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HEC-RAS ANALYSIS: RIVER L'AÏRE, GENEVA, SWITZERLAND

Flood Risk Assessment and Bank Stabilization Strategies for Sustainable River Management

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ABSTRACT

This study presents a detailed HEC-RAS analysis of the River L'Aïre, located in Geneva, Switzerland, focusing on flood risk assessment and bank stabilization. Conducted between January and March 2014, the analysis evaluates hydraulic behavior under varying discharge scenarios with recurrence intervals of 10, 30, 100, and 300 years. The study highlights the challenges posed by flooding, such as riverbank erosion and inundation of adjacent areas, exacerbated by intense rainfall and snowmelt.

The analysis identifies vulnerable sections along the 5.36 km river reach, particularly areas with eroded or unstable banks requiring stabilization. Existing measures, such as gabion protections and organic reinforcements, are evaluated alongside the need for additional interventions, including levees, flood storage basins, and retaining walls. The effectiveness of a newly constructed diversion structure at Pont Rouge, which successfully reduces discharge to manageable levels, is also demonstrated.

Using cross-sectional and hydrological data, the HEC-RAS model simulates flow velocities and floodplain extents, revealing critical areas prone to erosion and inundation. The findings underline the necessity of proactive measures, including temporary detention basins and structural reinforcements, to mitigate flood risks and safeguard nearby communities.

This analysis provides valuable insights for improving flood resilience along the River L'Aïre, offering practical recommendations for sustainable river management and infrastructure planning in flood-prone regions.

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1. HEC-RAS ANALYSIS: RIVER L'AÏRE, GENEVA, SWITZERLAND

This report presents a comprehensive HEC-RAS analysis conducted for the River L'Aïre in Geneva, Switzerland, during January to March 2014. The study evaluates the hydraulic behavior of the river, including flow velocities, potential erosion risks, and the impact of various recurrence discharges (Q10, Q30, Q100, and Q300). It aims to identify vulnerable areas along the riverbanks, propose protective measures, and assess the effectiveness of existing stabilization infrastructure. The findings highlight the critical need for additional flood control measures to safeguard adjacent settlements and infrastructure.

1.1. Introduction

Flooding can happen whenever flowing water surpasses its bank full stage and eventually inundates the surrounding adjacent areas. These may perhaps take place during the course of intense rainfalls and when a significant amount of snow melts. In conjunction with inundation, the increase of flow velocity may possibly erode and cause damage to fragile riverbanks resulting in more devastating damages. For this reason, it is best to consider proper protection measures along the vulnerable banks before the arrival of extreme flows.

Along the River Aïre many stabilization measures exist. For instance, one can see biological or organic protection as a measure to protect further degradation of banks. Moreover, certain gabion protections exist. Nevertheless, there are still spots where bank stabilization is needed. As it is pointed out in Figures 5 and 6, river-bank curvatures are prone to erosion and require protection. Construction of levees, temporary or provisional flood storage basins, and sometimes elevating the village above the flood line are some of the precautions that need to be implemented to alleviate future potential mishaps.

To demonstrate the impact of various time period discharges such as 10 years of recurrence time period (Q10), 30 years of recurrence time period (Q30), 100 years of recurrence time period (Q100), and 300 years of recurrence time period (Q300), the HEC-RAS model can be employed. In this analysis, the discharges for four recurrence time periods were assessed, and the findings of the analysis and the propositions of the result are stated in the following paragraphs.

Flooding along the River L'Aïre poses significant risks due to intense rainfall and snowmelt, causing the river to overflow its banks and erode fragile sections. This study uses the HEC-RAS model to simulate river behavior under various discharge conditions and propose effective solutions for mitigating flood risks and erosion.

1.2. The River Aïre

The River L'Aïre originates from the outskirts of Presilly, Beaumont, and Feigéres in France, merging at St. Julien en Genevois before flowing into Geneva. It passes through areas like Confignon and Lancy, eventually joining the River L'Arve. The study area includes a 5.36 km stretch of the river with diverse landscape features, as shown in Figures 1 to 6.

