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Integrated Hydrologic-Hydraulic Modelling of Lesser Slave Lake Watershed using MIKE-SHE Modelling Software

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The Lesser Slave Watershed Council, in partnership with Alberta Environment, the Sustainable Resource Development Department of Alberta, industry, municipalities, and other stakeholders, is currently in the process of developing a sustainable water management plan for the Lesser Slave River watershed, including the Lesser Slave Lake. A solid understanding of the hydrologic and hydraulic response of the watershed is required to develop such a plan. The integrated MIKE-SHE and MIKE 11 software has been adopted to develop an integrated hydrologic-hydraulic watershed model for this purpose. The MIKE-SHE software is a comprehensive deterministic, distributed and physically based hydrologic modelling system, capable of describing the entire land phase of the hydrologic cycle.

The Lesser Slave Lake watershed is located in north-central Alberta and is the third largest lake in the Province of Alberta, with a surface area of approximately 1160 km2. Its only outlet, the Lesser Slave River, flows about 80 km in a southwesterly direction and discharges into the Athabasca River. The drainage basin area, at its confluence with the Athabasca River, is approximately 20,600 km2. Flow into the Lesser Slave River from Lesser Slave Lake is controlled by a 30-m-wide fixed weir located approximately 1.5 km downstream from the lake outlet.

The MIKE-SHE model generates overland and subsurface runoff utilizing physical and meteorological variables, and the MIKE 11 model routes the generated runoff through the networks of rivers and lakes. In the current study, the overland flow has been simulated using the detailed finite difference modelling technique, and flows within unsaturated and saturated subsurface zones have been simulated using simplified modelling approaches due to lack of availability of field data. The watershed is represented by a network of sub-basins, river segments, and subsurface layers. Hydro-meteorological, bathymetry, surface, and subsurface data, along with the topography of the watershed, are the main inputs required to develop the watershed model.

The developed watershed model has been calibrated and validated against time series of observed discharge and water level data. In addition to qualitative assessment with graphical displays of daily runoff and cumulative discharges, the model simulation results have been evaluated quantitatively using statistical measures. Statistical parameters, including regression coefficients, root-mean-square error (RMSE), mean deviation, coefficient of determination (CD), and Nash-Sutcliffe coefficient (EF%), have been used. A reasonable agreement between the observed and simulated flow and water level hydrographs has been obtained for the simulation period extending from 1984 to 2004. Sound professional judgement must be exercised in interpreting model results since the deviations between simulated and observed variables indicate uncertainties in both input data and model parameters.

The developed watershed model will ultimately be used to establish the historical hydrologic and hydraulic responses of the entire basin under natural and existing regulated conditions, and to assess various lake water management scenarios based on different configurations of the weir structure and land use changes. The paper presents the findings of the application of the watershed model in assessing the effect of altering the geometry of the lake control structure on the lake levels.

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