Long-Term Generation Planning Model (SPLASH)

Bruce Hinton

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Presentation Outline

- Background
- Model Overview
- Model Applications
- Application: System Effects
- Summary

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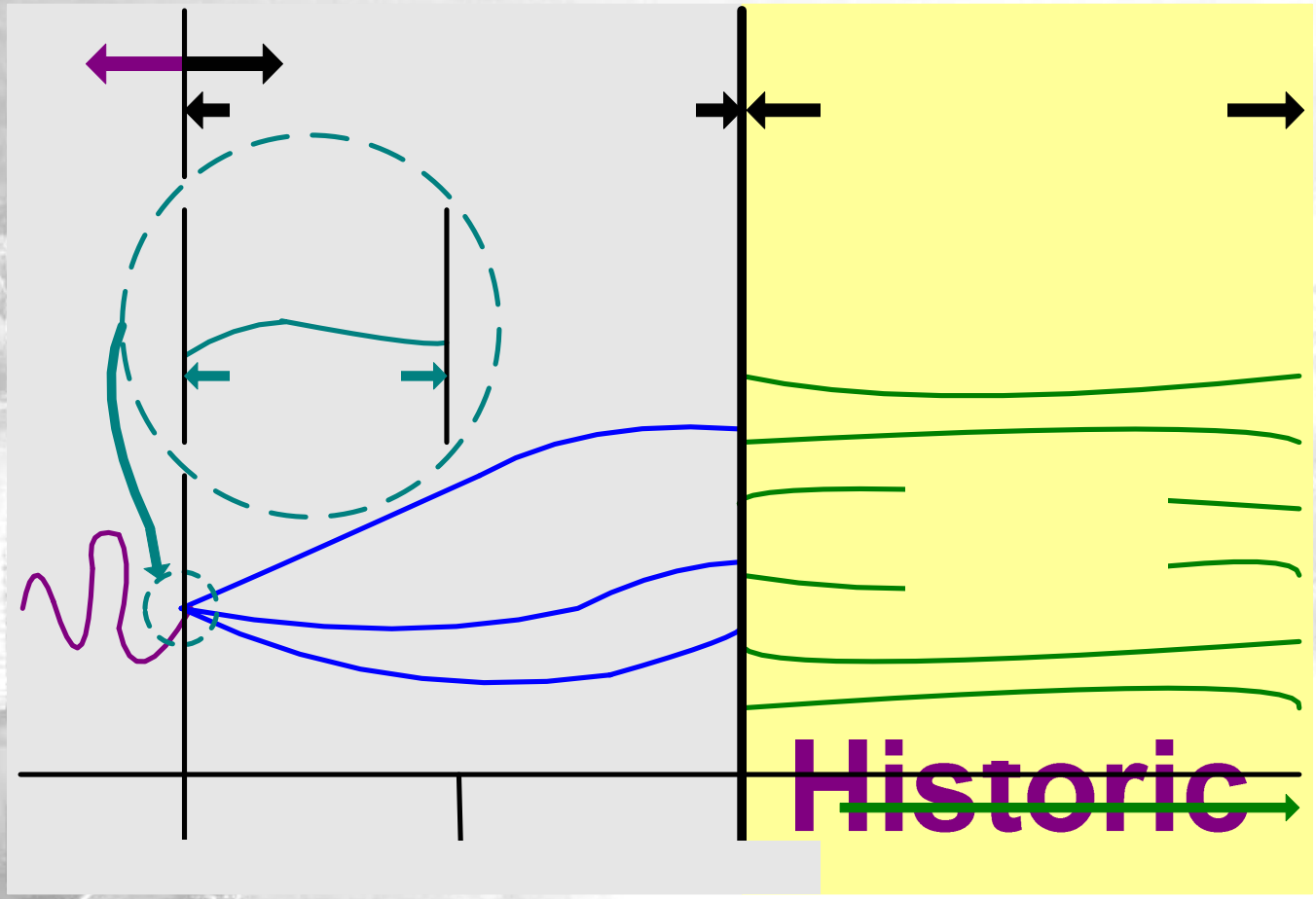
Long-Term Planning



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SPLASH Overview

- Computer Optimization Model: SPLASH
  - **S**imulation **P**rogram for **L**ong-term **A**nalysis of **S**ystem **H**ydraulics
- Developed in-house from 1990 to 1997

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SPLASH Overview

- Simulates the operation of the Manitoba Hydro integrated hydro-electric system, including extra-provincial energy transactions.
- Determines long-term production costing for all flow history

