Landslide prevention project

Municipality of Chelsea

Information session

February 26, 2018

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Summary

- Context
- Risk Assessment
- Technical Solution
- Mitigation Measures
- Cost

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Context

- Land-use management maps : 2011, 2012 and 2017
- Fieldwork and inspections for mapping purposes : 2003-2012
- Helicopter fly-overs in 2008, 2009, 2011 and 2012
- Fieldwork and inspections for risk analysis 2012
  - Chosen area for preventive work
- Field inspections in 2015 (locally)

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Types of landslides

To help with the mapping of landslide-prone areas in surficial deposits carried out by the government of Quebec, landslides are grouped into two types based on the area of land affected at the top of the slope.

Slightly or non retrogressive landslides

Retrogression ≤ 2H or 40 m

Surficial

Rotational

Large retrogressive landslides

Retrogression > 2H or 40 m

Flowslide

Spread

Large retrogressive landslide

- Large retrogressive landslides occur in clayey soils and they affect large areas of land.
- At the top of the slope, the area affected by the landslide can reach dozens or hundreds of meters in a matter of minutes.
- The volume of the debris involved is huge and it can sometimes travel considerable distances.
- Buildings and infrastructure located on the land affected by the landslide can be devastated. Those located on the path of the debris can also be severely damaged.

Sensitive clay

- Large retrogressive landslides generally occur in sensitive clay deposits with specific geotechnical properties.
- Sensitive clay can go from a relatively firm consistency in its intact state to a near-liquid material in its remoulded state. This change of state requires no added water to the system.
- This specific property is due to groundwater flow in the clay deposit. Salt particles within the deposit are thus leached by the water flow, causing the chemical bonds in the clay to be gradually weakened.
- Sensitive clay can be remoulded during a landslide, as it breaks apart, slides down the slope and as its inner structure changes.

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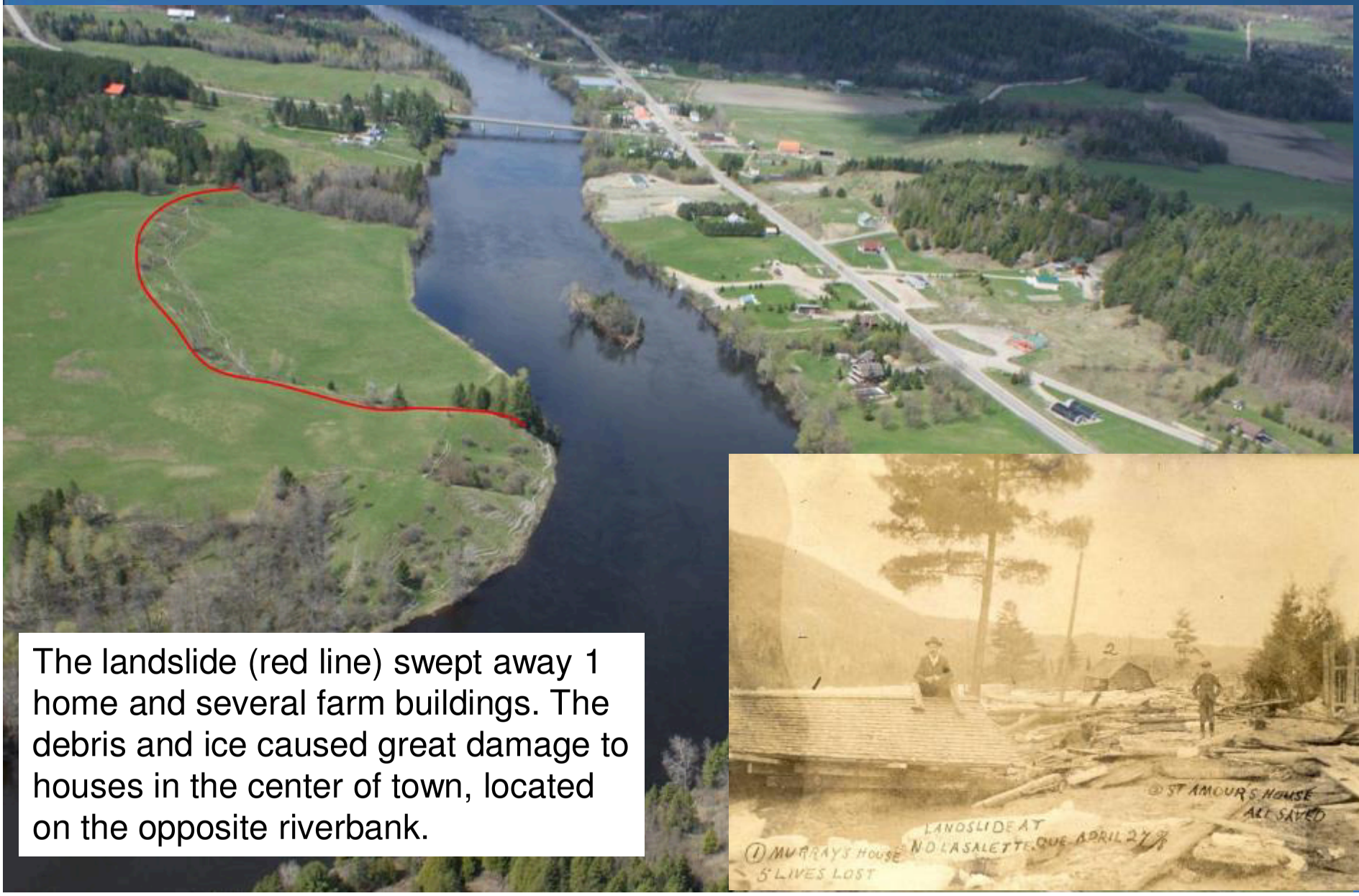
Notre-Dame-de-la-Salette, 1908



The landslide (red line) swept away 1 home and several farm buildings. The debris and ice caused great damage to houses in the center of town, located on the opposite riverbank.

Notre-Dame-de-la-Salette, june 2010

Landslide occured in an agricultural field and reached 425 m from the top of the slope.

