Development of an Integrated Hydrologic-Hydraulic Model for the Lesser Slave River Basin

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Lesser Slave Lake
Photo credit: Travel Alberta

Presentation Outline

- Project Objectives
- Overview of Modelling
- Data Preparation and Mike She Model Setup
- Data Preparation and Mike 11 Model Setup
- Model Calibration and Validation
- Conclusions and Further Works

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Project Objectives

- The Lesser Slave Watershed Council is in the process of developing a sustainable water management plan for the Lesser Slave River watershed
- A thorough understanding of the hydrologic and hydraulic response of the watershed is required to develop such a plan
- In order to model the various components of a hydrologic cycle including interaction between surface water and groundwater, MIKE-SHE software has been selected for the integrated model development
- The developed model will be utilized to assess various scenarios including land use changes and the configuration of the existing Lesser Slave Lake control structure on lake levels and outflows

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Overview of Modelling

- Two models have been built – MIKE SHE and MIKE 11 (software developed by DHI)
- Mike She Model computes surface runoff and baseflow based on climate and physical data
- Mike 11 routes flows through rivers and lakes
- Measured flows and water levels are compared against Mike 11 Modelled results (Calibration and validation)
- Calibrated models are then applied for scenario analysis

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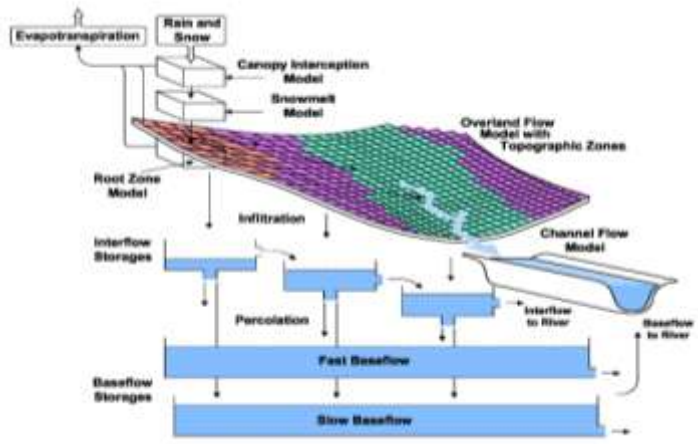
Watershed Modelling – Conceptual Representation



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Model Input Data Required

- Watershed Maps
- Digital Elevation Model (DEM)
- Landuse data
- Climate data (Precipitation, Temperature, Evaporation/Evapotranspiration)
- River and Lake Networks
- Cross sections of Rivers and Lakes
- Soil Type and Subsurface data
- Leaf Area Index and Root Depth
- Groundwater Elevation

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Mike She Model Setup

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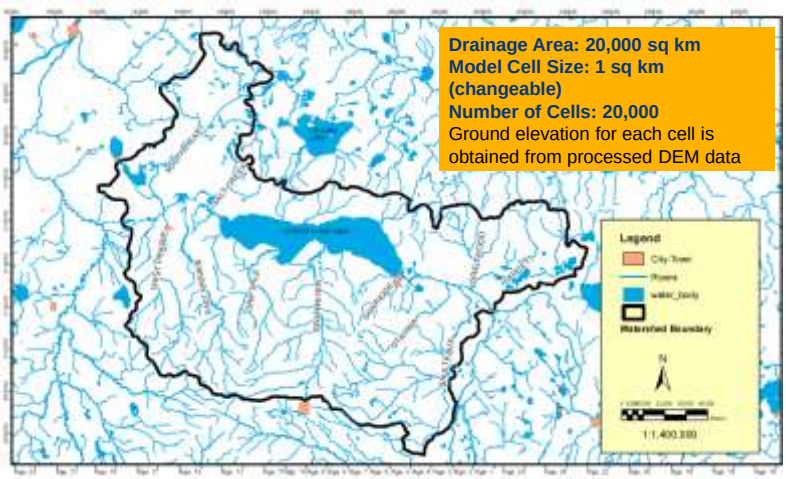
Study Area



