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Modelling engineering solutions to groundwater flooding in a lowland karst catchment

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The Gort lowland karst catchment covers an area of approximately 500km2 in south Co. Galway on the western coast of Ireland. The karst of the Gort lowlands is underlain by highly permeable epikarst with a well-developed conduit and cave system dispersed throughout the catchment. During groundwater flooding events, water is exchanged between the surface and subsurface in large volumes throughout the catchment through sinking streams, large springs and estavelles. The outlet for the catchment is through a submarine groundwater discharge (springs located at the intertidal zone of the bay) at Kinvara Bay. Groundwater flooding in the catchment typically occurs following periods of sustained heavy rainfall when sufficient capacity is not available in the bedrock to store and convey water to the sea. The underground karst conduit system therefore surcharges to the ground surface through a system of estavelles and floods low lying areas of ground known as turloughs (ephemeral lakes). Extensive flooding associated with these turloughs occurred twice in the last decade, which led to considerable damage and disruption.

A pipe network model of the karst conduit system of the Gort lowland karst was developed in order to simulate the flooding mechanisms of the turloughs/flood areas across the catchment and simulate flood alleviation options. A critical aspect of the model calibration involved ascertaining the degree of underground karstic connections between turloughs and the likely location and pathway of associated karst conduits. The calibration process therefore utilised a combination of available field data (dye tracing, water chemistry data etc.) and cross-frequency analysis on the turlough fluctuation time series data in order to determine the nature of connections. The availability of high accuracy LiDAR data of the catchment allowed the flooding regime to then be accurately simulated on the ground surface. The model was calibrated using historic continuous water level data which was available for a number of turloughs in the catchment and was then validated using historic peak spot flood levels. A 2D model utilising a mesh linked with the pipe network was also developed allowing further validation of peak flooding extents and more accurate modelling of overland flow paths. The model was then used to identify and investigate appropriate groundwater flood alleviation measures for the catchment. The implementation of any solution to groundwater flooding within the catchment is complicated by the need to also protect the sensitive groundwater habitats within the turloughs which are protected under the European Habitats Directive. Any potential change designed to alleviate flooding must also consider potential impacts on the functioning of the sensitive turlough habitats across the lowlands. Engineering solutions considered included channelising overland flood pathways, the construction of hard defences, re-routing floodwater between flood basins and the construction of a new channel from the lower end of the catchment to the sea. Various combinations of potential engineering solutions have been simulated in order to identify an optimum suite of measures, which would mitigate the impacts of extreme flooding whilst also maintaining the functioning of the turloughs from an ecological perspective.