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Recent events

Saint-David, dec. 2015

Saint-Maurice, may 2017

Saint-Luc-de-Vincennes, nov. 2016

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Risk Assessment

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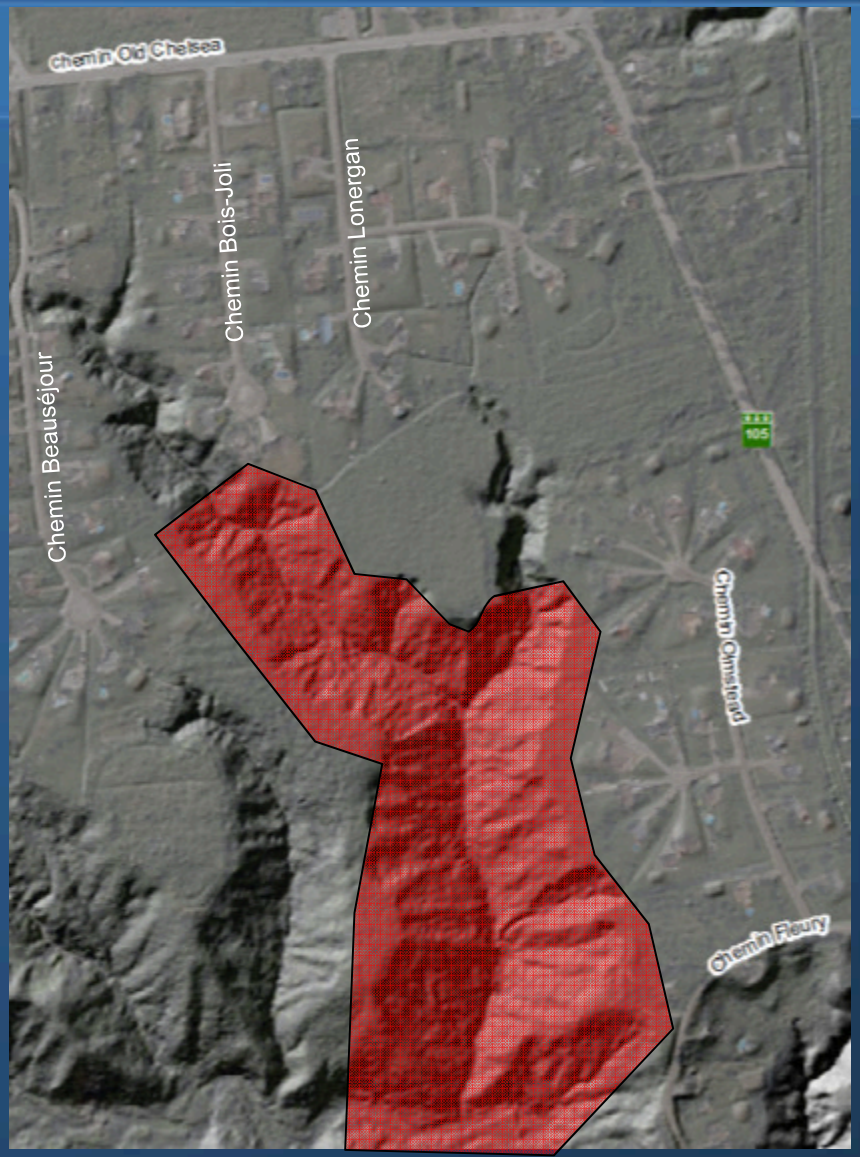
Study area

Affluent of Chelsea creek

- Area was chosen because level of risk is highest
- Risk (R) is calculated as the product of the probability that a landslide occurs (P) multiplied by the potential consequences (C) caused by that landslide.
- R= P x C



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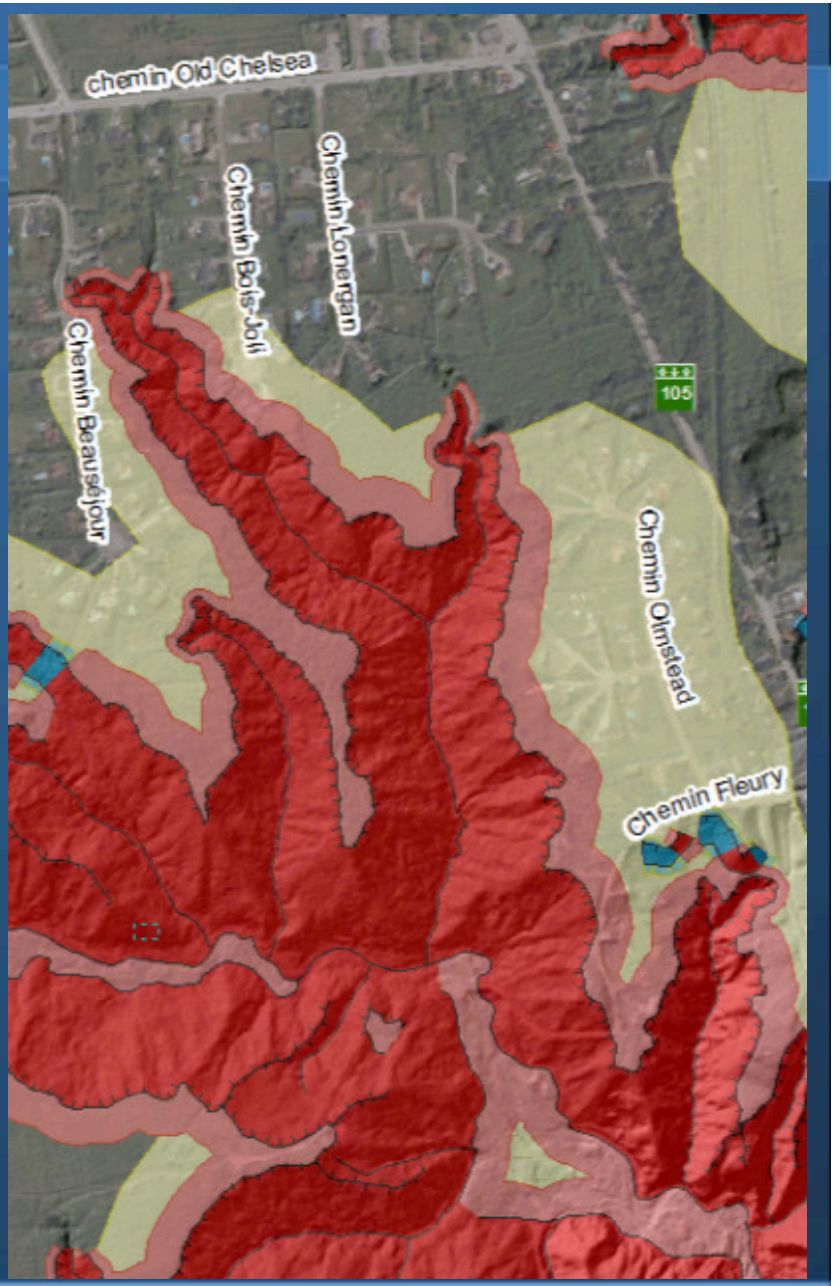
Study area