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SPLASH Components

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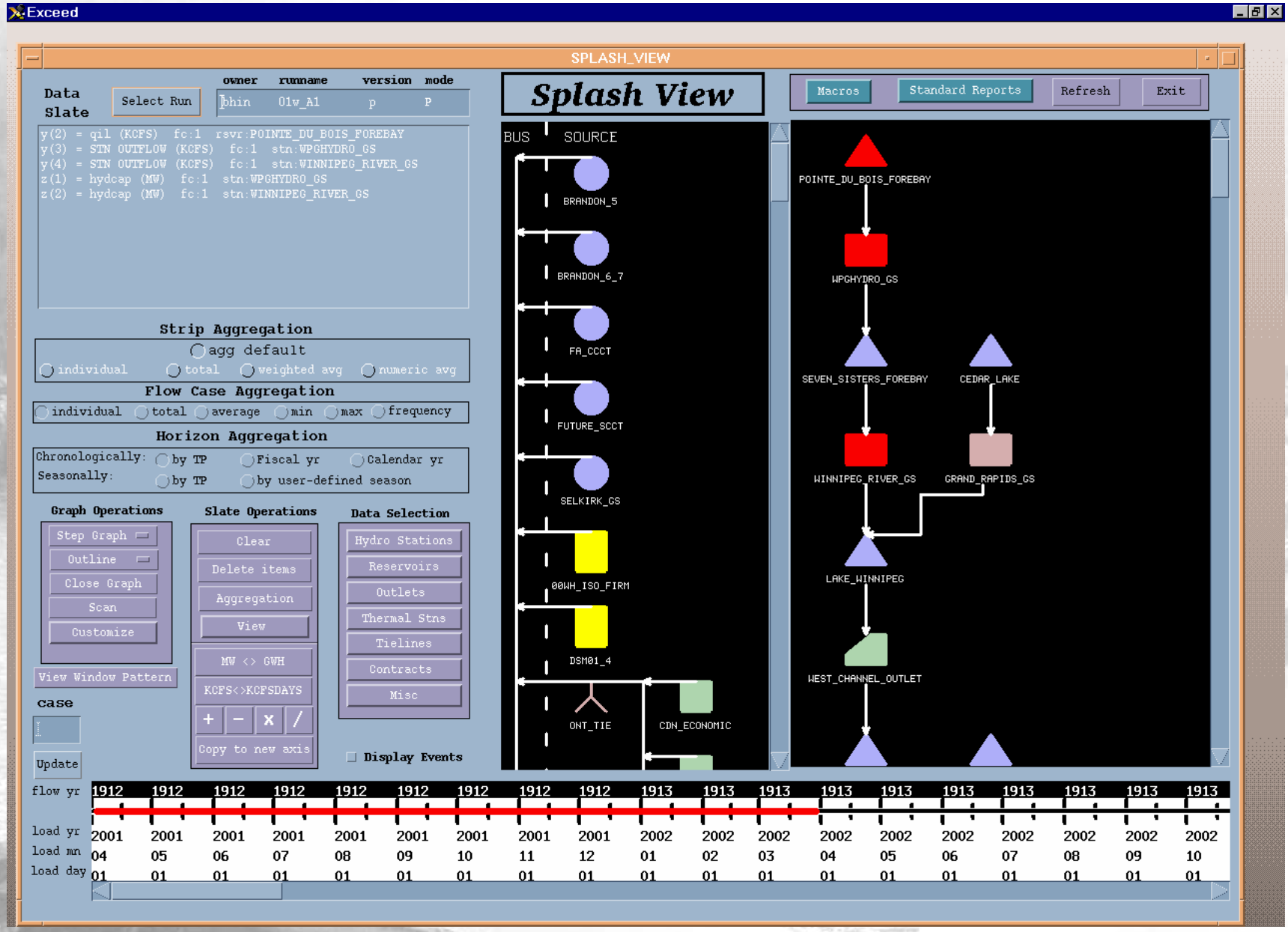

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SPLASH Methodology

- Subdivide planning horizon into discrete windows
- For a given window, formulate the integrated, multi-reservoir, hydro-electric system as Linear Programming (LP) problem

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SPLASH Methodology (Cont'd)

- Objective function: Maximize net flow-related revenue over all time periods within the window
  - Benefits: opportunity export sales
  - Costs: import purchases, thermal generation, water rental costs
- Constraints
  - Water balance
  - Energy balance
    - Satisfy Manitoba load and long-term export sales
    - Extra-provincial energy transactions

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SPLASH Methodology (cont'd)

- Power equation is non-linear
- Piece-wise linear segments are required to represent concave curves
- LP problem must be solved iteratively
- No guarantee that a global optimum is obtained

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Model Applications

- SPLASH is used in long-range resource planning studies:
  - Annual Power Resource Plans
  - Integrated Financial Forecasts
  - Marginal Cost Analysis
  - Evaluate Candidate Generation Plants
  - Evaluate Proposed Long-Term Export Sales

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Model Applications

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  - Evaluate Candidate Generation Plants
  - Evaluate Proposed Long-Term Export Sales
  - Water Regime (System Effects)

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Water Regime: System Effects

- System effects represent the operational changes that result from the addition and/or change to the supply and demand balance of the integrated hydro-electric system.

