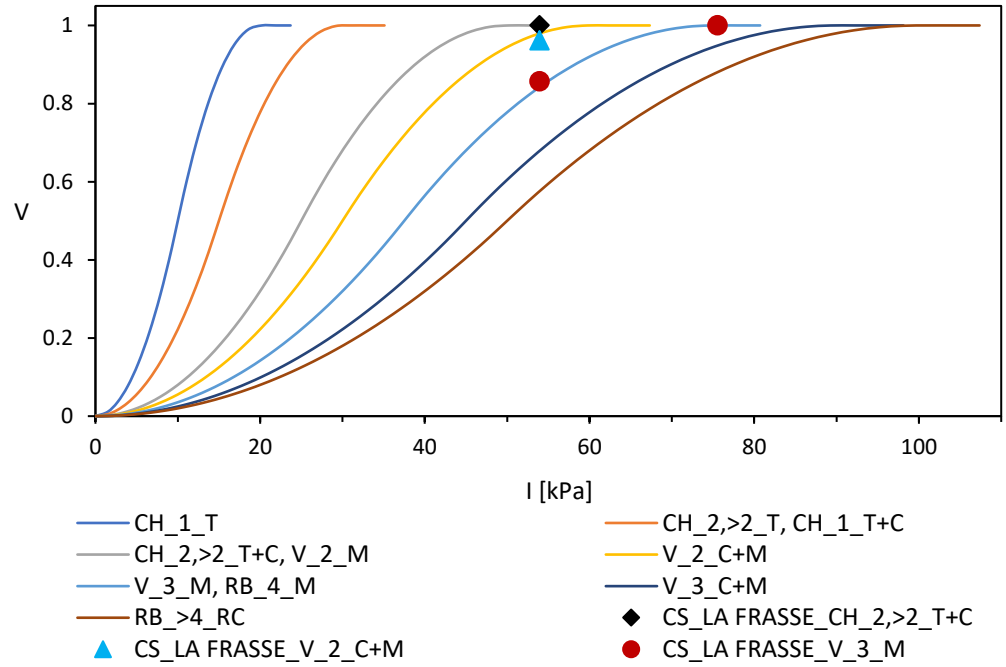

*Figure 9: Vulnerability curves obtained for case **D** when the maintenance state is very poor*

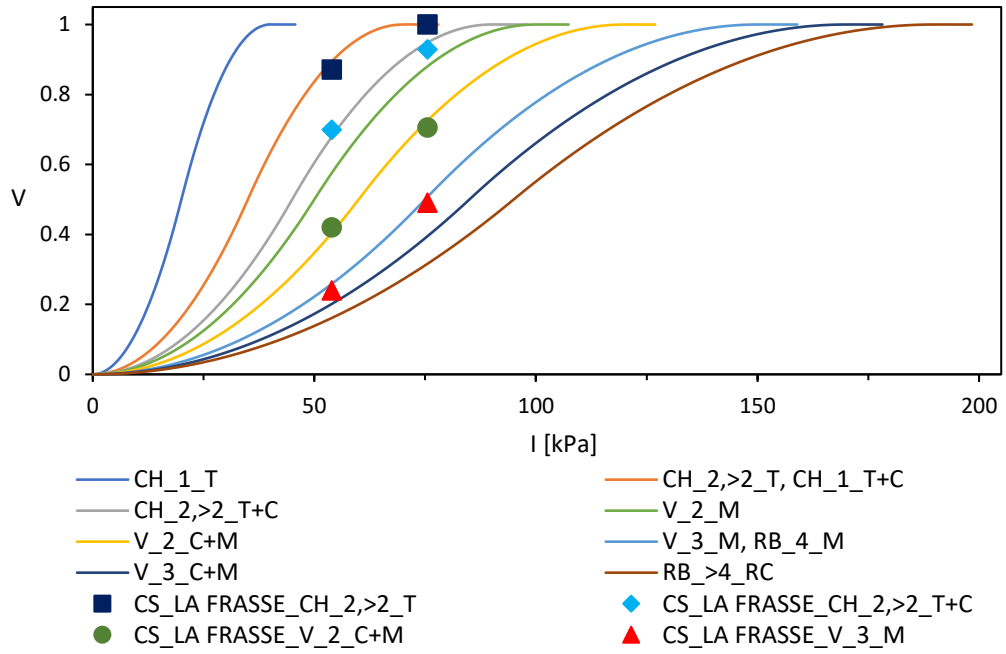

*Figure 10: Vulnerability curves obtained for case **D** when the maintenance state is medium*