Probability (P)

- 12 to 35-meter high slopes
- Very severe erosion
- Sensitive clay
- Lateral spread scar in neighbouring creek

Potential Consequences (C)

Buildings	Roads
Top: 42	0,7 km
Base: 3	0,4 km



It is important to know that no imminent danger has been identified and the project consists of preventive works

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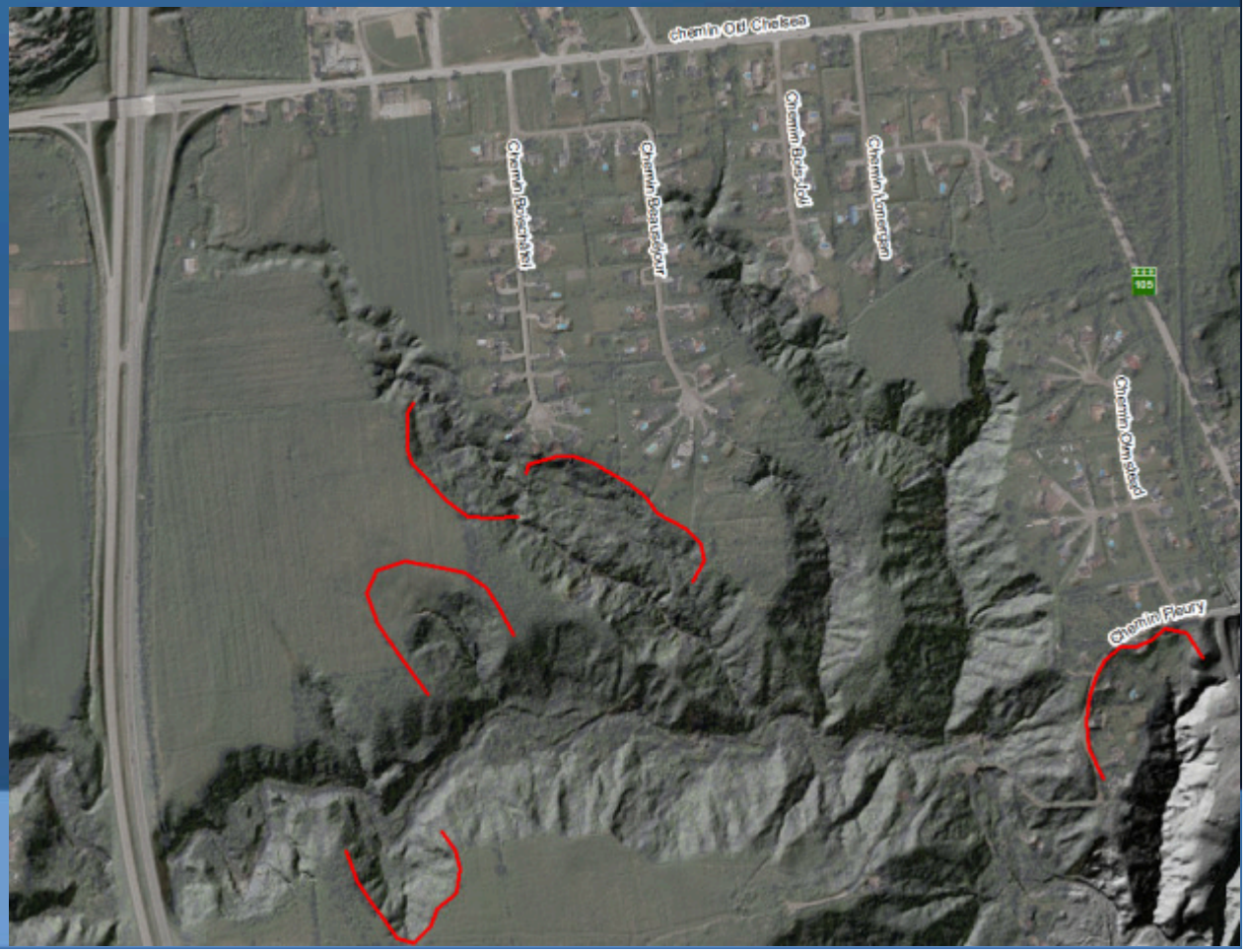
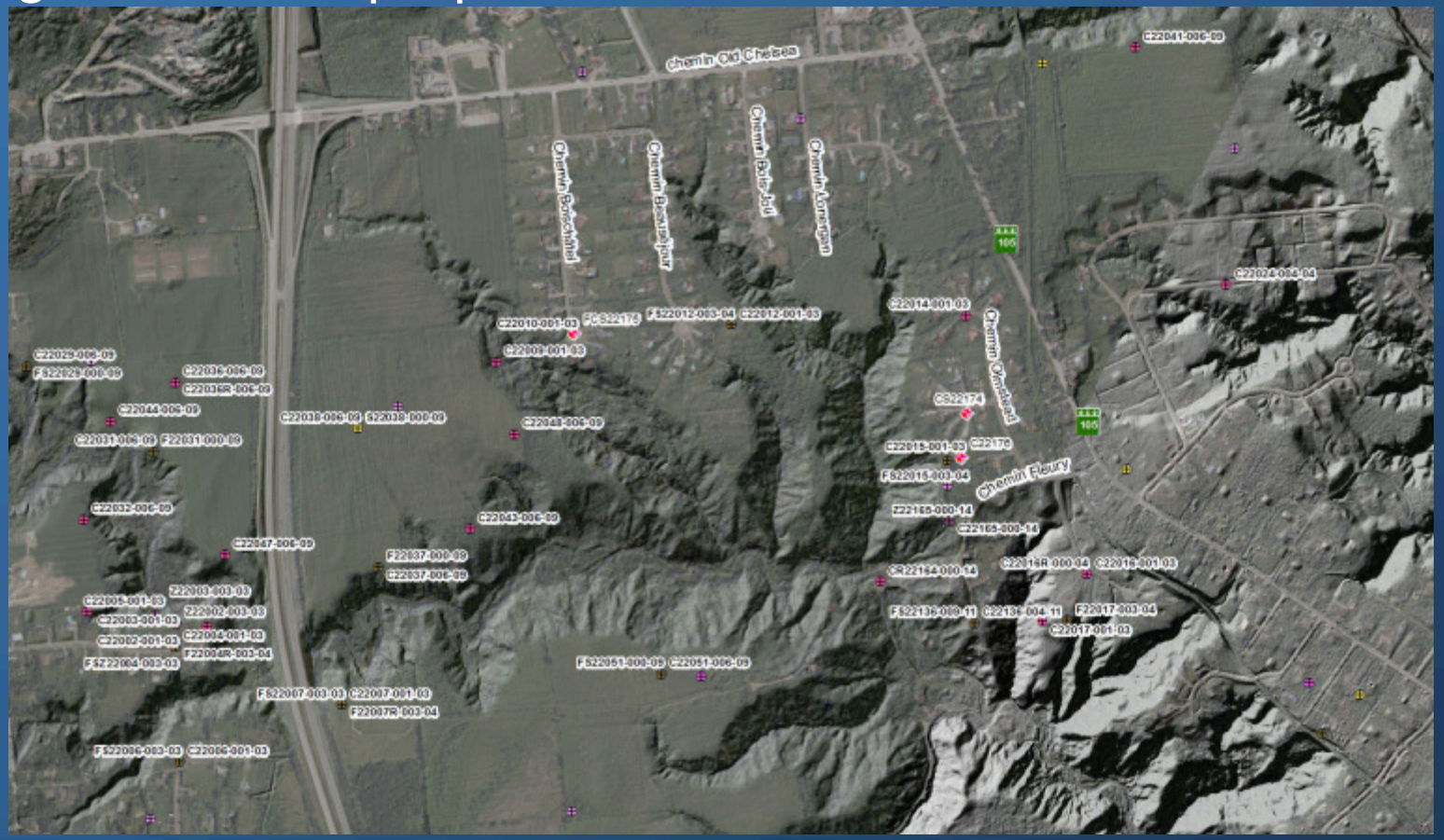
Geotechnical conditions