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Water Regime: System Effects

- The system effects analysis forms part of the input to the Environmental Impact study for the project.
- System effects was an important component of the public hearings for the proposed Wuskwatim generating plant.

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Need for System Effects Analysis

- Canadian Environmental Assessment Act (1993)
  - Analyze the operational changes bought on by the addition of new plant
  - Other projects must also be considered if they are linked to the proposed plant
  - Retrospective and prospective

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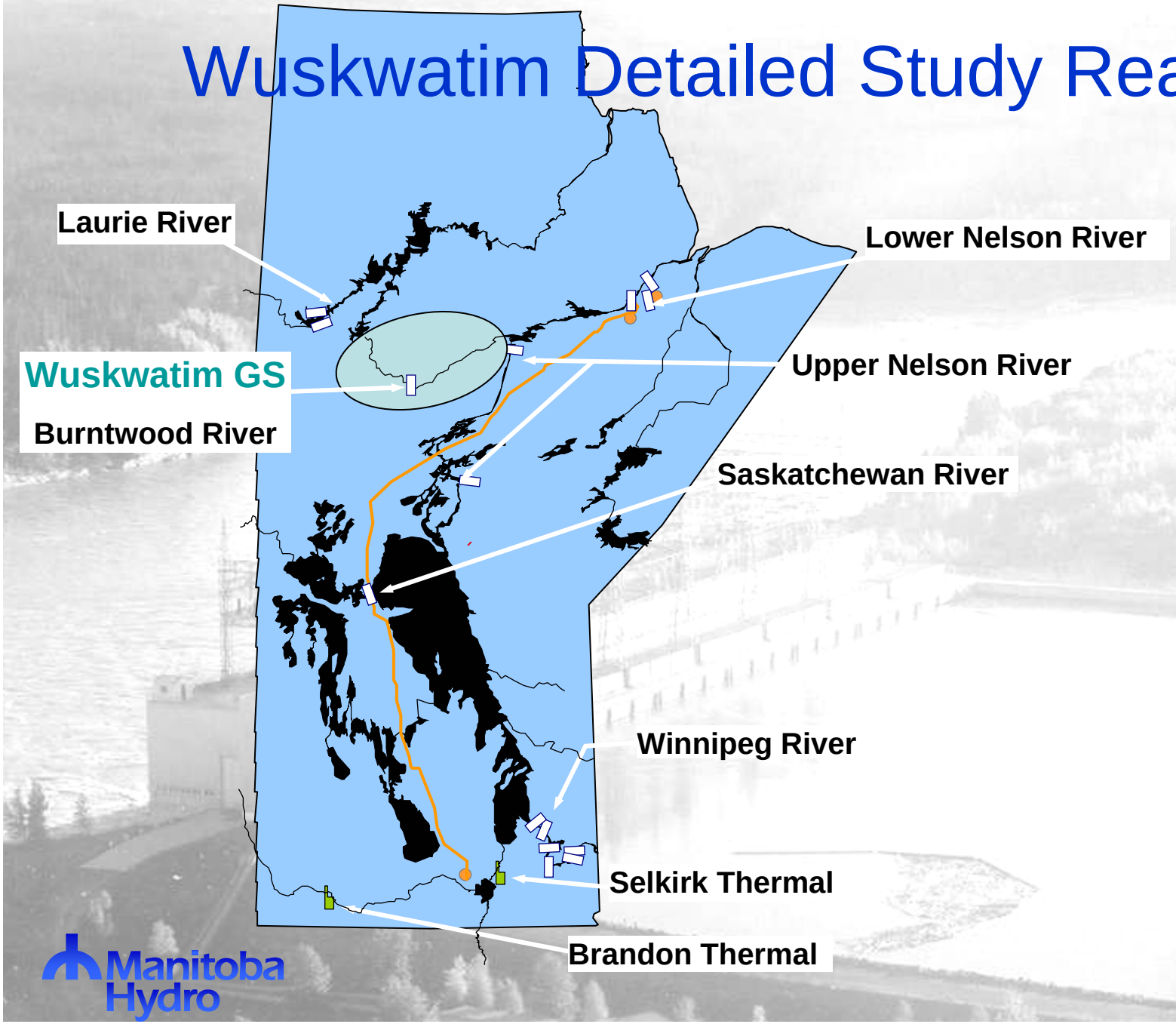
Wuskwatim Detailed Study Reach