Drainage Area: 20,000 sq km
Model Cell Size: 1 sq km (changeable)
Number of Cells: 20,000
Ground elevation for each cell is obtained from processed DEM data

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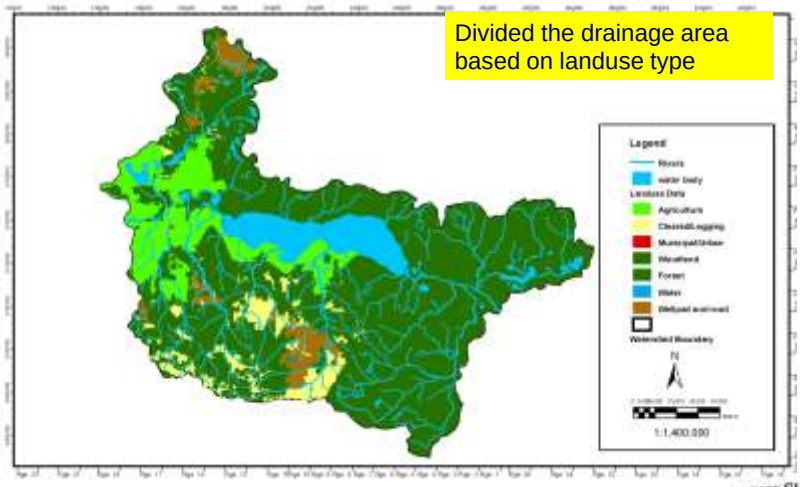
Landuse Input Data



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Climate Data Collection

- Inadequate historical climate data readily available for the study area
- Inadequate number of monitoring stations located in the study area
- Based on literature search, estimated historical climate data were obtained from Alberta Agriculture (1960-2005)
- Alberta Agriculture prepared historical climate data on a township basis
- Climate data were processed to meet model needs
- 30 Precipitation and Temperature locations were selected within the study area as shown in the following slide

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Meteorological Stations

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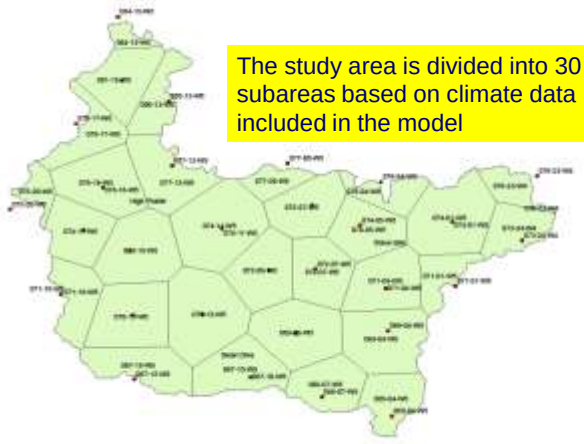
Distribution of Township Climate Data



The study area is divided into 30 subareas based on climate data included in the model

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Evaporation and Evapotranspiration

- Evaporation and Evapotranspiration data are computed to cover the period from 1960 to 2005
- Computed data were compared against the limited available data
- Estimated historical data were processed to meet the model needs

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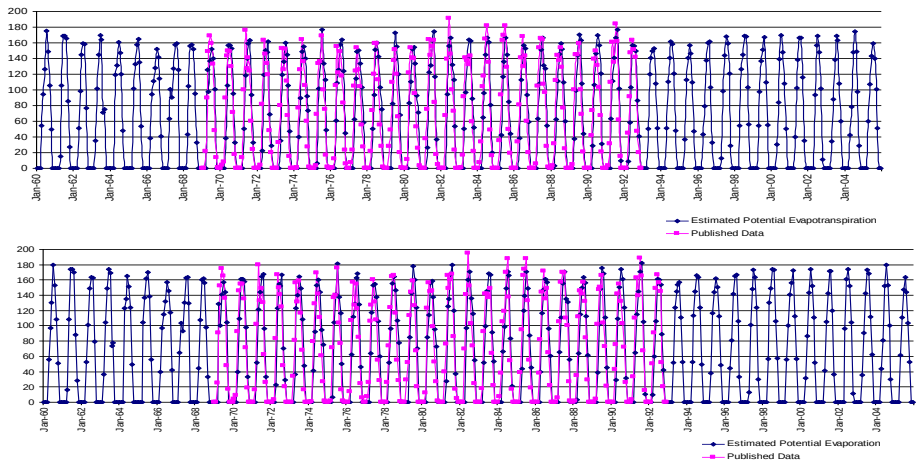
Evaporation and Evapotranspiration