Large retrogressive landslide scars (in red on the map) are visible in the landscape. They indicate that the necessary conditions for these landslides are met in the area.



Geotechnical investigations

- Investigations allowed to determine local stratigraphy and geotechnical properties.



Field inspections were carried out from 2003 to 2015

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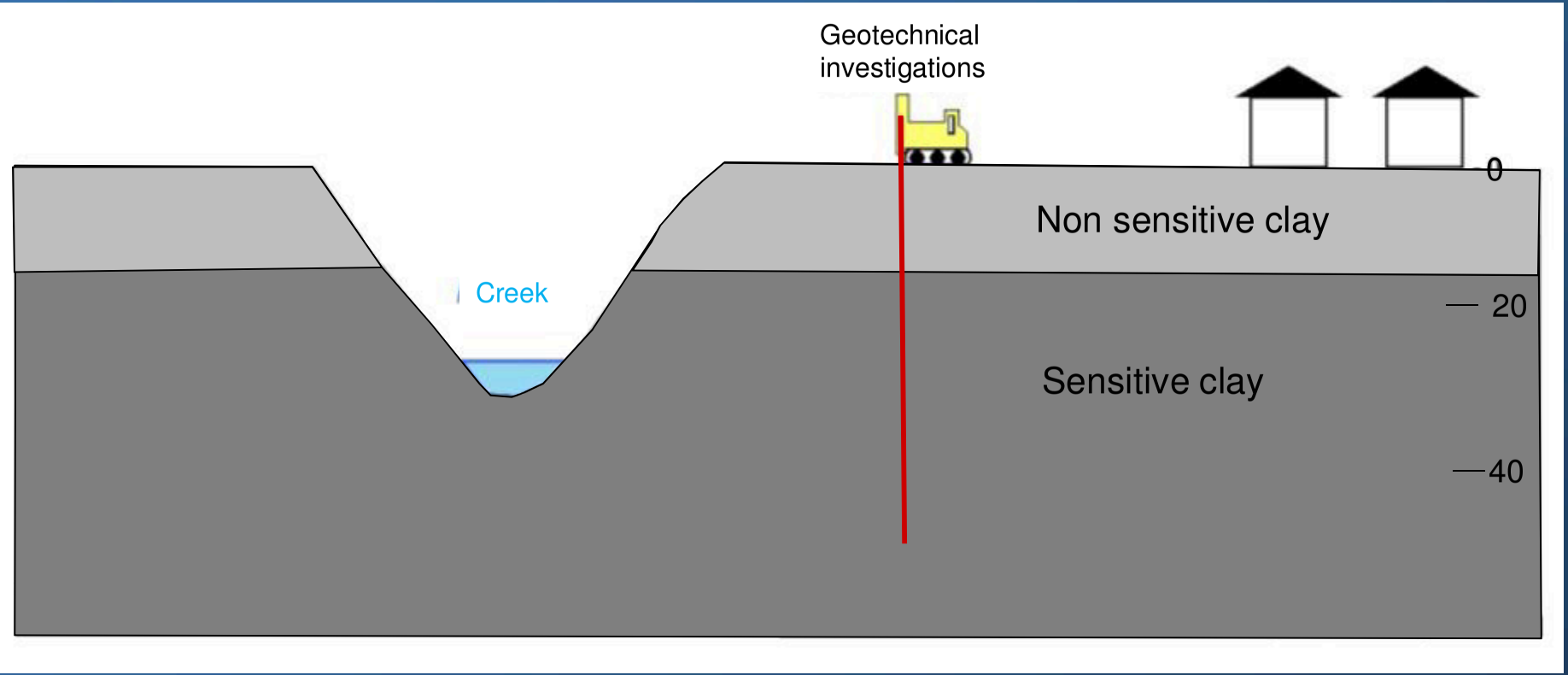
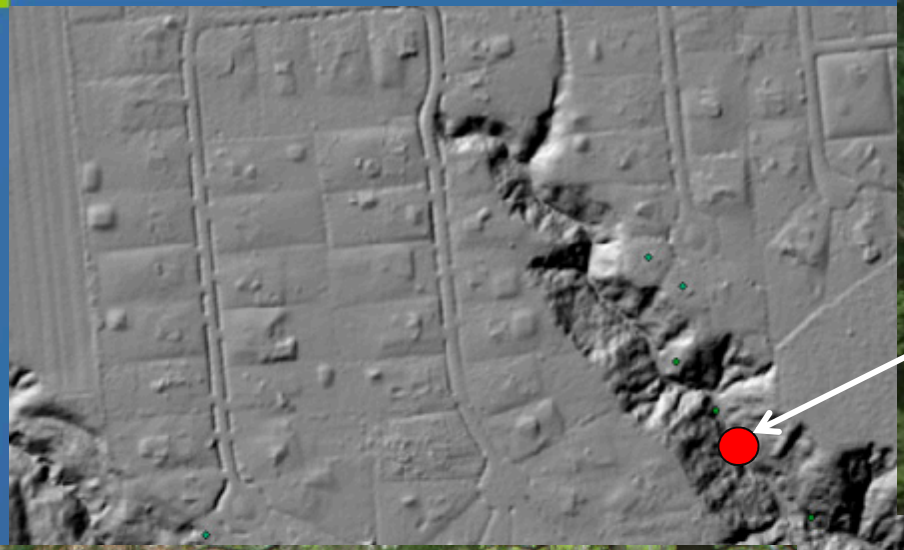
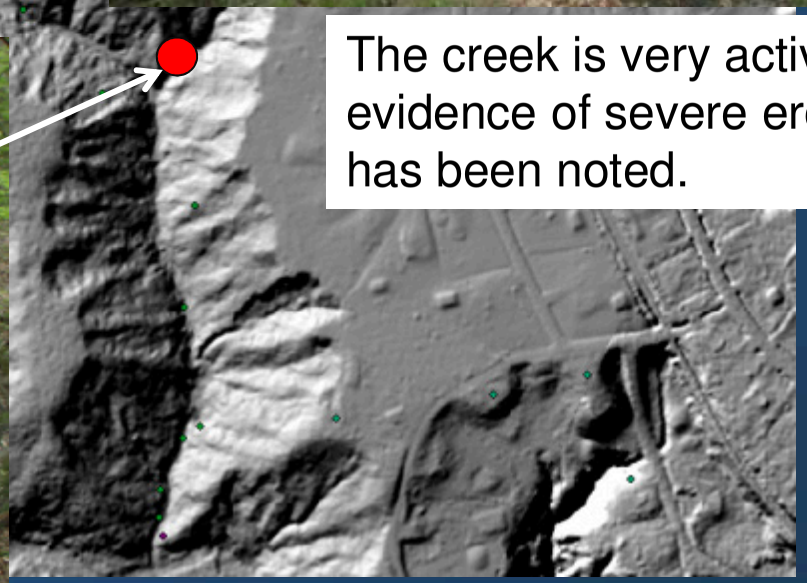