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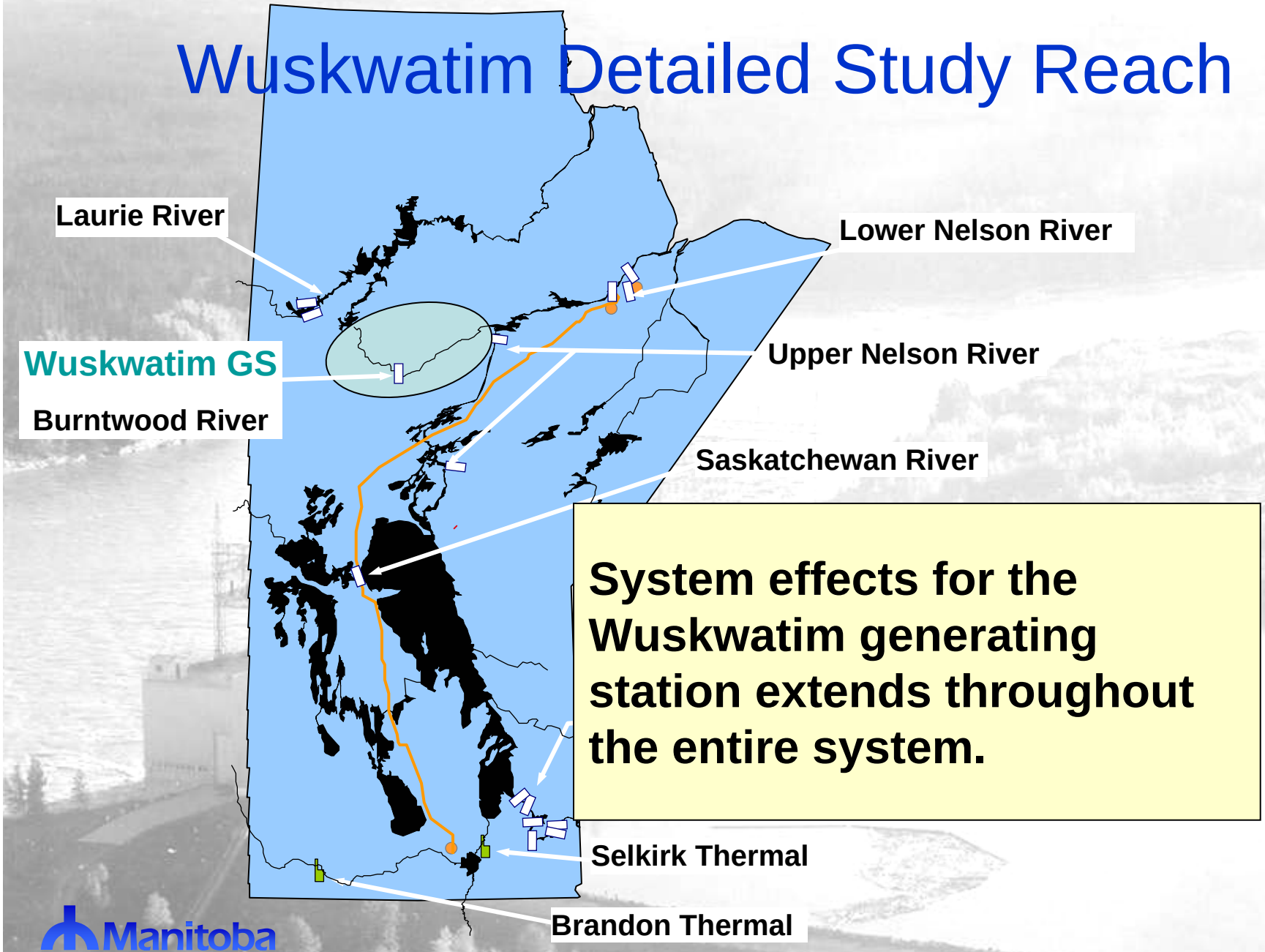
Wuskwatim Detailed Study Reach



System effects for the Wuskwatim generating station extends throughout the entire system.

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System Effects

- Other factors affect system operation (system effects):
  - Domestic load growth,
  - Addition of thermal-fired generation,
  - Addition of wind generation,
  - Inter-provincial export / import transactions
  - Additional extra-provincial tie-line capacity

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System Effects

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  - Domestic load growth,
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- Should these factors also trigger system effects analysis?

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System Effects Analysis

Base Case:

- Base case (existing system) without project

Project Scenario:

- Simulate system operation with proposed generating station
- Consider additional long-term export sales
- Consider influence of market pricing into which long-term export sales are made

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System Effects Analysis

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System effects represents the differences in water regime between the two runs.