Estimated EVP and ET data matched well with AENV data

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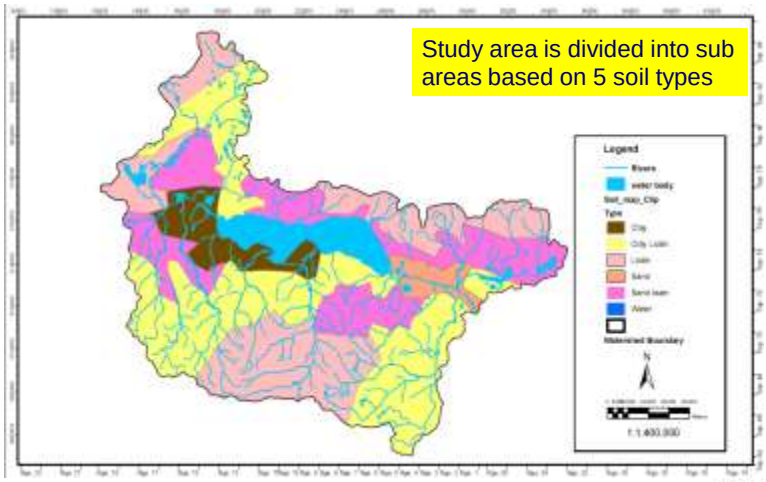
Soil Distribution



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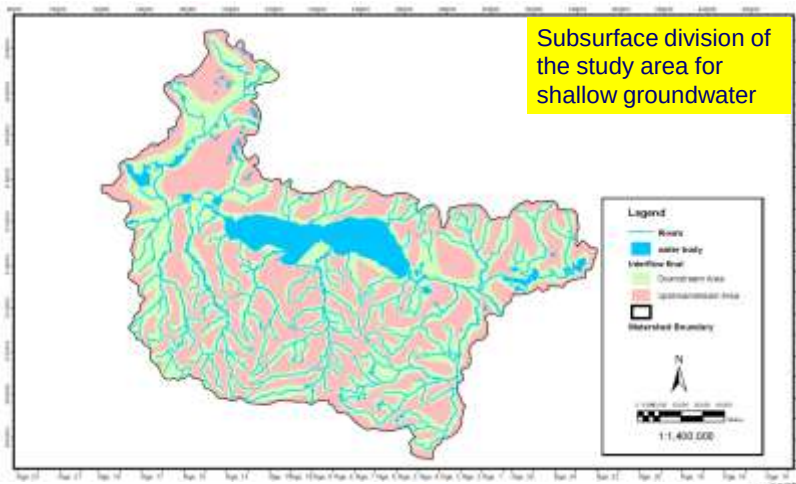
Subsurface Flow Modelling



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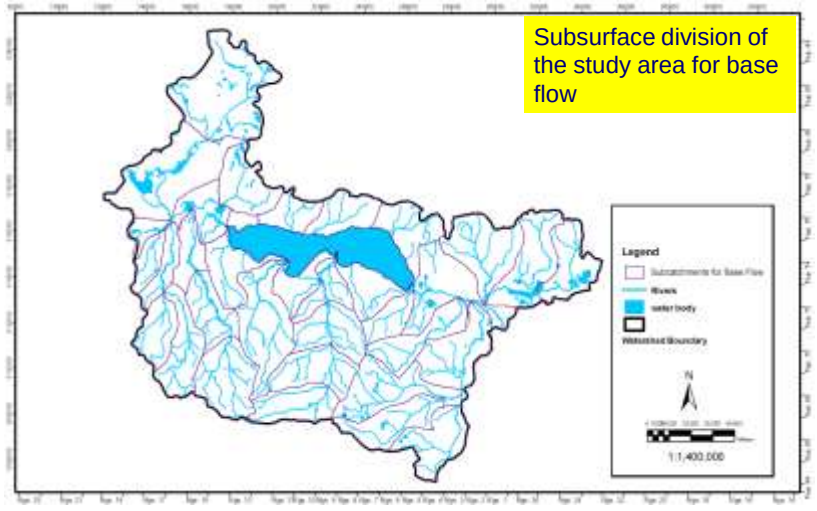
Subsurface Flow Modelling Continued