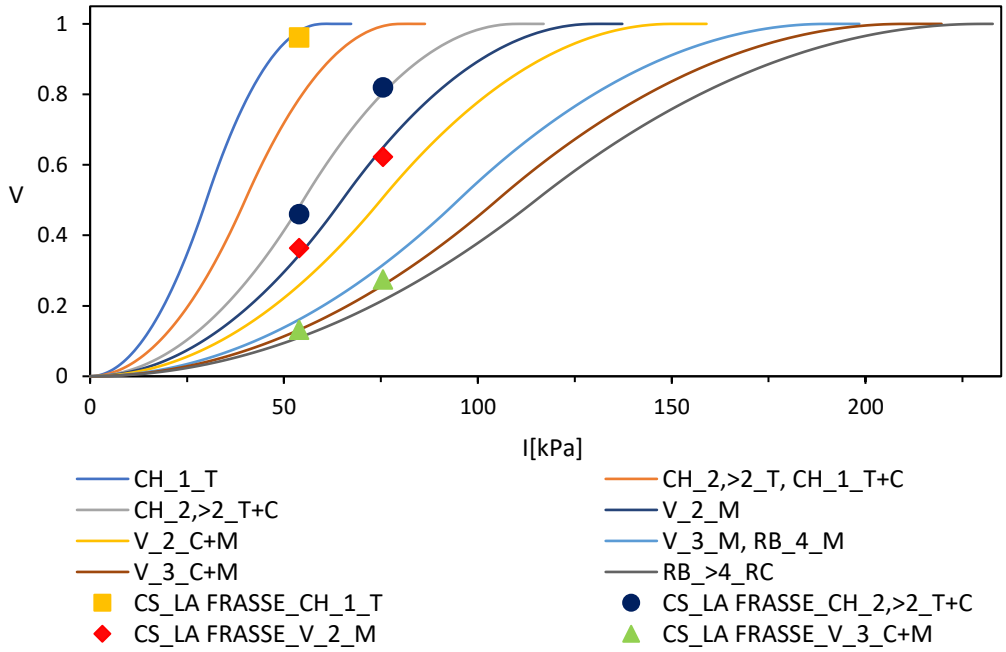

*Figure 11: Vulnerability curves obtained for case **D** when the maintenance state is very high*