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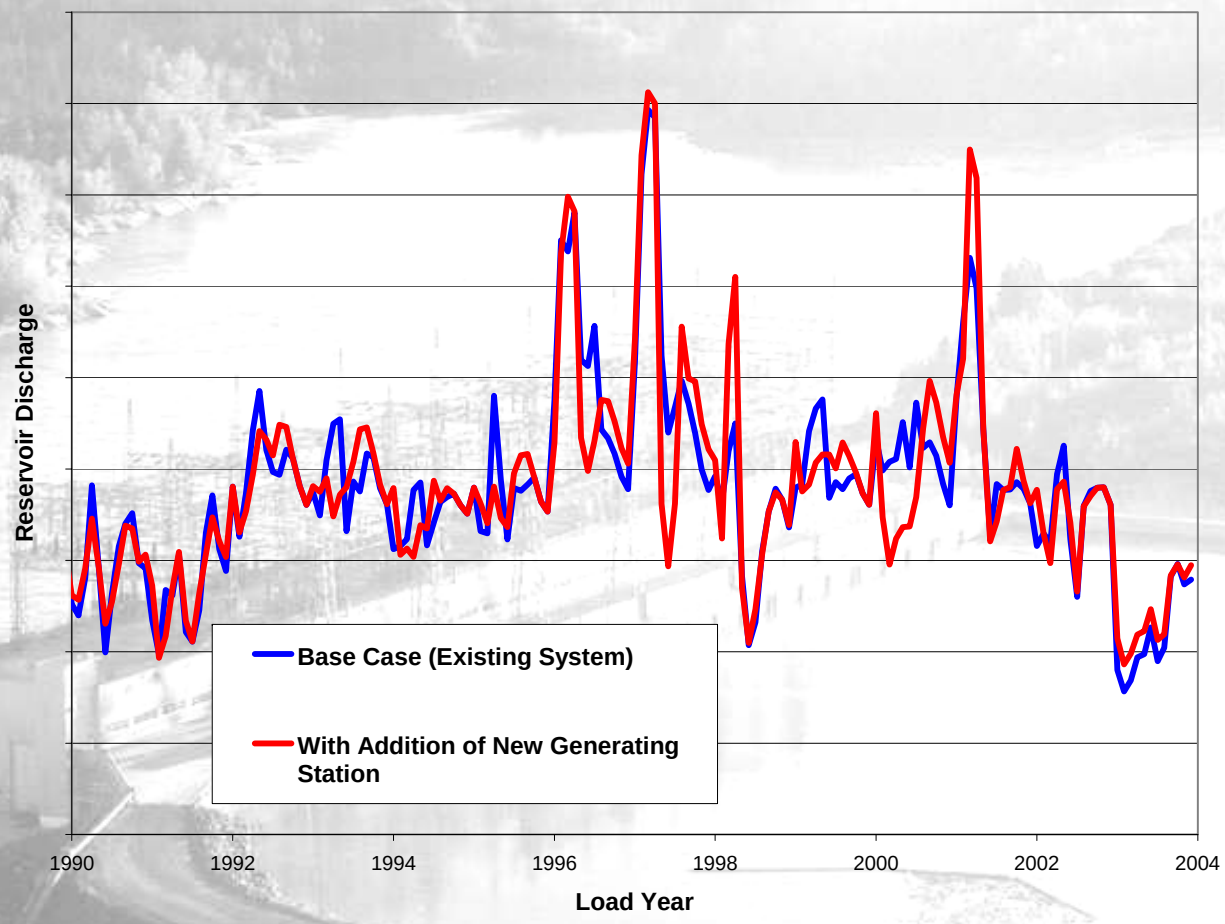
Chronological Plot of Reservoir Trajectories Base Case vs. New Generating Station



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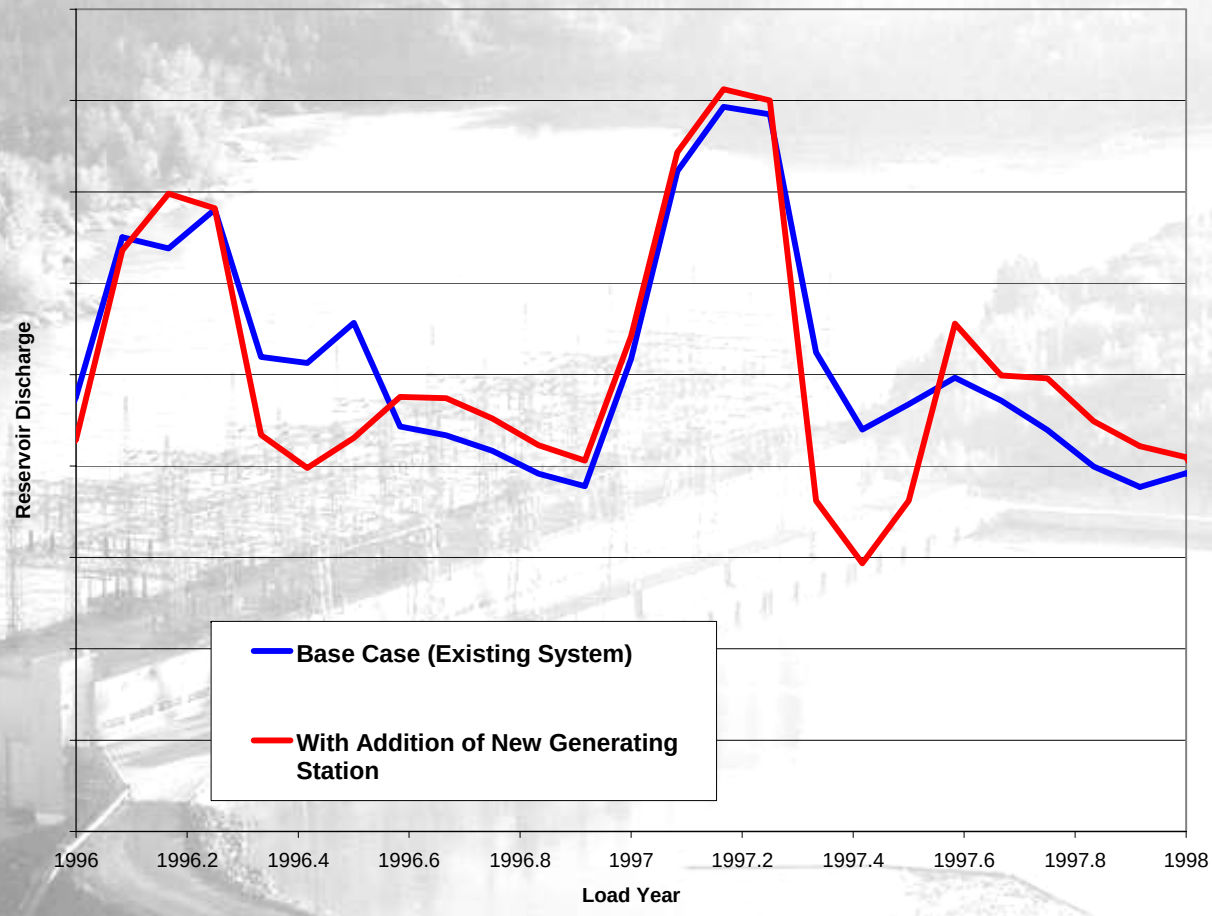