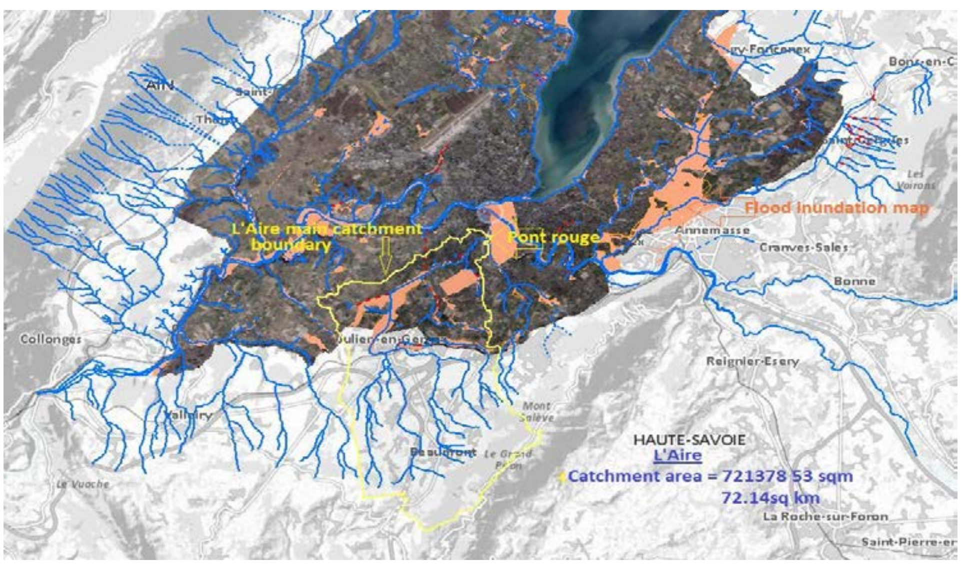

Figure 1 Catchment and watercourse of L'Aïre.

Figure 2 The river reach (5.36km).

Figure 3 Newly constructed diversion structure and tunnel.

Figure 4 Vegetation covers around 2.8 km of the Pont-Rouge (photo taken on 4.03.2014).

Figure 5 Eroded bank at around 4km upstream of the D/S end (Photo taken on 4.03.2014).

Figure 6 Unstable bank at around 4km of the D/S end (Photo taken on 4.03.2014).

1.3. Data and Methodology

The analysis utilized cross-sectional and hydrological data, though the data source was not clearly specified. Corrections were applied where necessary to ensure model accuracy. The roughness coefficients were assumed to be 0.05 for riverbeds and 0.1 for banks, reflecting the presence of cobbles and vegetation. Flow measurements for four recurrence periods (Q10, Q30, Q100, and Q300) provided the basis for simulating hydraulic conditions. Flows for the given recurrence time periods are presented in Table 1.

Table 1 Flow measured for four return periods.

Q (m^3/s)	Ouvrage détournement	Autoroute	Pont des Marais	Pont Rouge
Q10	**avant 3ème étape**	**63**	**18**	**28**
	après 3ème étape	63	33	42
Q30	**avant 3ème étape**	**80**	**35**	**45**
	après 3ème étape	77	36	45
Q100	**avant 3ème étape**	**102**	**57**	**67**
	après 3ème étape	84	39	48
Q300	**avant 3ème étape**	**120**	**75**	**85**
	après 3ème étape	98	46	56

Figures 7 and 8 indicate representation of the riverbed, the right and the left banks of the river.


Figure 7 Cobbles along the main riverbed.


Figure 8 Vegetation covers along the river (represent 60-70%).

1.4. Results and Analysis

As the highest possible discharge that can be taken care of at the Pont Rouge (tunnel entrance) is 60 Cumec, lowering the discharge below 60 Cumec is essential. The new construction work of the diversion structure reduced effectively the amount of discharge at the Pont Rouge. The result of this HEC-RAS analysis has also demonstrated the same.

The HEC-RAS simulations revealed flow velocities ranging from 0.63 to 3.95 m/s, with higher velocities causing significant erosion risks. At higher discharges, such as Q100 and Q300, inundation of adjacent areas becomes a serious concern. Protective measures like gabion walls, retaining structures, and temporary flood storage basins are essential to mitigate these risks.