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Mike 11 Model Setup

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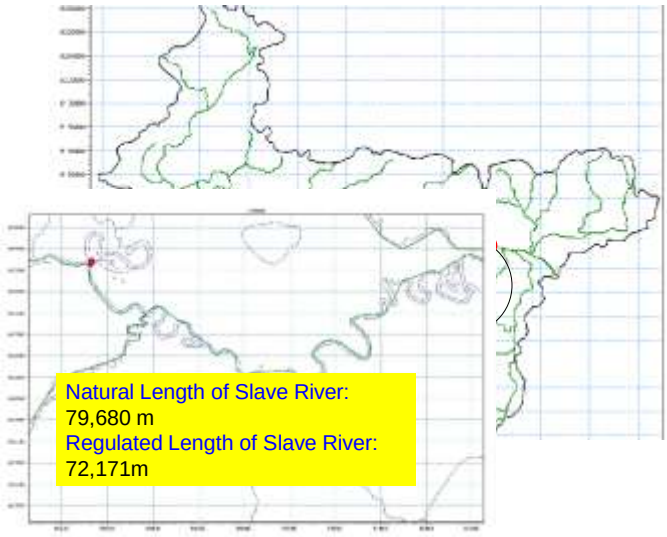
Mike 11 Model Network



Main Rivers	Modelled River Length (m)
West Prairie	76,912
East Prairie	106,795
Drift Pile	82,057
Swan	109,781
Otauwa	73,109
Saulteaux	122,114
Driftwood	50,536
Faucett	81,108
Slave River	72,171
South Heart	154,802
Slave Lake	117,565

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Cross Sections Input Data

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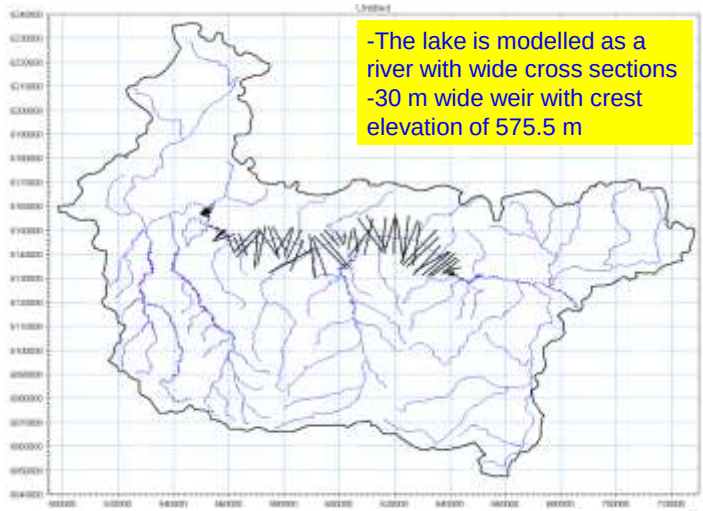
Cross Sections for the Lake



