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Flood protection analysis in artificially drained basins: lithology, land use and hydrology

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An interdisciplinary study is presented dealing with the flood prevention techniques designed and applied to two artificially drained basins in Northern Italy (Parma Province). The analyses include lithological, land use, hydrological, hydrodynamic and environmental aspects, in addition to structural and economical computations. This poster (Part 1) comprises lithology, land use and hydrology, while Part 2 describes hydrodynamic and ecological studies, although many subjects are coupled and a distinction in the information and modelling flow cannot be sharply traced.

The Lorno and Galasso Channels are the main outlets of two adjacent basins, whose areas are 20.8 and 91.3 km^2respectively. Their catchments are both very flat and are drained by a dense network of smaller artificial canals whose bed slope is often much less than $1m \cdot km^{-1}$: during the flood events the driving energy is provided by the water surface slope. The main channels share the final reach of 0.5 km just before their common outlet in Parma River, which in its turn flows into Po River 8 km down-stream. High stages in both Rivers cause huge backwater effects in the final 8 km of Lorno and the final 4 km of Galasso main Channels: to prevent the flood risks to the densely populated and historical town of Colorno, a lock is operating at the confluence of the channels, whose movable gates close whenever water level down-stream gets higher than upstream, so disconnecting both artificial channels from the natural streams.

While floods in Parma River are comparatively short (hours), floods in Po River may last weeks: moreover they usually happen during the fall season when high flows in the Lorno e Galasso basins are most likely to occur, lasting days. So in the October-December period, the joint probability of high water stages downstream of the lock, causing the closure of the gates, and of high discharge from the upstream catchments is not negligible: the probability of upstream water levels exceeding the local levees is therefore higher than the usually accepted standards for hydraulic safety.

From the lithological point of view, the soil within the region around the channels outlet is mainly silt and clay: till the XIX century it was a marshy area, with a complex ecological system, where many species of birds found their dwelling.

In conjunction with the project of three clay open quarries for the local brick industry, the analyses aim at ascertaining if these structures, once exploited, might be transformed and operate both as qualified ecological sites where the original natural environment can be restored, and as hydraulic devices (lateral reservoirs) to reduce the local risk of flooding.

Part I of the paper describes the lithology and land use in Lorno and Galasso basins, together with hydrological evaluations and modelling. In particular the following aspects are presented:

1. Zonation of overall catchment area into smaller tributary sub-basins; check of topology, functioning and efficiency of the drainage network; evaluation of morphological, lithological and land use features of sub-basins sides in view of the overland processes; evaluation of morphological and hydraulic properties of each canal within the drainage system, in view of the channel processes.
2. Rainfall analysis, focussing on the statistics of extreme event likely to generate the flood waves relevant to the hydrodynamic modelling in the main channels, to the design of flood prevention devices and to the risk analysis of the system.
3. Through hydrological simulation, evaluation of probabilistic flood hydrographs as a function of return time likely to occur within the drainage system; evaluation of the joint probability distribution of downstream boundary water stages (Po and Parma Rivers) and discharge hydrographs in Lorno and Galasso basins.

Both catchments are ungauged, as far as discharge measurements are concerned. There is one rainfall time series available at an upstream boundary location, whereas the downstream boundary conditions can be reasonably interpolated between the stage observations at two hydrometers along the Po River; the water levels in Parma River are locally available.

The hydrological simulation is performed through a physically based rainfall-runoff transformation model, whose parameters are estimated: a) from physical properties of the features they describe, b) from previous modelling of similar basins within the same region (although very close analogies cannot be established between local catchments), c) by assuming each parameter as a random variable normally distributed and calibrating the hydrological model trying to minimize the square distance of the final vector of parameter estimates from the vector of their distribution averages.

The lack of discharge time series entails a complex coupling of hydrological and hydrodynamic models in order to match some qualitative records of flooding periods and effects available during the last 60 years in the overall network system.