- **Pont Bourquin landslide (case C)**

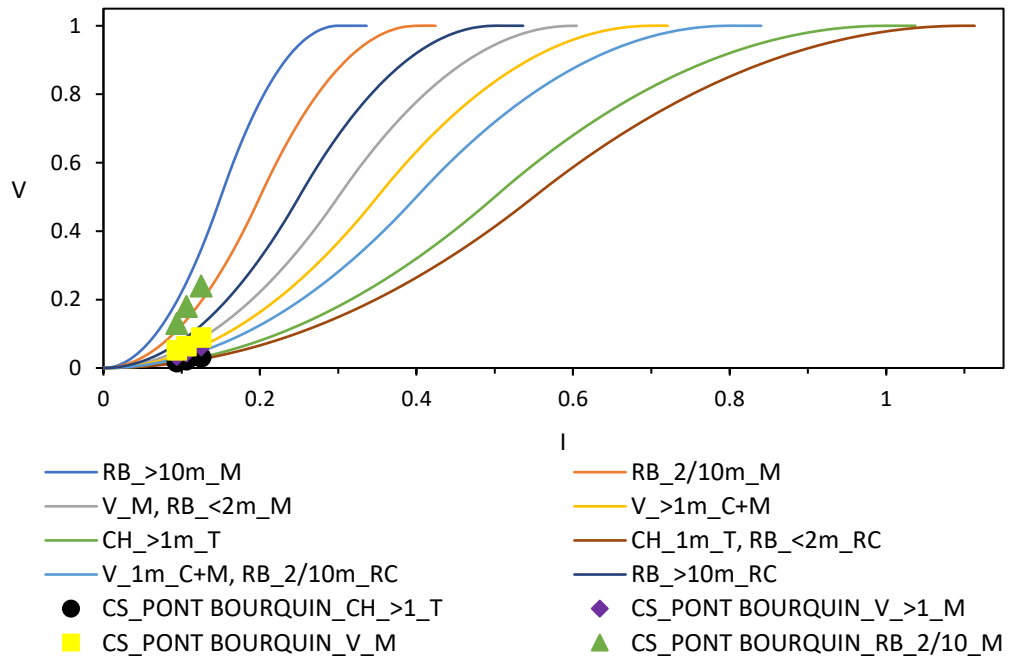

*Figure 12: Vulnerability curves and indicators obtained for case **C** when the depth of the sliding surface is assumed to be between 5 and 30 metres*

GIS DRAWING BOARDS ABOUT LANDSLIDE ANALYSED IN THE CASE STUDIES

This chapter provides a geographical framework of the landslides analyzed in the case studies described in *Chapter 7* of the thesis.