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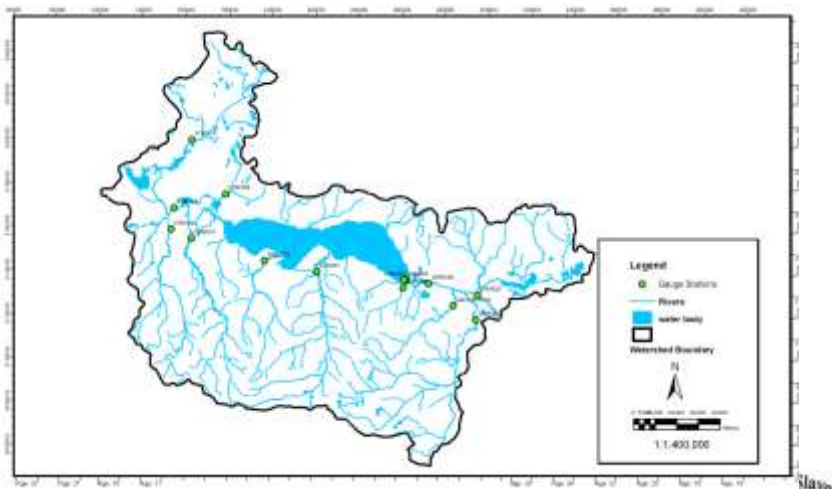
Hydrometric Gauging Stations



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Modelling Results

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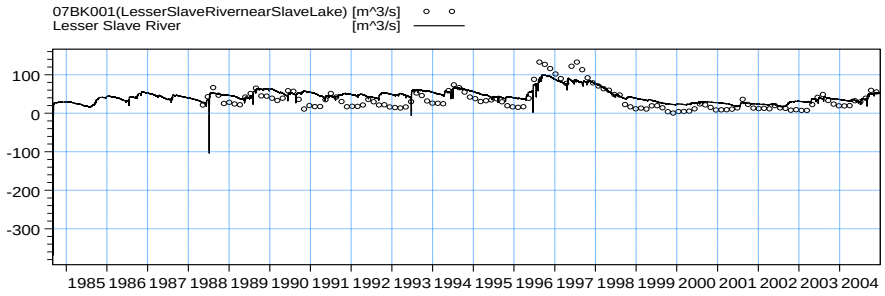
Simulated & Observed Outflows from Lesser Slave Lake



ME=-9.86927
MAE=15.9033
RMSE=18.972
STDres=16.2029
R(Correlation)=0.854637
R2(Nash_Sutcliffe)=0.552701

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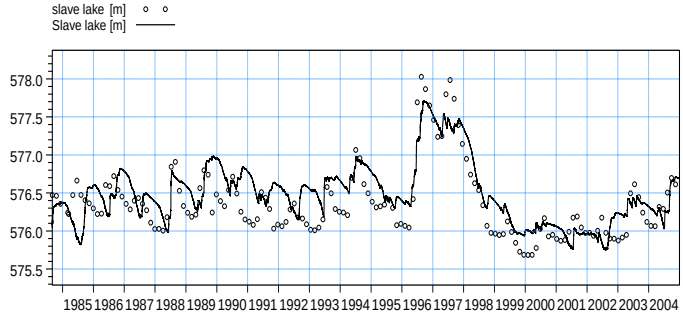
Simulated & Observed Water Levels at Lesser Slave Lake



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RMSE=0.298734
STDres=0.27457
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R2(Nash_Sutcliffe)=0.575724

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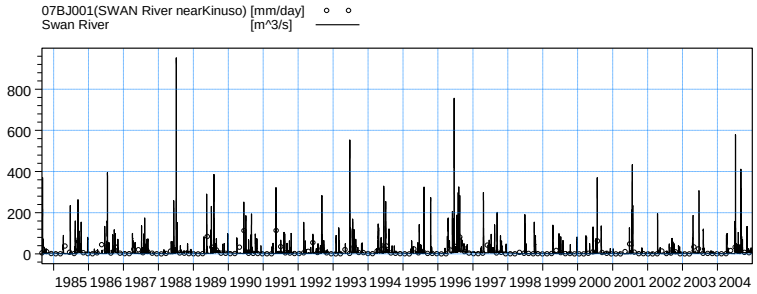
Simulated & Observed Hydrographs-Swan River



