Impacts of Retention Basins on Downstream Flood Peak Attenuation in the Odaw River Basin, Ghana

The indication of a changing climate has raised concerns regarding the future sustainability of current flood protection systems. Accra is the most populated urban city in Ghana and it is estimated that 172,000 residents are at risk of at least a 10-year flood return period. The Odaw River basin has been identified as one with the highest flood risks as it passes through most urban communities in Accra. Over 58 percent of Accra's population live within this catchment. The Greater Accra Resilient and Integrated Development (GARID) Project funded by the World Bank proposed the idea of two retention basin sites (i.e., Atomic East and Atomic West) aimed at building long-term capability for flood risk management and mitigate flooding within the Odaw River Basin. According to Hydrological Services Department (HSD), the design for the Atomic West retention pond has begun with peak discharges simulated but none for the Atomic Eastern site. This study focuses on the development of an event-based hydrological model of the Odaw River Basin (ORB) focusing on the impacts of a retention basin structure on flood peak attenuation downstream of the ORB using HEC-HMS coupled with HEC-RAS models for different flood scenarios. Calibrated and validated HEC-HMS Models were used to forecast floods in terms of peak flows corresponding to different return periods using IDF tables followed by flood inundation maps caused by a return period flooding event. The results from the HEC-HMS calibration and validation (NSE > 0.65) indicates a good model performance in representing the runoff characteristics of the basin and therefore very reliable for flood forecasting. The application of the calibrated model to forecast the peak flows corresponding to return periods of 30-to-1-year recorded values ranging from 131.1m^3 /s, 121.6 m^3 /s, 106.4 m^3 /s, 88.8 m^3 /s and 59.3 m^3 /s without a retention basin structure at Atomic East within ORB. Depth of water, velocity distribution and water surface height obtained after 2D flow simulation were utilized to decide the degree of flooding. Simulated discharges from HEC-HMS were used for the 2D Unsteady flow simulations in HEC-RAS to generate a flood inundation map. The presence of a retention basin structure iv caused an attenuation in peak flows downstream the ORB by 8.1%, 8.4%, 9.1%, 13.6% and 13.2% respectively for the different return periods. Furthermore, the flood volumes reaching downstream of the basin also reduced by 2.3%, 2.5%, 2.7%, 3.0% and 3.8% respectively due to the presence of the retention basin structure. The retention basin also increased the basin lag time by an average of 4-hours across all different flood scenarios. It has been established that the presence of a retention basin significantly reduces the impact of flood at downstream reaches of the ORB causing a flood peak attenuation and increasing the basin lag time which is essential information and a flood warning tool required by stakeholders such as the Disaster Management Organizations (DMOs) for decision making and effective flood management in the basin.