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Analysis of System Effects

- Variation in water regime, may be caused in part by:
  - Physical operational constraints
  - Modeling anomalies
  - Economic impacts

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Analysis of System Effects

- Variation in water regime, may be caused in part by:
  - Physical operational constraints
  - Modeling anomalies
  - Economic impacts
- Are the system effects real?

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Analysis of System Effects
Physical Operational Constraints

- Energy supply, which exceeds the capacity of the extra-provincial tie-line, must either be stored in reservoirs or spilled.

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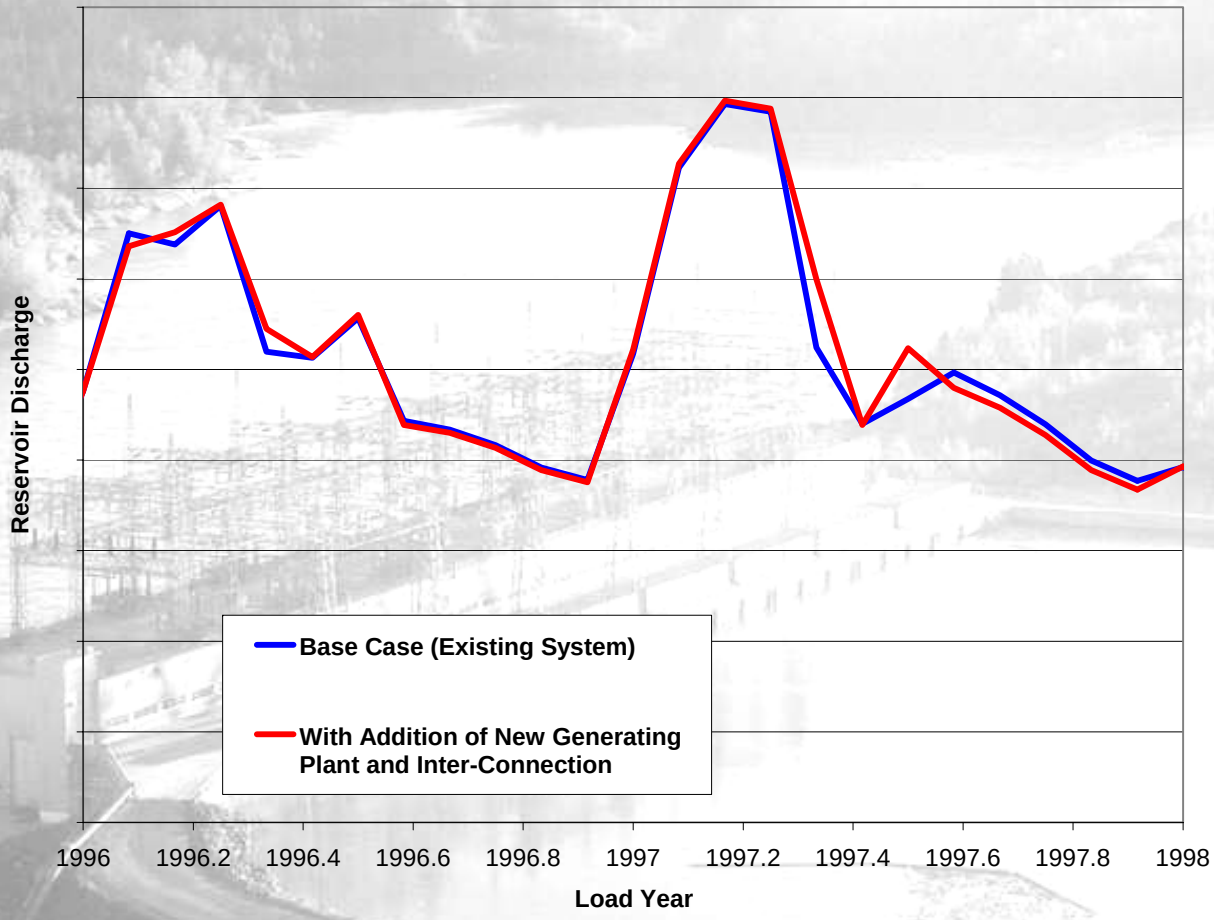
Analysis of System Effects With Generating Station and Additional Inter-Connection Capacity