ME=2.30063
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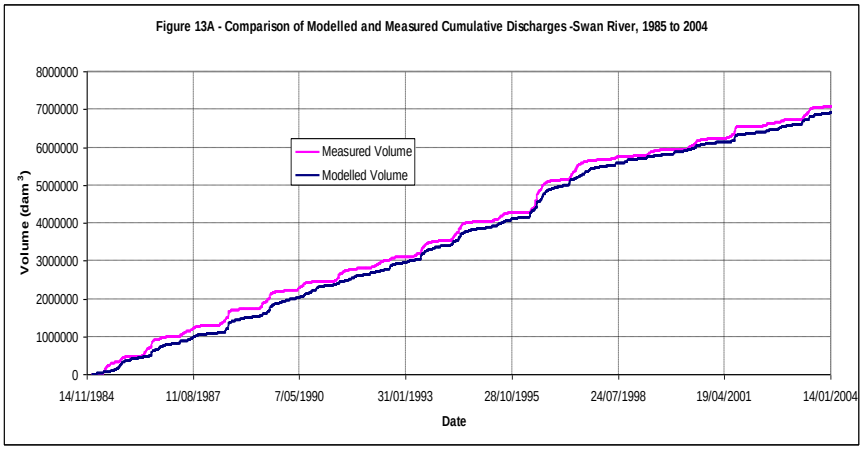

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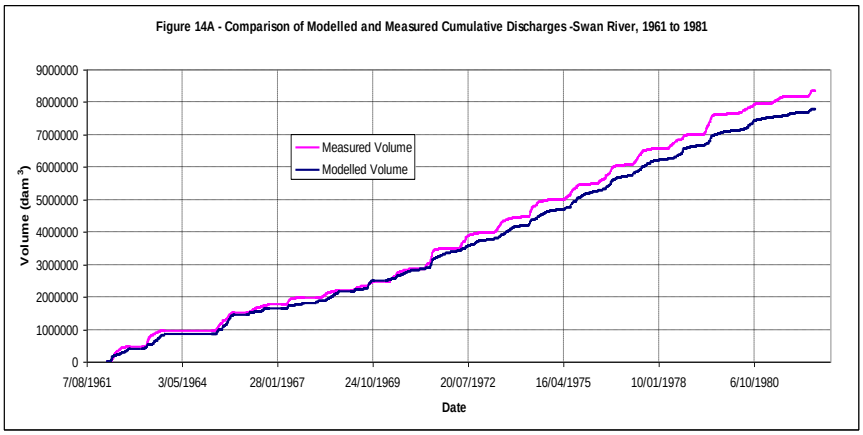

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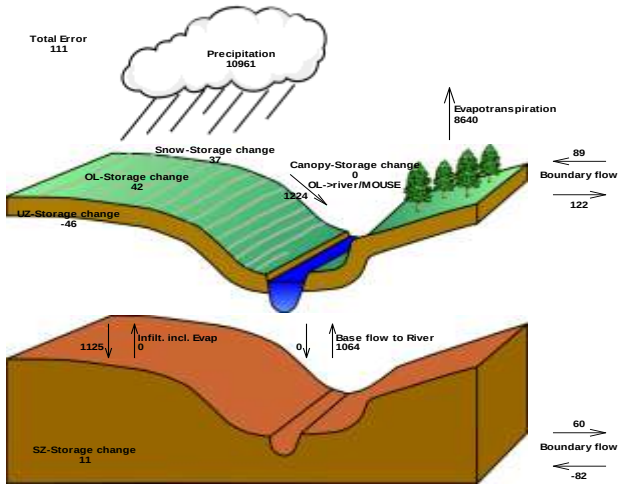
Water Balance-Saulteaux River (1984-2004)



Accumulated waterbalance from 1/09/1984 12:00:00 PM to 29/12/2004 12:00:00 PM. Data type : Storage depth [millimeter].
Flow Result File : D:\MIKESHEModelruns\Regulated\July_3\Regulated__30-station_DDC_Nov27_08.she - Result Files\Regulated__30-station_DDC
Title : Text :