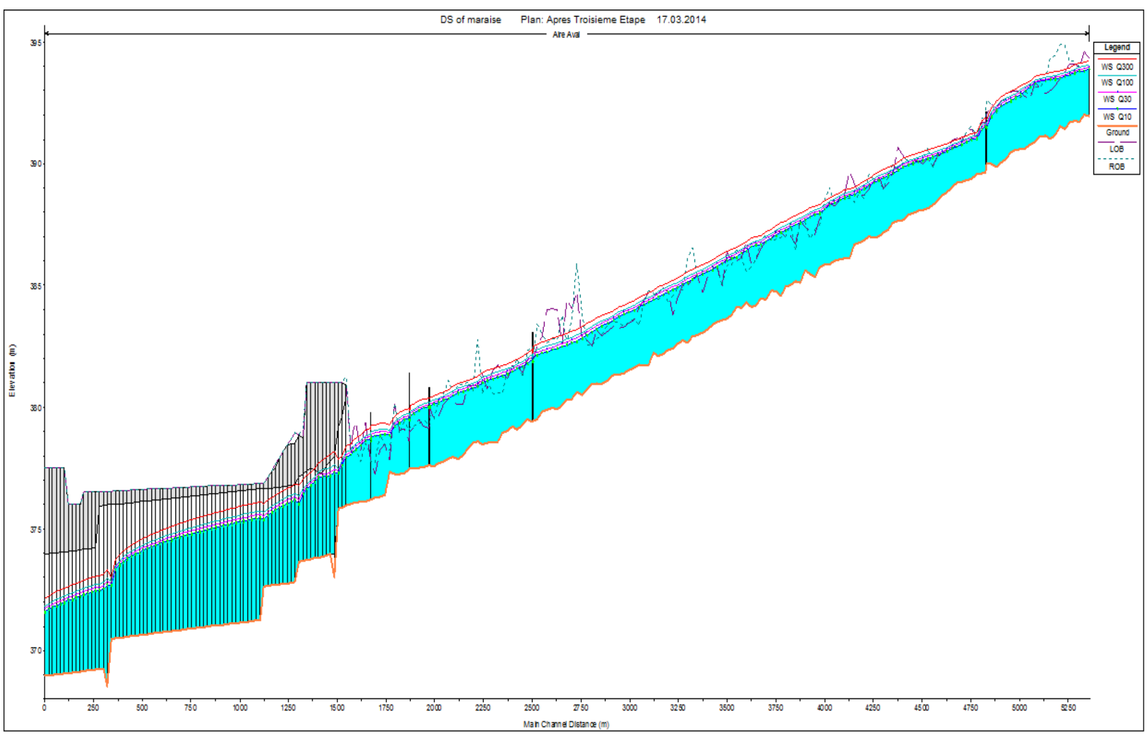

Figure 9 Longitudinal profile of the river for each return period.

