Application of the Hydrological Simulation Program FORTRAN (HSPF) Model to Two Large Scale Environmental Impact Assessments in Northeastern Alberta, Canada

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1. Introduction

- ***Introduction***
- *Project Overview*
- *Model Selection*
- *Model Calibration*
- *Model Results*
- *External Review*
- *Regulatory Decisions*
- *Conclusion*

In 2003, EIA for two large open-pit oil sand mines in northeast Alberta were submitted

- Hydrological modeling was used for baseline characterization and impact assessment
- Regulatory review was by a joint federal-provincial panel
- The modeling was intensively reviewed during regulatory hearings
- External review and regulatory decisions accepted model use and results

2. Project Overview

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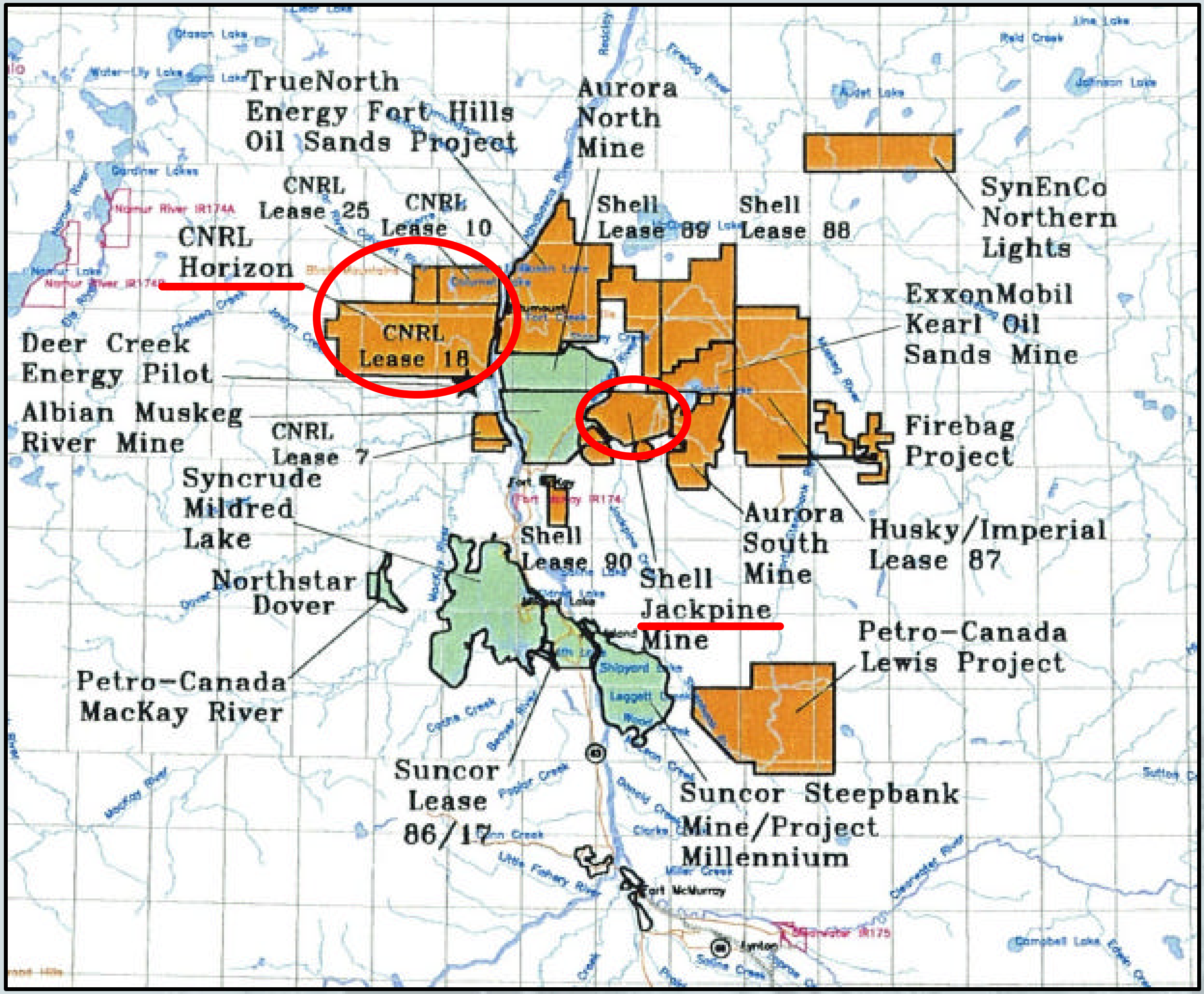

Note high degree of existing and planned development on the Athabasca River north of Fort McMurray

2. Project Overview

- Open-pit oil sands mine development includes stream diversions, closed-circuiting of operational mine areas and changes to reclamation landscape and drainage

- Canadian Natural Resources Ltd. Horizon Project:
  - Production: 270,000 bbl/day bitumen
  - Mine operation: 2007 to 2044
  - Disturbed area: 173 km^2

- Shell Canada Jackpine Mine Phase I:
  - Production: 200,000 bbl/day bitumen
  - Mine operation: 2010 to 2032
  - Disturbed area: 77 km^2

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3. Model Selection

Model selection depends on its intended use!