Geotechnical conditions



Investigations carried out in the area indicated that slopes are composed entirely of clay deposits. Sensitive clay is encountered from a depth of 15 meters.

Erosion





The creek is very active and evidence of severe erosion has been noted.

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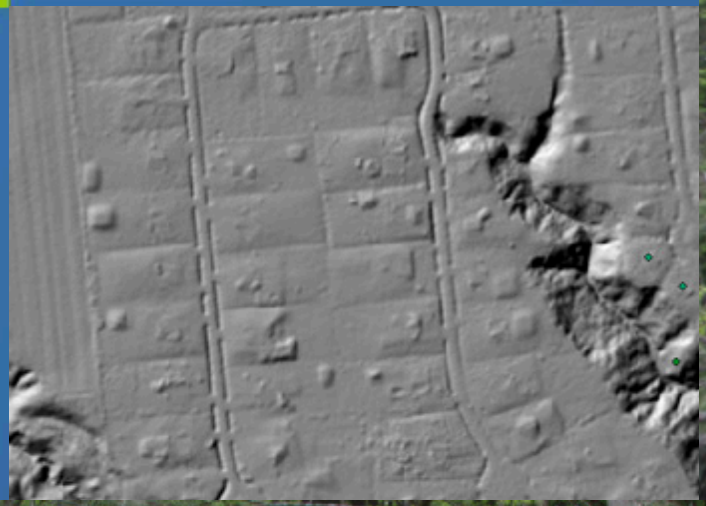
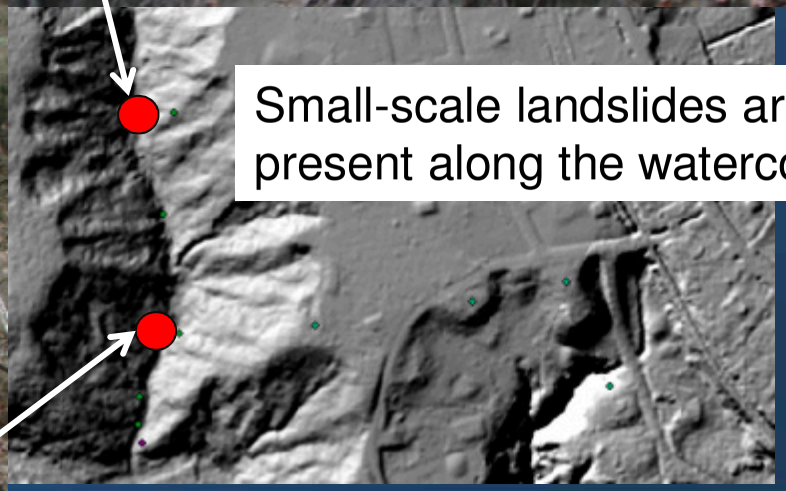
Erosion





Small-scale landslides are also present along the watercourse.