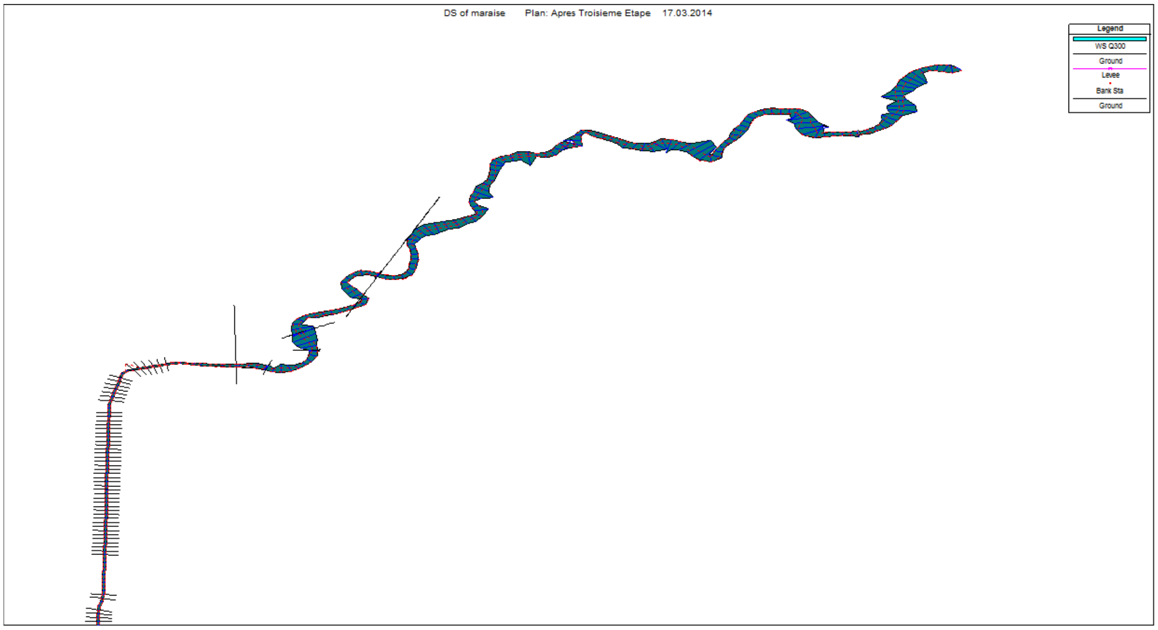

Figure 10 Plan view.

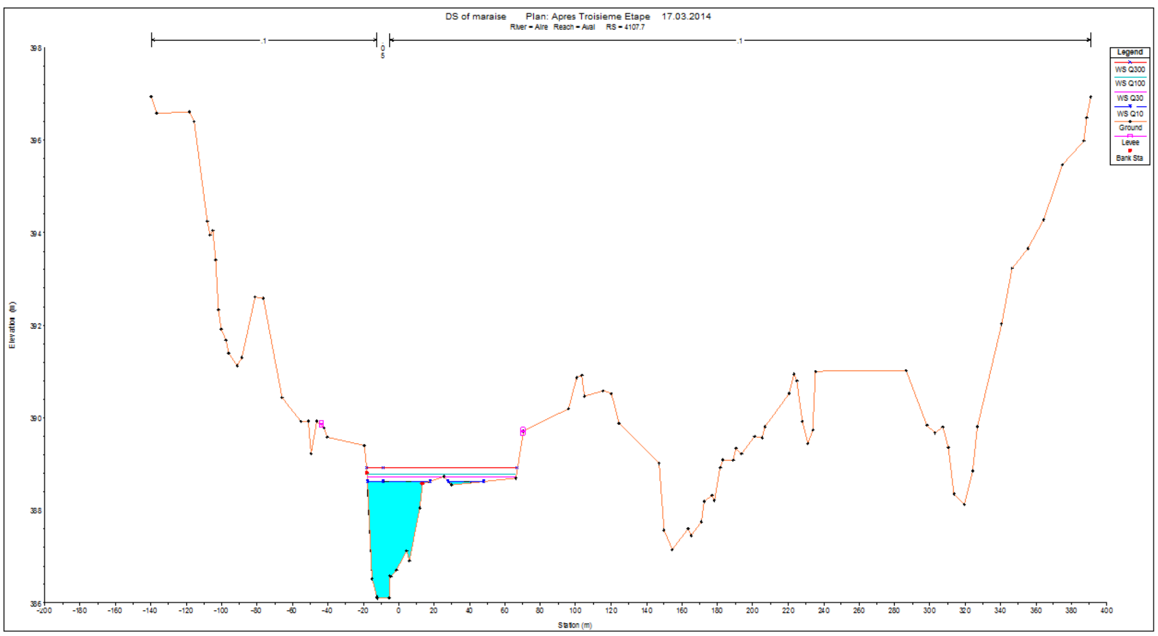

Figure 11 Cross-section at station 4107.7m.

1.5. Propositions

To address the identified vulnerabilities, the following measures are recommended:

- Installation of gabion walls or concrete retaining structures along eroded banks.
- Creation of temporary detention basins upstream to reduce peak discharges.
- Regular maintenance of existing stabilization structures to ensure long-term effectiveness.

1.6. Key Points

Location: Geneva, Switzerland

Reach Length: 5.36 km

Catchment Area: 72 sq. km

Period of Analysis: January – March 2014