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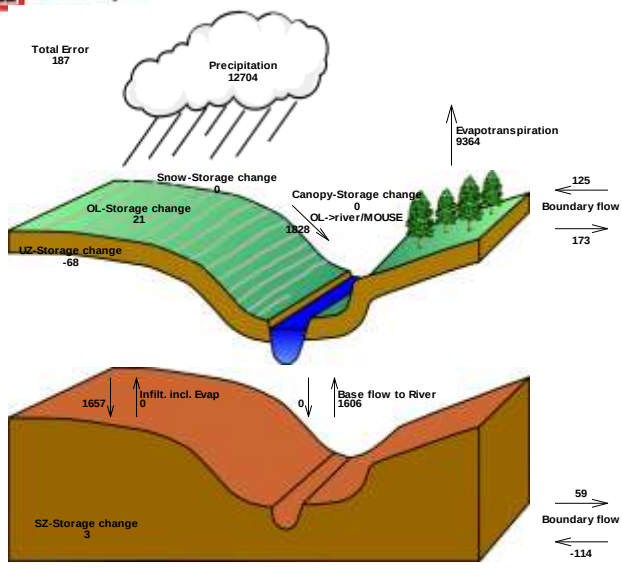
Water Balance-Saulteaux River (1961-1981)



Accumulated waterbalance from 1/02/1961 12:00:00 PM to 3/07/1982 12:00:00 PM. Data type : Storage depth [millimeter].
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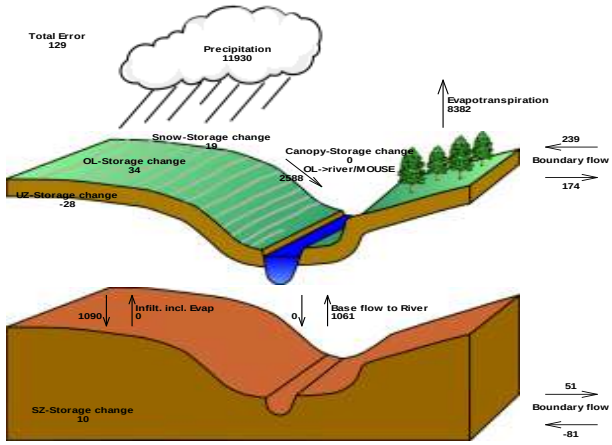
Simulated Water Balance-Swan River (1984-2004)



Accumulated waterbalance from 1/09/1984 12:00:00 PM to 29/12/2004 12:00:00 PM. Data type : Storage depth [millimeter].
Flow Result File : D:\MIKESHEModelruns\Regulated\July_3\Regulated__30-station_DDC_Nov27_08.she - Result Files\Regulated__30-station_DDC_Nov27_08
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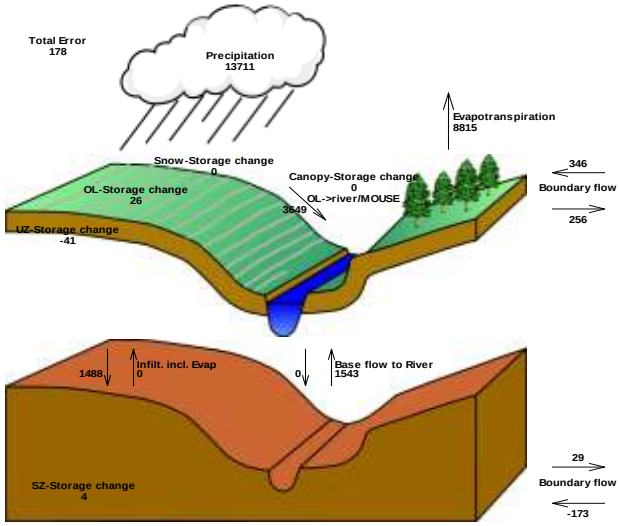
Simulated Water Balance-Swan River (1961-1981)



Accumulated waterbalance from 1/02/1961 12:00:00 PM to 3/07/1982 12:00:00 PM. Data type : Storage depth [millimeter].
Flow Result File : D:\MIKESHEModelruns\Natural\July_3\Natural__30-station_DDC_Nov27_08_60-04.she - Result Files\Natural__30-station_DDC_Nov27_08_60-04
Title : Text :