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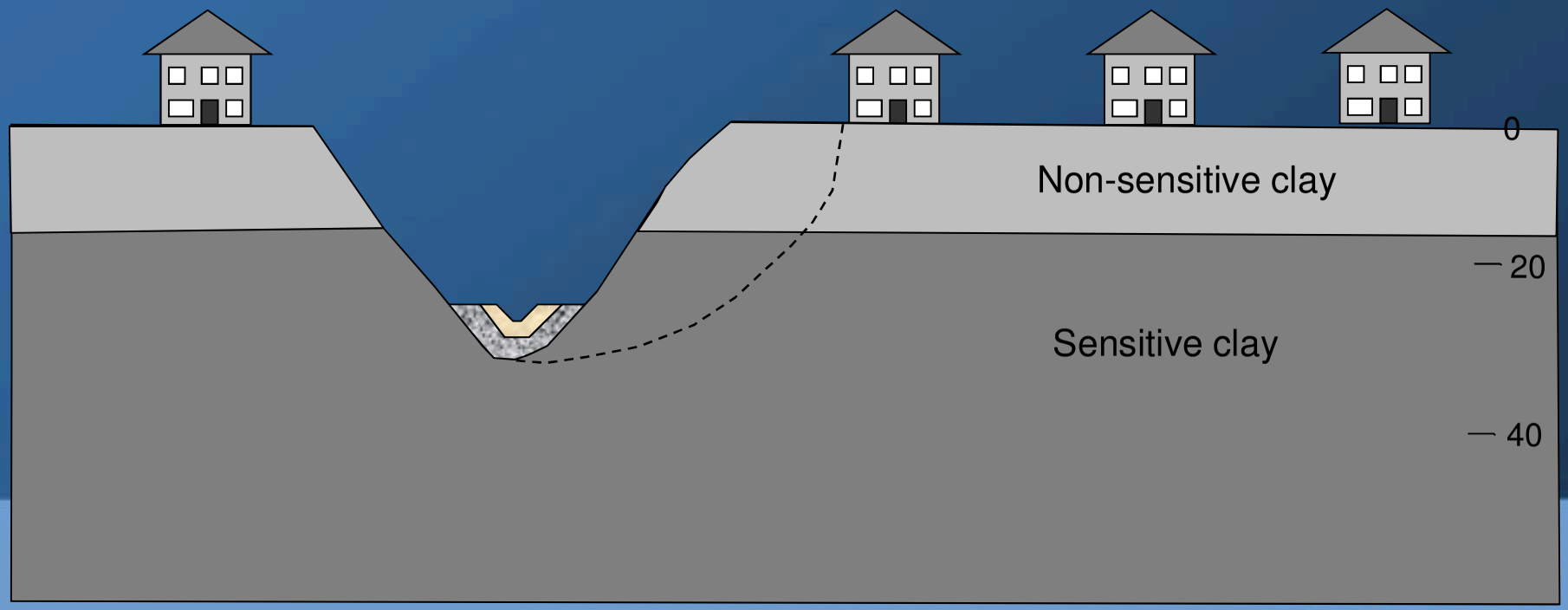
Technical Solution

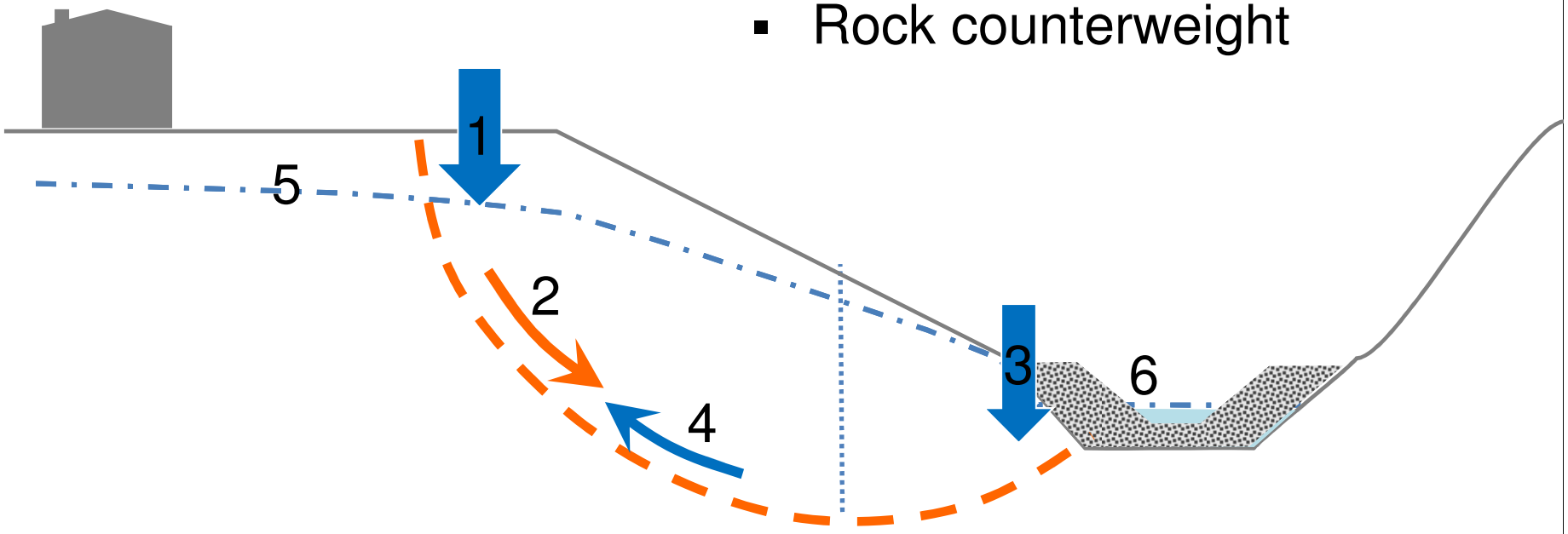
Solution

- Upon analysis of several possible alternatives, rock counterweight at the base of the slope was chosen as the solution to stabilize the slopes.