- **Geographical framework Canton of Vaud**

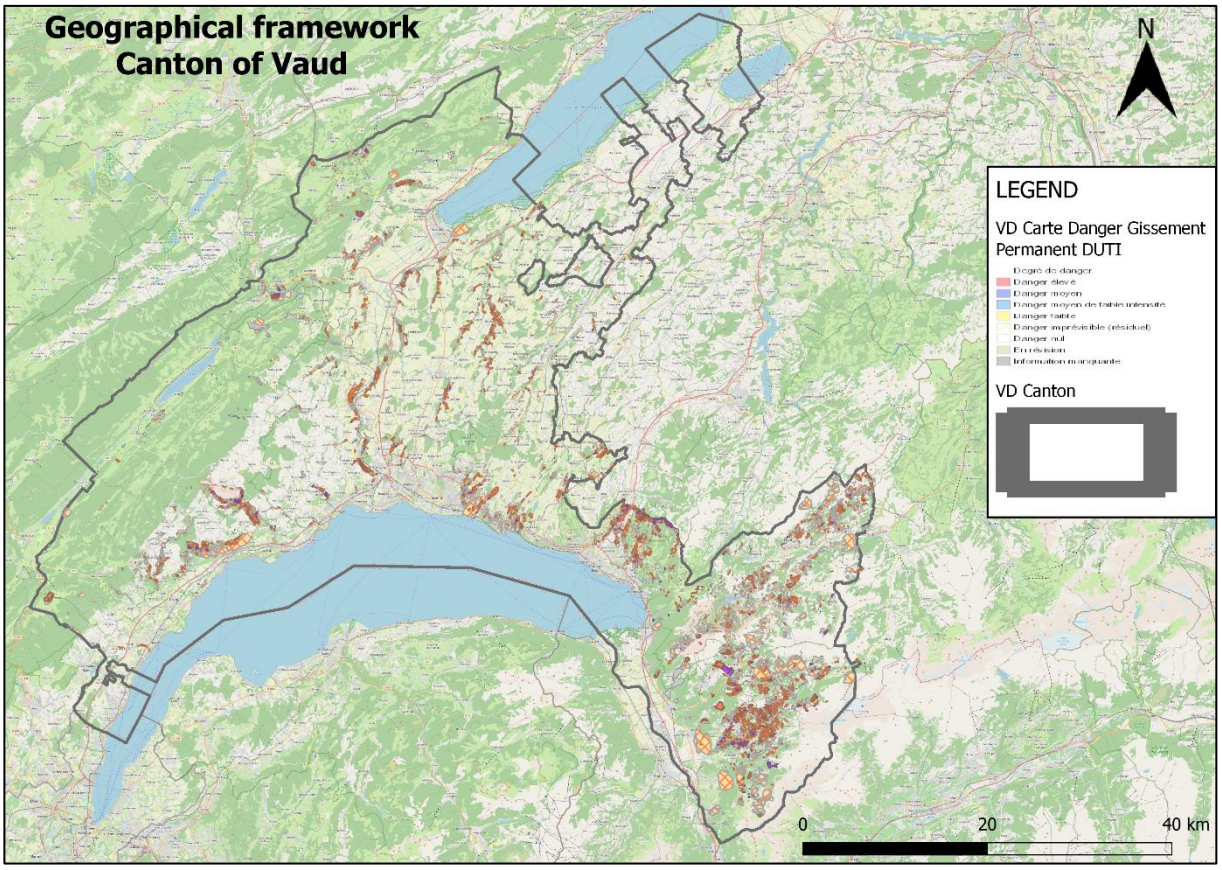

Figure 13: Geographical framework Canton of Vaud

- **Converney-Taillepied Landslide**