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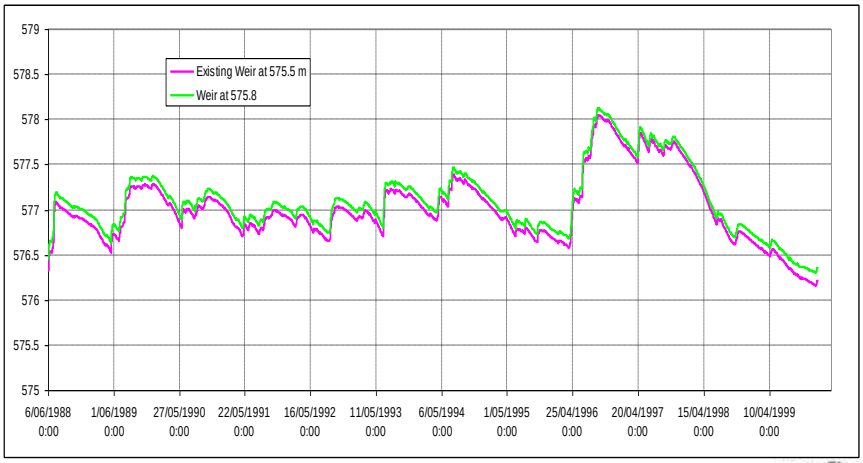
Hypothetical Scenario Analysis

Comparison of Water Levels at Lesser Slave Lake Weir at 575.5 m (Existing) and Weir at 575.8 m (Hypothetical)



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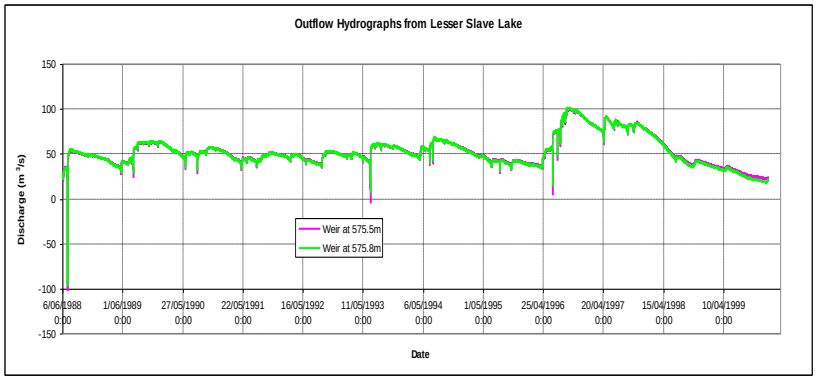
Hypothetical Scenario Analysis Contd.

Comparison of Outflows from Lesser Slave Lake Weir at 575.5 m (Existing) and Weir at 575.8 m (Hypothetical)



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Conclusions and Further works

- The developed models simulated historical daily flow hydrographs and water levels in the Lesser Slave Lake reasonably well
- The measured cumulative volumes (long term average values) are in close agreement with the modelled cumulative volumes for most of the rivers
- Water balance analysis indicates that evapotranspiration accounts for the largest water loss from the study area
- The ratio of base flow to total flow ranges from 28% to 60% indicating that surface water-ground water interaction play a significant roles in overall water balance of each sub-basin

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Conclusions and Further works

- The MIKE 11 model domain should be extended to include as many branches of all the rivers as possible
- Interpolated ground elevations (1 km by 1km grid used) should be further reviewed to address any obvious discrepancy in the actual topography and the modelled topography
- The developed model adopted a simplified approach to compute flows in the subsurface zone. The adoption of a detailed modelling approach for computing flows in the subsurface zone may further improve the model accuracy
- The Lesser Slave River flows downstream of the weir structure may not be accurate since the tributary flows are not calibrated well due to limited data.

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Conclusions and Further works Contd.

- Use of variable depressions storage and snow storage for the study area may further improve the model accuracy
- Use of a smaller grid size may further improve the model accuracy
- Computation of snowmelt using an energy balance model may further improve the model accuracy
- Collection of additional relevant field data for the calibration and verification of the model will further improve the model accuracy
- The model can be applied to assess the relative effect of various management scenarios
- Developed Models need to be refined through continuous calibration to further improve the model accuracy

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Thank You

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