Slope stability

- Rock counterweight



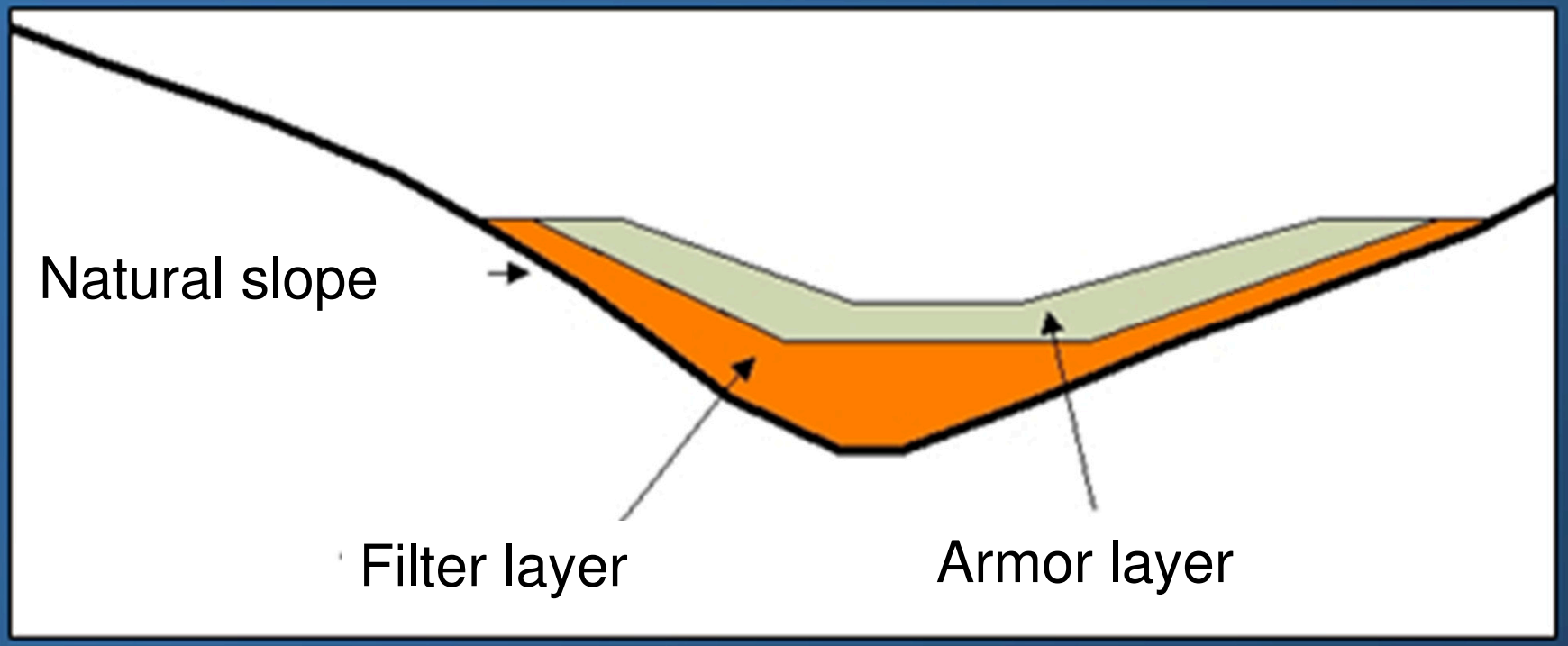
Very simply put, a landslide is the movement of a slope downward under the influence of gravity (1). In clayey soils, landslides often occur along a circular-shaped failure surface.

In order for the landslide to occur (2), the force in (1) must overcome several counteracting forces. The weight of the base of the slope, also under the influence of gravity (3), and the intrinsic strength of the material (cohesion and friction, 4) also act as counteracting forces. The slope is stable for as long as there is balance of the opposing forces. The balance can be disrupted when material is removed from the bottom of the slope, whether it is due to the erosion of the watercourse (natural causes) or to an excavation (human-related). Seasonal variations of the underground water table can also trigger a landslide. When the water table rises, the strength of the soil decreases, which affects the balance of forces.

A rock counterweight (6) acts as an additional weight to the natural counteracting force of the base of the slope (3) and helps stabilize a slope.

Examples of similar interventions

- Typical cross-section



Riprap will be put in place at the base of the slopes. The riverbed will be raised in order to add enough weight for an adequate increase of the factor of safety,

Examples of similar interventions

- Intervention carried out from the base of the slope.
- Heavy machinery uses counterweight as access road.
- To help water flow back on top of riprap as soon as possible, hydraulic pressure is used to clog riprap with finer rock particles.

During construction

Examples of similar interventions

- Riprap is covered with topsoil.
- Seeding is conducted to provide natural appearance.

During construction

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Examples of similar interventions