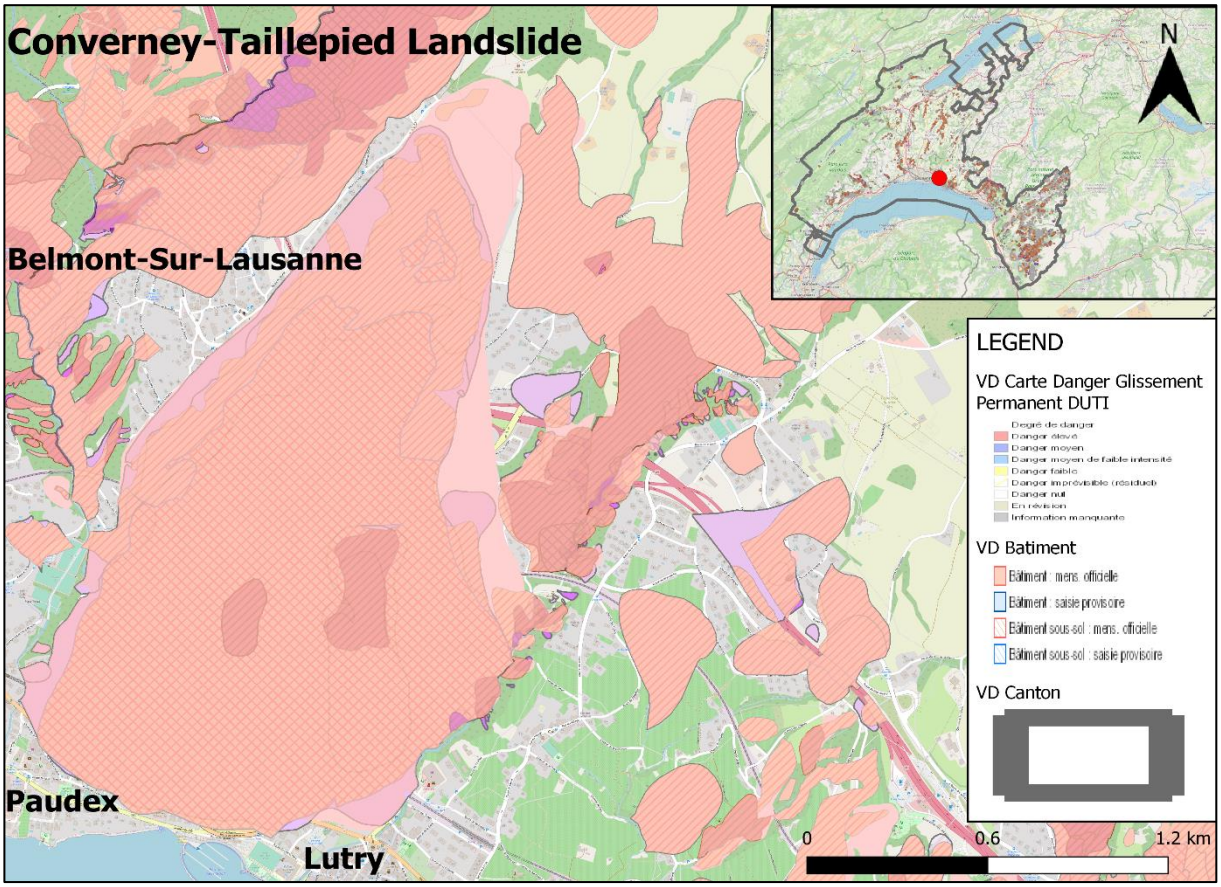

Figure 14: Geographical framework of Converney-Taillepied Landslide

- **La Frasse landslide**

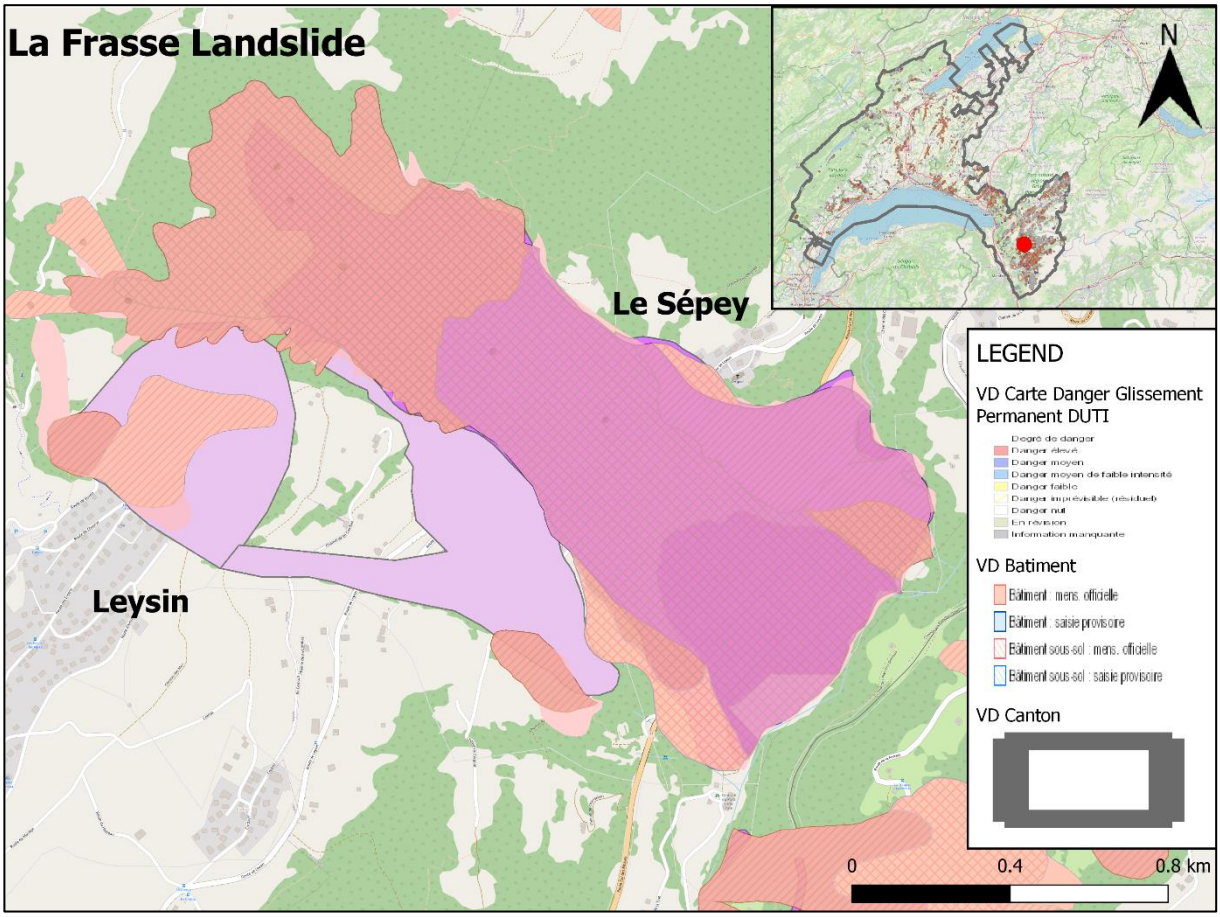

