Modeling Reservoirs in NWSRFS Workshop

OBJECTIVES

- Available reservoir models in NWSRFS
  - Single Reservoir
  - Streamflow Synthesis and Reservoir Regulation System
  - Joint Reservoir
  - Dynamic Wave
- Features of each model
- Data requirements
- Model input detail
- Set up and run operation in NWSRFS
- Model comparison

Available reservoir models

- Single Reservoir
  - Modeled in RES-SNGL Operation
- Streamflow Synthesis and Reservoir Regulation System
  - Modeled in SSARRESV Operation
- Joint Reservoir
  - Modeled in RES-J Operation
- Danamic Wave
  - Modeled in FLDWAV Operation

RES-SNGL Operation Description

- The single reservoir model operation allows for the simulation of a single independently operated reservoir. It was developed as a means for forecasting releases from a reservoir when the user is not provided with future releases from the operating agency.
- In the real world of reservoir regulation, a single independently operated reservoir is a rare item. Operation of systems of reservoirs for optimization of objectives (such as flood control or power generation) is the more common find.

SSARRESV Operation Description

- The SSARRESV Operation is based on the Streamflow Synthesis and Reservoir Regulation System developed by U. S. Army Corps of Engineers and North West River Forecast Center of National Weather Service. The operation routes streamflows from upstream to downstream points through lake storage and reservoirs under free flow or controlled-flow modes of operation. Flows may be routed as a function of multivariable relationships involving backwater effects from a downstream reservoir.

RES-J Operation Description

- The Joint Reservoir Operation (RES-J) models either a single reservoir or a system of reservoirs. It uses topology information to describe the Tree-net to be modeled. Tree-net may consist of reservoirs, reaches and nodes. The RES-J operation solves the tree-net from upstream to downstream one time step at a time. Local flows to reaches and reservoirs should be generated before the RES-J operation so that they are available as tree-net inputs.

FLDWAV Operation Description(1)

- The FLDWAV Operation models either a single reservoir or a system of reservoirs using level pool routing in the upstream reservoir and level routing or dynamic routing in the subsequent reservoir. When doing dynamic routing, cross section information is used to describe the river system (channel reaches and reservoirs).

FLDWAV Operation Description(2)

- FLDWAV computes elevations and flows simultaneously at each location one time step at a time. All inflows (local flows and boundary flows) should be generated before the FLDWAV operation. FLDWAV can handle subcritical and mixed flow condition.
- The FLDWAV operation can only be used to route uncontrolled flows (spillway, gate, and dame overtopping).

RES-SNGL Operation Features

- Models single reservoir
- Uses Schemes and Utilities to model reservoir physics
- Uses Reservoir Command Language (RCL) to control reservoir operation
- Models fairly sophisticated operating rules
- Requires little run-time interaction
- Some run-time control available
- Long implementation process

SSARRESV Operation Features

- Models single reservoir with or without backwater effect
- Models 2 reservoir system with or without backwater effects
- Regulates downstream reservoir to achieve desired flow condition at upstream station.
- Doesn’t model operating rules
- Uses observation and run-time input to define regulating rules
- Requires run-time interaction
- Total run-time control
- Quick to implement

RES-J Operation Features

- Models single or several tree-structured reservoirs in parallel or in series
- Reservoirs may be in parallel or in series or in combination of both
- Models only tree structured reservoir system
- Models limited operating rules
- Requires little run-time interaction
- Some run-time control available
- Long implementation process

FLDWAV Operation Features(1)

- Models one or more reservoirs with or without backwater effect
- Models tree and bifurcation reservoir systems
- Models only reservoirs with uncontrolled flows
- Doesn’t model operating rules
- Require little run-time interaction
- Some run-time control available

FLDWAV Operation Features(2)

- Requires somewhat extensive data input
  - Although FLDWAV may require extensive data input, it may be used with a minimal amount data; e.g. use average cross section and let the model interpolate. Assume constant n values. Etc. when applicable, these assumptions will produce similar or better results than the level pool routing method.

FLDWAV Operation Features(3)

- Long implementation process
  - A long implementation process is necessary when the model is calibrated for the purpose of generating information at the forecast points. If the goal is to determine reservoir releases, short cut methods are applicable. (I don’t recommend this path.) The model should be calibrated; however, it should be know that the by-product of this process is forecast info at gages in addition to the reservoir release info.

RES-SNGL Data Requirements

- Minimum Input
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
    - Mean inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - RCL -- At least one scheme
- Additional Input
  - Data needed for schemes/utilities to be used
  - Instructions on when schemes and certain utilities should be used (RCL)

SSARRESV Data Requirements

- Minimum Input
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - Run-time
    - SSARREG mod
- Additional Input
  - Data needed if used as part of 2 reservoir system or as reservoir or station with backwater effects

RES-J Data Requirements

- Minimum Input (at least one reservoir)
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - RULES – at least one method
- Additional Input
  - Data needed for multiple reservoirs

FLDWAV Data Requirements

- Minimum Input
  - Elevation-storage curve
  - Dam elevation, length, and weir coefficient
  - Spillway crest, length and weir coefficient
  - Gate centerline and opening
  - Turbine flow
  - Channel cross Sections
  - Upstream and downstream boundaries
  - Carryover - flow and stages for all channel sections at start of run
  - Run-time - none
- Additional Input
  - Data needed for multiple rivers and dams
    - flow and stages for all channel sections at start of run

RES-SNGL Operation Input

- There are 3 sections used to define RES-SNGL parameters
  - General section: used to define elevation storage curve, units (english, SI), title, description, carryover, time series to be used.
  - Specific section: used to define parameters for schemes and utilities.
  - RCL section: used to define constraints on scheme execution so the model knows when to execute a particular scheme. Constraints may be based on flow, elevation, or storage characteristics as well as day of year.