Objectives:

- Characterize baseline hydrologic regime:
  - Flood flows (stream geomorphology)
  - Seasonal mean flows (fisheries and water quality)
  - Low flows (fisheries and water quality)
- Predict changes due to mine operations and closure
- Water quality modeling capability?

Challenges:

- Sparsity of data:
  - Geographical
  - Temporal
- Cold region with muskeg terrain
- Variable surficial geology

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3. Model Selection

Solution:

- A physically-based model will allow assessment of changes to drainage areas and terrain
- A model that simulates rainfall and snowmelt runoff
- A continuous simulation model will generate a flow series that can be calibrated to the observed series
- Water quality modeling capability preferred

Selection:

- USEPA recommends HSPF as “the most accurate and appropriate tool available for the continuous simulation of hydrology and water quality in watersheds”
- Other physically-based, continuous simulation models not selected due to high spatial data requirements or lack of support/experience

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4. Model Calibration

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- Calibration Strategy:
  - Use long-term climate data for Fort McMurray, with local adjustments to temperature and precipitation series
  - Calibrate based on long-term data from local watersheds (Beaver River, Jackpine Creek, Muskeg River)
  - Minimize deviations between hydrograph shape, peak, base length and position
  - Reproduce *statistics* of key parameters
- Validate based on data from local watersheds (Steepbank River, Joslyn Creek)
- Non-concurrent calibration uses longer simulation period than streamflow period of record: driven by regional data

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5. Model Results

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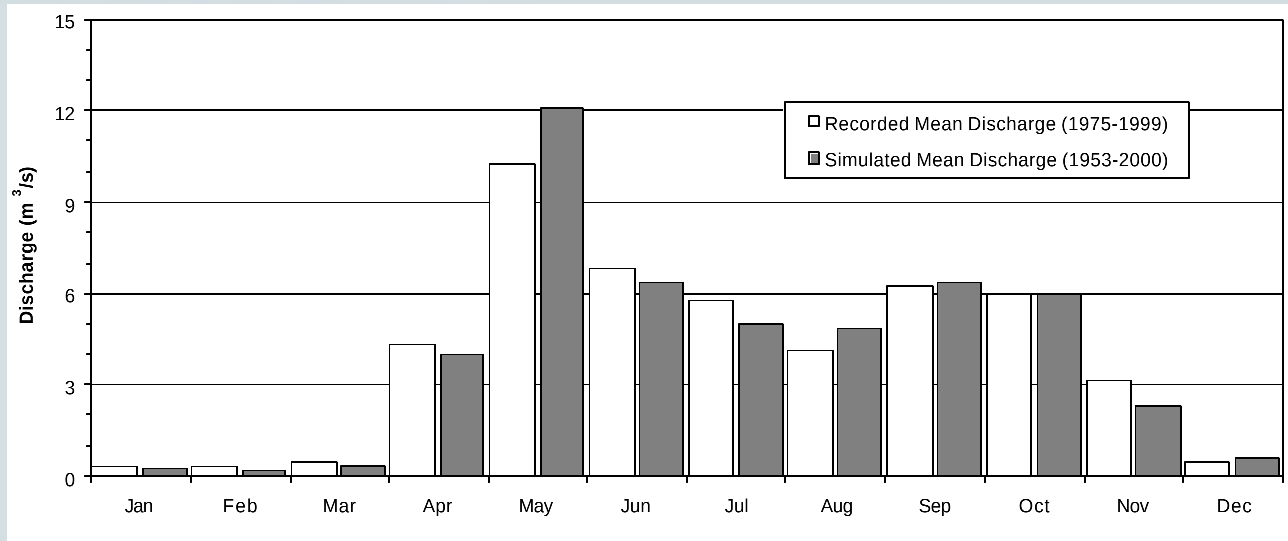

Watershed	Differences Between Observed and Generated Flow Statistics							
	Calibration							
	Mean Annual Flow		Mean Annual Flood		Mean Open-Water Flow		Mean Winter Flow	
	D (%)	D (abs)	D (%)	D (abs)	D (%)	D (abs)	D (%)	D (abs)
Beaver R.	0.0	0.0	1.9	0.19	-2.5	-0.02	14.3	0.01
Jackpine Ck.	0.0	0.0	2.8	0.22	-3.1	-0.05	25.0	0.02
Muskeg R.	0.0	0.0	11.5	2.24	7.1	0.39	-6.8	-0.03
Mean	0.0		5.4				10.8	
	Validation							
Steepbank R.	-0.4	0.02	2.6	0.97	-3.2	-0.23	16.4	0.10
Joslyn Ck.	0.0	0.0	-14.2	-1.54	6.1	-0.06	50.0	0.02
Mean	-0.2		-5.8		1.5		33.2	