Figure 15: Geographical framework of La Frasse Landslide

- **Pont Bourquin landslide, Les Diablerets**

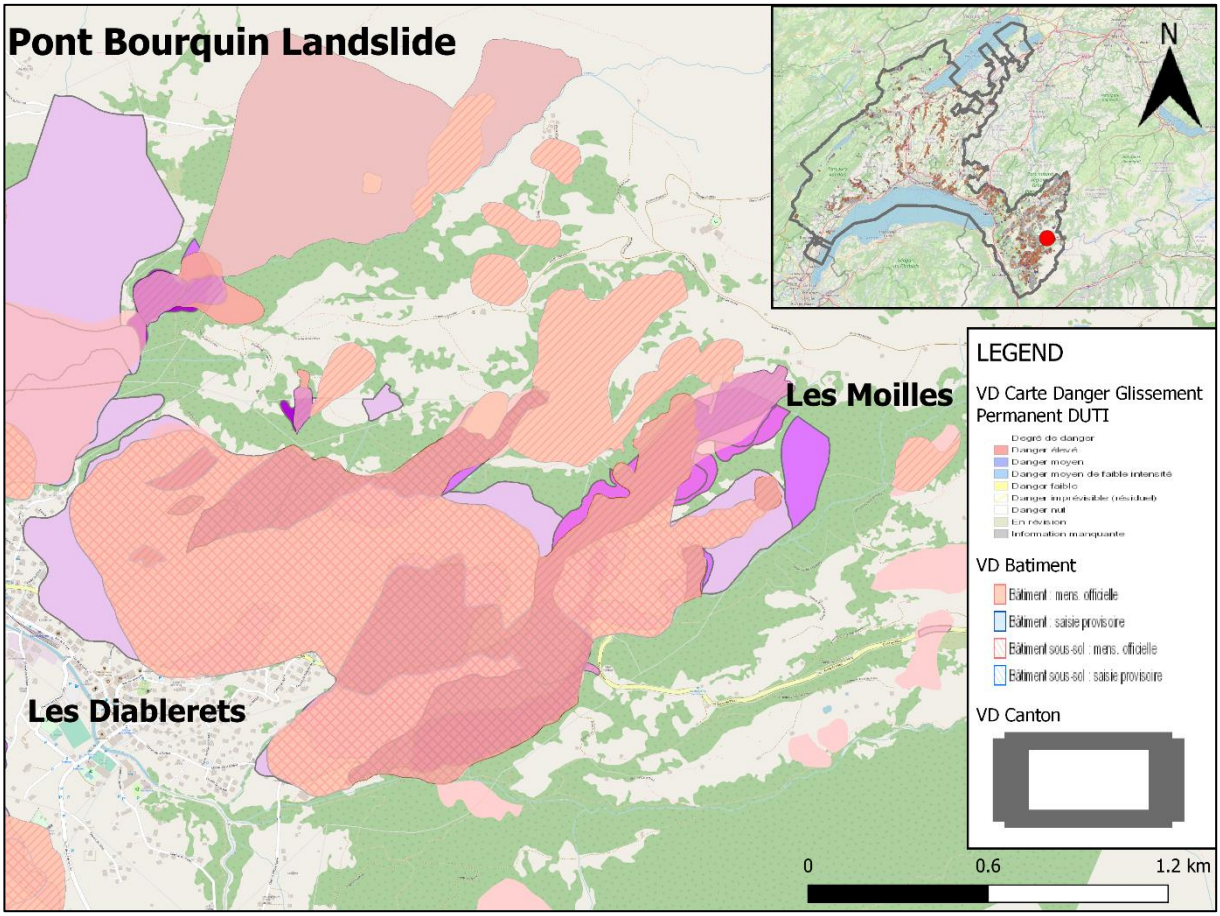

Figure 16: Geographical framework of Pont Bourquin Landslide