RES-SNGL Schemes

- Inflow passage (PASSFLOW)
- Prescribed discharge (SETQ)
- Prescribed elevation (SETH)
- Rule curve (RULECURVE)
- Fill and spill (FILLSPILL)
- Uncontrolled spillway (SPILLWAY)
- Pool elevation controlled discharge (POOLQ)
- Discharge minimization (MINQ)
- Upstream stage minimization (MINH)
- Induced surcharge (INDSRCHGE)
- Flashboard control (FLASHBDS)
- Power generation (POWERGEN)
- Maximum daily change in discharge (SETDQ)

RES-SNGL Utilities

- Rule curve adjustment (RULEADJ)
- Inflow summation (SUMINF)
- Rainfall/evaporation on the reservoir (RAINEVAP)
- Adjust utility (ADJUST)
- Back-computed inflow (BACKFLOW)
- Maximum dam outflow (MAXQ)
- Entry into induced surcharge (ENTERISC)
- Set minimum element (SETMIN)
- Set maximum element (SETMAX)
- Entry into flashboard scheme (GOFLASH)

SSARRESV Operation Input

- The SSARRESV model is parameterized by providing an elevation storage curve and spillway rating curves.
- The reservoir operations are provided to the model via SSARREG runtime MODS.
- SSARREG Keywords:
  - FREEFLOW – free flow
  - SETQ – outflow specified
  - SETH – elevation specified
  - SETDQ – change in storage specified
  - SETDH – daily change in elevation specified
  - SETDS – daily change in storage specified

RES-J Input Organization

- Times series
- Topology
- Parameters
- Rules

RES-J Operation Input

- RES-J input method identifiers
  - ADJUST – reservoir output adjustment method
  - BALANCE – storage balancing for multi-reservoir system
  - LAGK – reach Lag and K routing method
  - MAXDECREASE – max daily decrease in reservoir discharge
  - MAXINCREASE – max daily increase in reservoir discharge
  - MAXSTAGE – downstream discharge control method
  - RAINEVAP – rainfall / evaporation on lake surface method
  - SETELEVATION – prescribed elevation method
  - SETMAX – select maximum element method
  - SETMIN – select minimum element method
  - SETRELEASE – prescribed release method
  - SETSUM – prescribed element summing method
  - SETWITHDRAW – prescribed withdrawal method

FLDWAV Operation Input

- Number of rivers in the system
- Channel cross sectional data for all the rivers
- Upstream and downstream boundaries for all the rivers
- Parameters depict hydraulic characteristic of all the dams for all the rivers
- Channel flow regime
- Local flow

Reservoir Operation Set up and Run

- All reservoir operations are defined in FCINIT or MCP3 programs
- All segment definition rules are applicable
- Forecast run of all reservoir operations are run in FCST or MCP3 programs

RES-SNGL Operation Set Up

- All schemes or utilities must be defined before they are used in RCL
- All defined schemes or utilities MUST be used in RCL

RES-J Operation Set Up

- Separate input files are created for each segment
- Input files are used in both FCINIT and FCST programs
- All methods must be defined before they are used in RULES
- All defined methods may or may not be used in RULES

Use RES-SNGL Operation

- Is a single reservoir
- Have the operation rules
- No backwater effects excepts on power generation
- Requires more sophisticated operation such as power generation, flash board, and induced surcharge etc.
- Short or long term forecasts

Use SSARR Operation when

- Do not have the operation rules or
- Dam operator does not follow rules stated in operation manual
- Have reliable release data
- Is a single reservoir with or without backwater effects
- Two reservoir with less than operation time interval travel time
- Short term forecasts

Use RES-J Operation when

- Have the operation rules
- Is single or multiple reservoirs without backwater effects
- Tree structured reservoirs in parallel or in series
- Short or long term forecasts

Use FLDWAV Operation when

- Do not have the operation rules
- Uncontrolled spillway release
- Have channel cross sectional data
- Allows for backwater effect
- Is tree or bifurcation river network
- Rapid rising or falling floods
- Short or long term forecasts
- Long reservoirs where level pool routing is not applicable

What to Do When You Have Little/No Information

- Dig / Ask questions
- Be creative
  - Derive info from other sources
  - Expertise from past experience
    - Make reasonable estimates
  - Use SSARRESV
  - Do you need to model it?

Rules of Operation

- RES-SNGL
  - Use Reservoir Command Language (RCL)
  - Equivalent to RULES in the RES-J Operation
  - Allow inbeded IF
  - Use value from last scheme executed for the next IF decision
- RES-J
  - Use RULES to control the operation of a reservoir. RULES in the RES-J Operation is equivalent to RCL in the RES-SNGL Operation
  - No inbeded IF
  - Use value from previous time step for all the applicable rules

Comparison of Reservoir Models (1)

	Numerical method	Program language	Reservoir system	Tree or network
RES-SNGL	explicit	Fortran	single	no
SSARR	explicit	Fortran	max two	series
RESJ	explicit	C, C++ & Fortran	Single or multiple	tree
FLDWAV	Implicit / explicit	Fortran	Single or multiple	Tree & network

Comparison of Reservoir Models (2)

	backwater	Operation rules	Channel cross section data	Downstream boundary
RESJ-SNGL	no	yes	no	no
SSARR	yes	no	no	no
RES-J	no	yes	no	no
FLDWAV	yes	no	required	required