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Analysis of System Effects (Cont'd)

- Modeling Anomalies
  - Non-convergence
- Economic Impacts
  - Optimization of two problems (unrelated, with significant data changes) may result in water regime changes
  - Modified operation could reduce system impacts

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Issues with System Effects Analysis

- Severity of system effects must be evaluated as part of the EIS
- System operation fluctuates within the license limits as result of various factors
  - Supply / demand balance
  - Market forces
  - Hydrologic conditions
- Addition of major projects
  - Timing and scope

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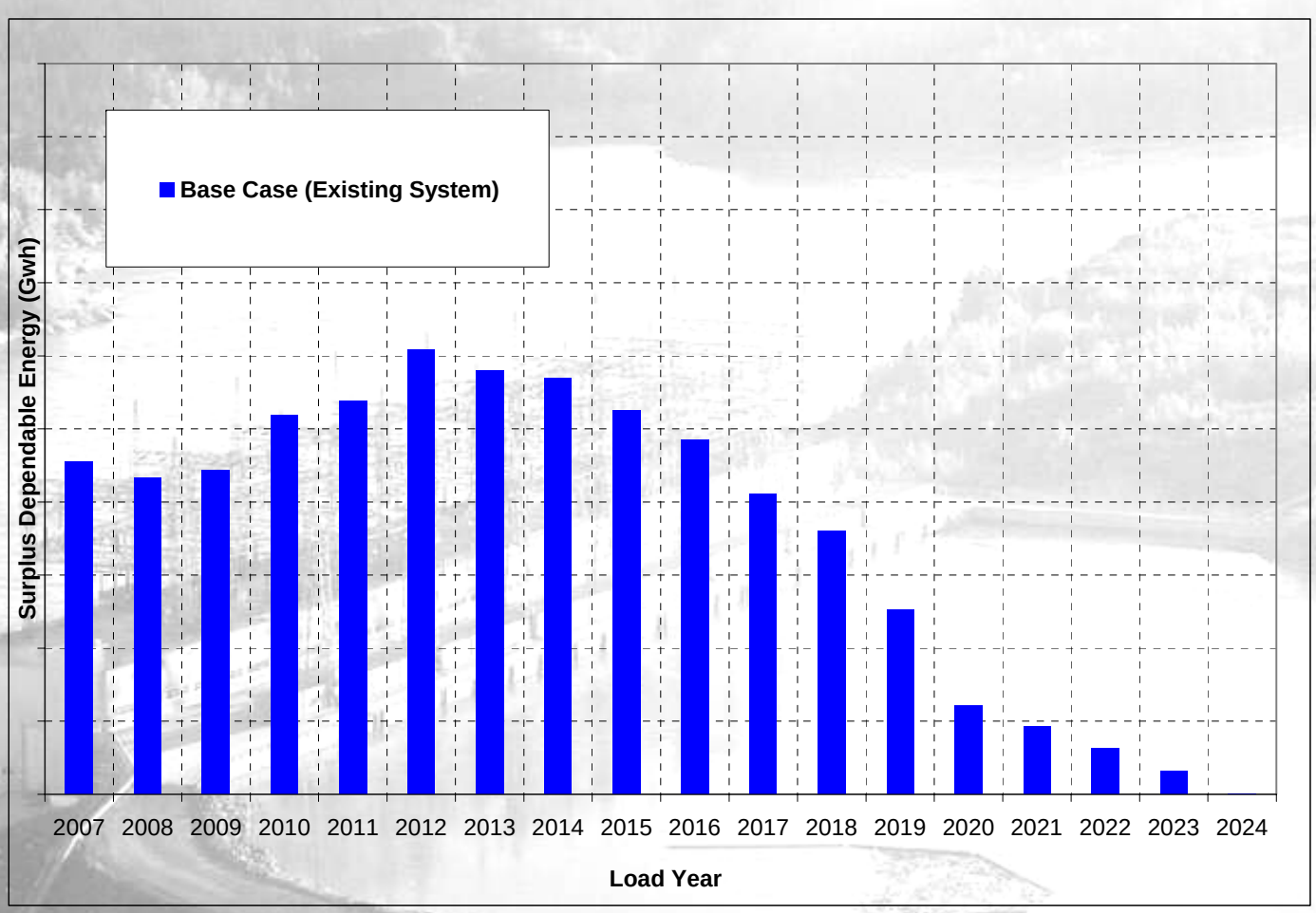
Surplus Dependable Energy
Base Case (Existing System)