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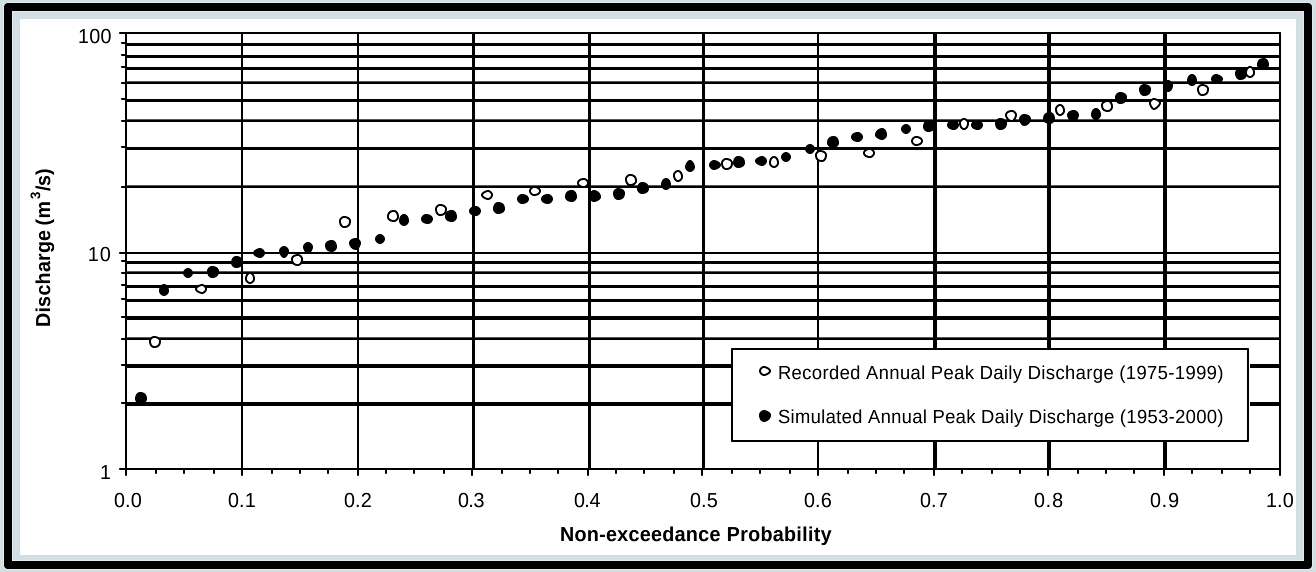

Return Period (years)	Observed		Simulated	
	Discharge (m^3/s)	95% Confidence Limits	Discharge (m^3/s)	95% Confidence Limits
2	24.1	24.1±5.6	24.9	24.9±4.6
5	40.5	40.5±10.3	42.2	42.2±8.2
10	52.5	52.5±14.2	53.7	53.7±11.2
20	61.7	61.7±18.2	64.7	64.7±14.3
50	75.1	75.1±23.5	78.9	78.9±18.4
100	89.8	89.8±27.4	89.5	89.5±21.5

6. External Review

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- Fisheries and Oceans Canada (DFO) retained Dr. Wayne Huber (Oregon State University) for independent review
- CNRL retained Dr. Thian Gan (University of Alberta) for independent expert witness testimony
- The DFO review asked the following questions:
  - Is HSPF the appropriate assessment tool?
  - Is the database sufficient?
  - Are the assumptions reasonable?
  - What is the level of uncertainty in predictions?
  - How well was the model validated?
  - Why a non-concurrent calibration?
- Main point of contention was non-concurrent calibration

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7. Regulatory Decisions

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- Joint Panel decisions for the two projects were released on:
  - 27 January 2004 (CNRL Horizon Project)
  - 5 February 2004 (Shell Jackpine Mine Phase I)
- Both projects were approved subject to various conditions
- Hydrologic modeling was accepted by the Joint Panel, however additional site-specific climate and hydrology data collection, and future verification or recalibration of the HSPF model, will be required

8. Conclusion

- Hydrological modeling may be required for large project baseline characterization and impact assessment
- Results provide input to water quality and fisheries impact assessments: compatibility of hydrological and water quality models is an advantage
- Results will inevitably be used to provide a design basis for project development
- Model selection, calibration and results may be the subject of scrutiny by regulators and stakeholders: *Be prepared to defend your work!*
- Sparsity of data in this case required:
  - use of regional data
  - calibration to statistics derived from continuous record/simulation
  - use of non-concurrent periods of record for input and calibration data

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