

# Second Generation Hydro Scheduling

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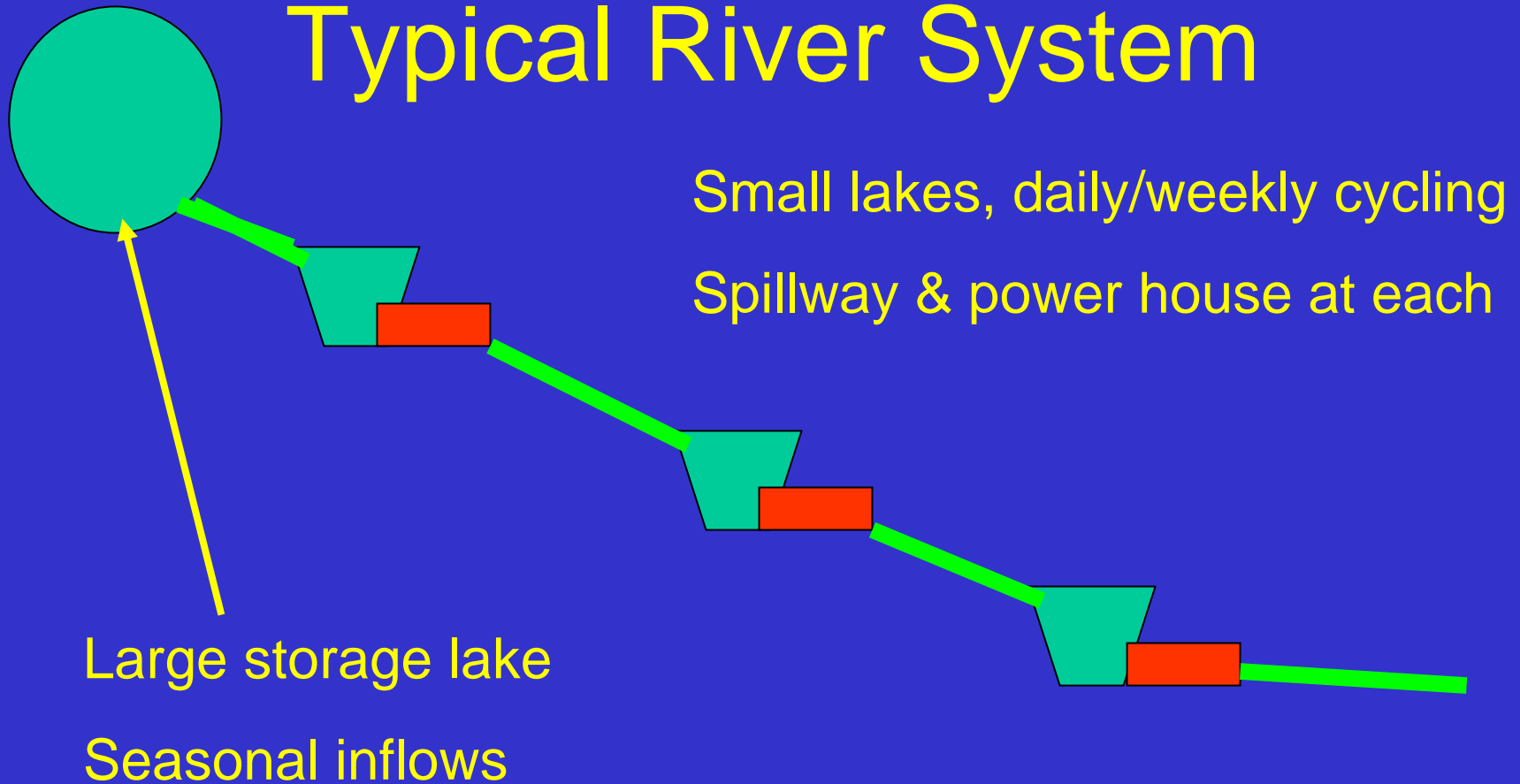
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# Outline

- Typical river system
- Objective of model
- Old and new technologies
- Mosel experience
- Lessons

# Typical River System



# Objective of Model

- Meet specified load at least cost  
or
- Maximize revenue
- Assume:
  - Known opportunity cost of water
  - Forecast of market prices

# Old and New Models

1991/92

- Fortran
- Unix - dedicated
- Text or SCADA interface
- Matrix built in Fortran
- Cplex - initially MINOS
- Research project - controversial, risky

2002

- Visual Basic
- PC - any
- Spreadsheet or SCADA interface
- Mosel
- Xpress
- Simple consulting contract

# Old and New Models continued

1991/92

- Heuristics - initially no integers
- One linear water / electricity conversion
- 18 months to build

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- MIP solver - integers for detailed modelling levels
- Piecewise linear conversion curve
- 5 weeks to first user/prototype tests

# Typical Problem Size

- Model 196 periods, 8 stations
- After presolve
  - 11666 rows
  - 14456 columns
  - 53575 non zeros
  - 1001 integer variables
- CPU times on 866 MHz P3
  - relaxed LP 8 seconds
  - MIP search 8 seconds (to completion)

# Why Replace the Old Model?

- Expensive UNIX hardware - IT is PC focussed
- Unable to maintain old model
  - Loss of key person with Fortran and modelling expertise, long learning curve
- Lack of flexibility - time horizon, length of time steps, level of detail
- Low cost of new development



# Greater Flexibility

- Variable number of time steps
- Input a profile of time step lengths
- Level of detail of modelling variable
- Suitable for real time planning through to asset management studies
- SCADA & Excel interfaces needed
- Ease of code maintenance

# Mosel Experience

- Build model, solve, output all in one process - programming language feel
- Syntax resembles Xpress modeller
- IVE major productivity gain
  - Syntax checks, debugging, scanning results
- Work arounds for all problems:
  - No external basis file
  - Incomplete MIP search, Mosel returns error code
- Bugs in IVE but no “gotcha” features

# Lessons

- Model documentation - adapt the code
- version 1 problems? Not serious
- Non-linear head effect difficult - candidate for new SLP solver
- Huge gains in model development productivity, solver power since 1991

# Better Hardware, Better Software

- PDS-30 Problem  
49944 rows, 177628 columns, 393657 non zeros:

CPLEX		CPU (seconds)
1	1988	57,840
3	1994	4,555
5	1996	3,835
6.5	1999	165

- Maybe 1000 improvement in hardware
- Total improvement:  $3.5 \times 10^5$

from “MIP: Theory and Practice - Closing the Gap”, Robert Bixby et al  
Tom Halliburton Xpress-MP Users Group Meeting, London, 2002