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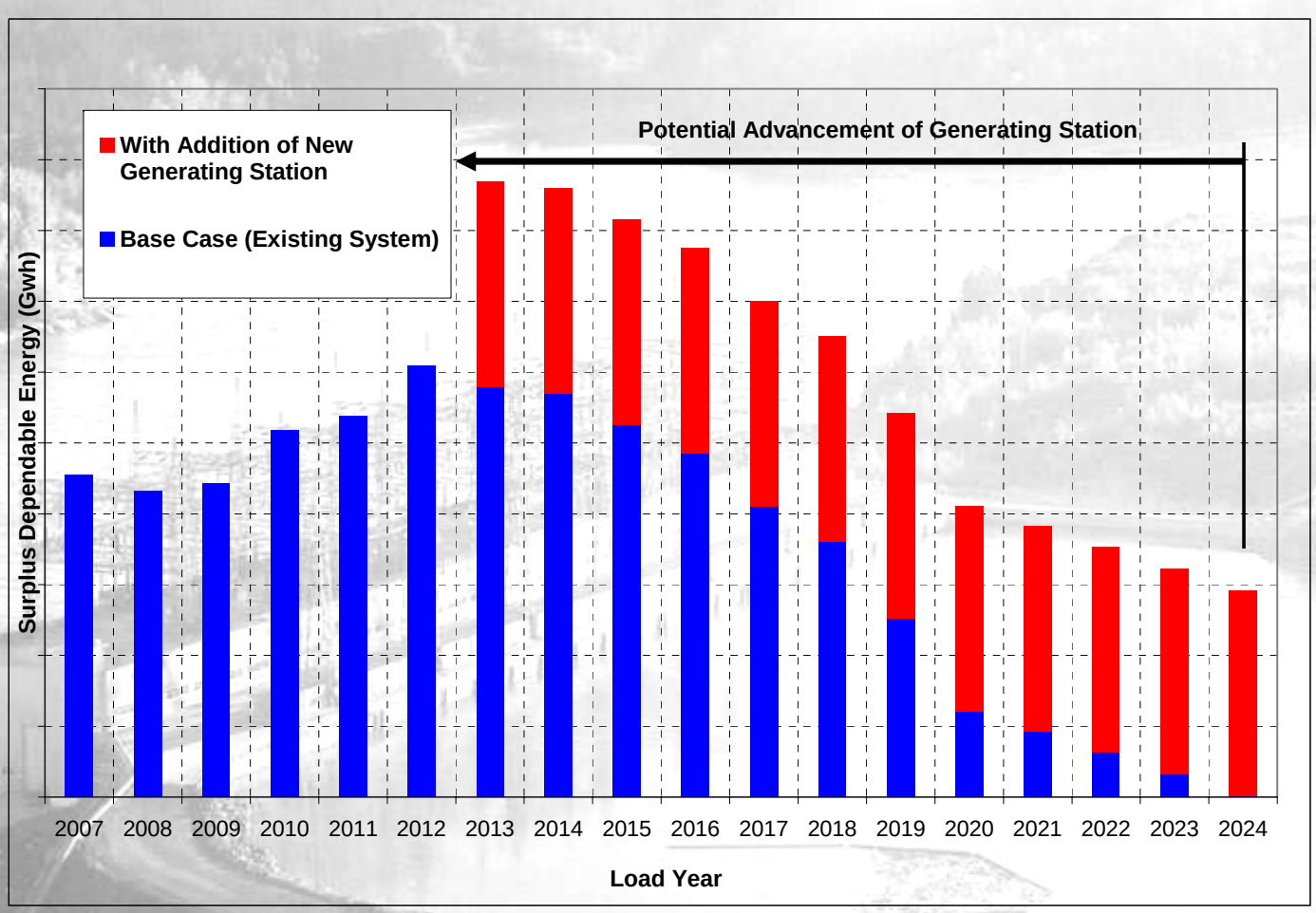
Surplus Dependable Energy
- With Addition of New Generating Plant



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Issues (cont'd)

- Modify operation to reduce impact?
- Monitoring of system effects?

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Summary

- SPLASH model continues to be used by Manitoba Hydro to determine economic benefits of plant additions, sales contracts, etc
  - Model yields stable economic results
- System effects analysis provides input data to the Environmental Impact study
  - Model results are much more erratic
  - Requires model development and further analysis to adequately define system effects

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