Work completed

2 years after completion

After

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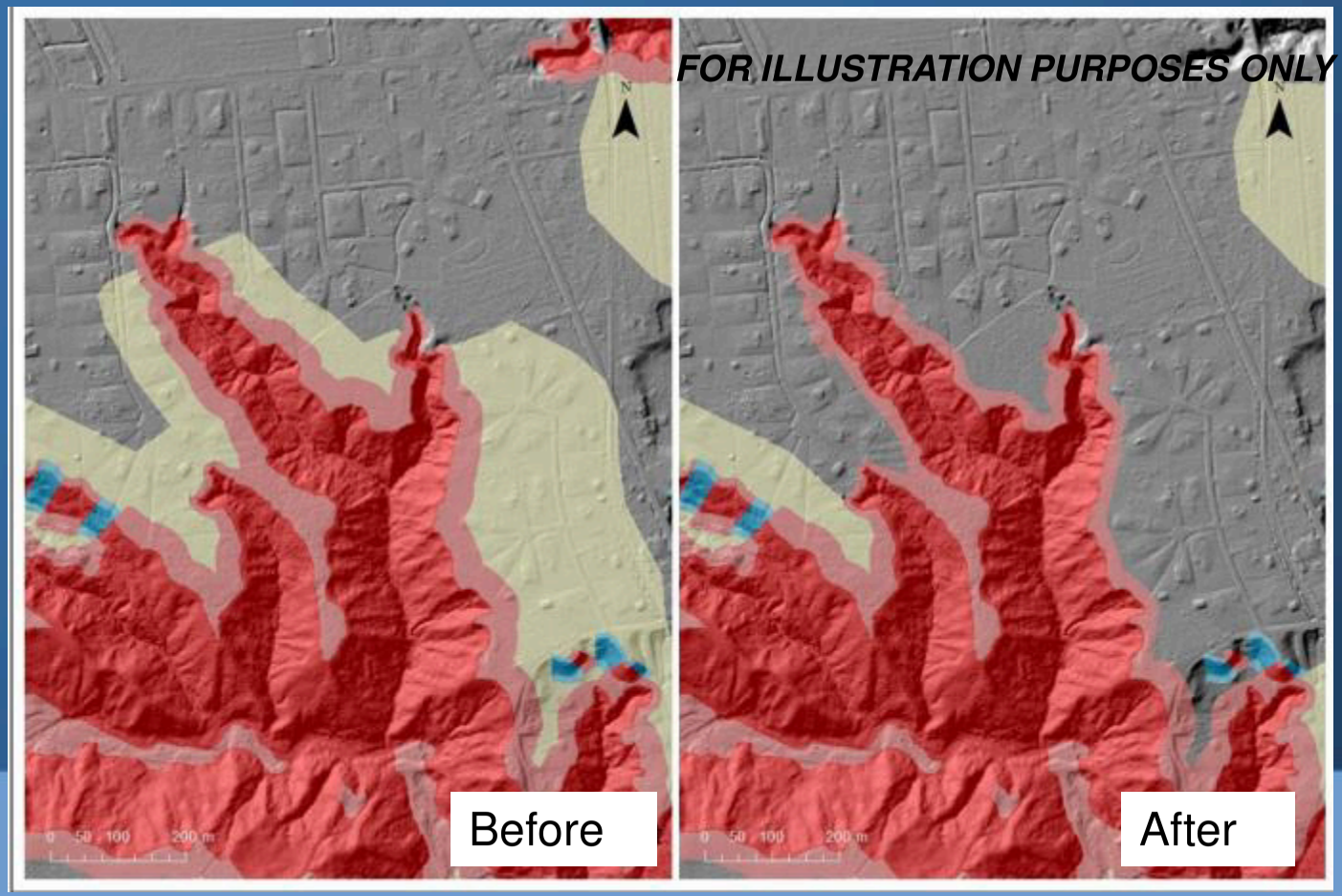
Review of land-use management maps

- Land-use management maps will be reviewed upon completion of the work. RA1 zones will be removed, while NA1 located at the top of stabilized slopes will be reduced from a width equivalent to two times the height of the slope (2H) to the equivalent of the height of the slope (1H).



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Mitigation Measures

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It is important to reiterate that no imminent danger has been identified and the project consists of preventive works

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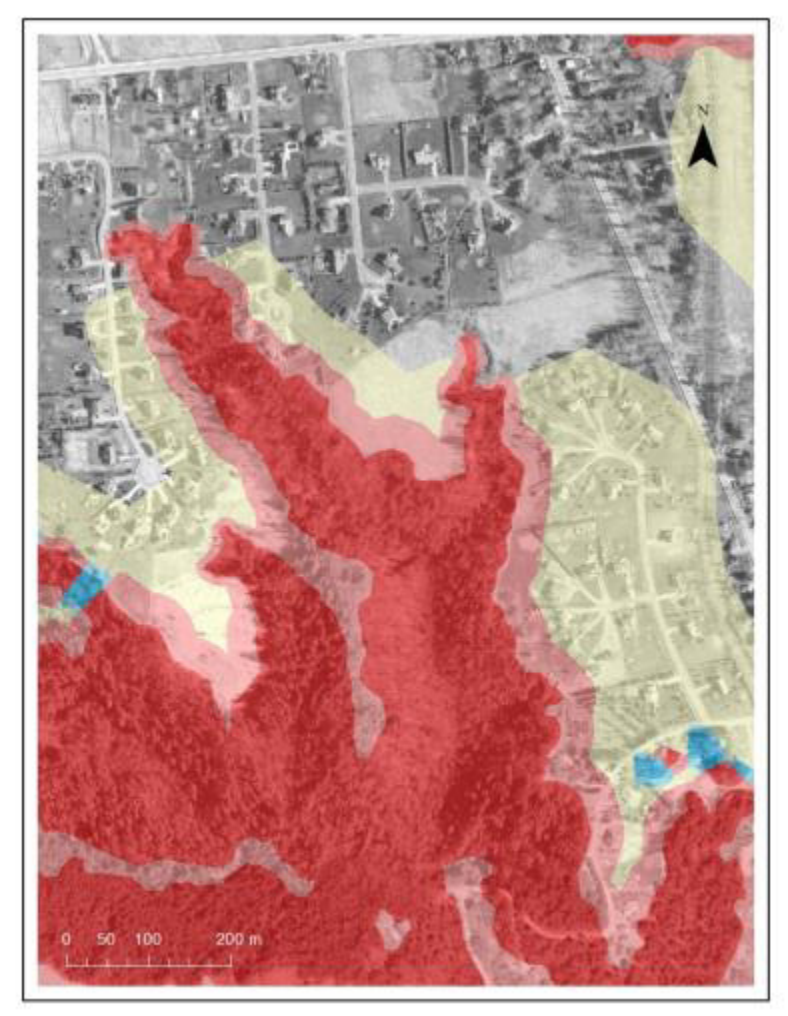
Compliance with regulations



Until works is completed , the best way to prevent landslides from happening is to comply with regulations by avoiding all backfilling, stockpiling and water concentration at or near the top of a slope.

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Report landslide activity

If you observe a landslide along the creek, report it to the municipality as soon as possible so that the situation may be assessed and dealt with.

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Aerial surveillance & monitoring

Drone fly-overs will be carried out in the Spring and in the Fall until construction is completed. Pictures and videos will then be taken to monitor the watercourse dynamics. These inspections will allow to identify new landslides and identify signs of recent severe erosion.

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Estimated cost

A preliminary estimate based on similar interventions carried out over the last 3 years indicates that the cost could range between $2 200 000 and $4 500 000.

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