RiverWare

CADSWES University of Colorado

Center for Advanced Decision Support for Water and Environmental Systems

USACE – Overview of Modeling Approach and Enhancements

RiverWare User Group Meeting
August 13-14, 2008

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Outline

- Summary of methods and how they work together
- New functionality
  - Cumulative Flow Disagg (previous presentation)
  - Iterative mode and yield study (later presentation)
  - Alternative routing coefficients
  - Initialization for routing
- Upcoming Work

Overview

- Methods and rule functions are used to replace the approach used by USACE in the SUPER program
  - Flood Control
    - Surcharge Release
    - Regulation Discharge
    - Flood Control Releases
  - Conservation Operations
    - Low Flow / Demand Releases
    - Reservoir Diversions
    - Reach Diversions
  - Hydropower

Surcharge

- Mandatory releases made regardless of downstream channel constraints
- Pool elevation exceeds top of the flood pool
- Ensures safety of the structure

Rule: Set Surcharge Release Flag (S) on Res.Outflow slot of each Reservoir in Computational Subbasin

Simulation: Surcharge releases and Outflows are computed and set by the resulting dispatch method for entire forecast period

Regulation Discharge

- Methods determine the maximum flow permitted at the control point and empty space available in the channel based on the current flow

Rule: Set Regulation Discharge (G) Flag on all Control Point.RegDischargeCalc slots

Simulation: Calculate Regulation Discharge and dependent methods; removes G flag; does not reset any Outflows

Flood Control

- Determine additional flood control releases for each reservoir in the subbasin
- Respect downstream channel constraints
- Balance reservoir storages to extent possible

Rule: FloodControl(): Function executes Flood Control Method on subbasin and the calling rule sets Reservoir.FloodRelease and Res.Outflow on subbasin (outflow = surcharge release + flood release)

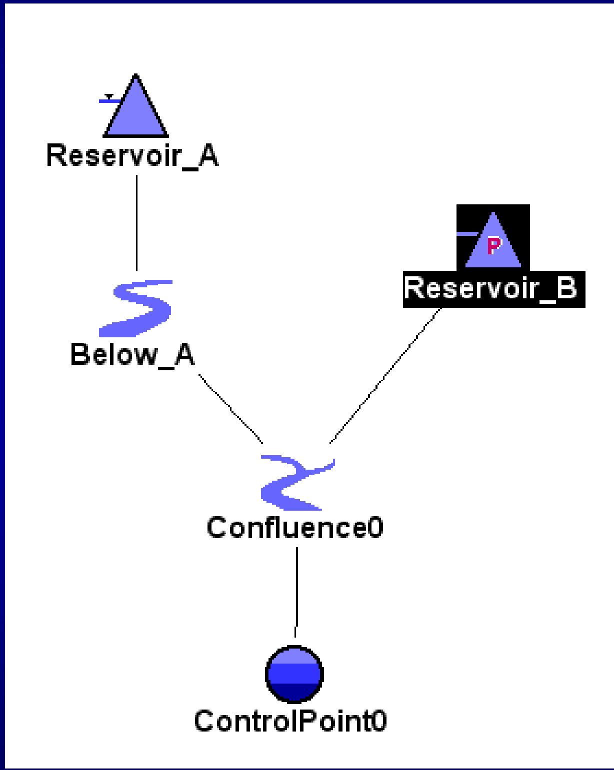
Simulation: Objects dispatch and results propagate downstream

Conservation Operations: Low Flow / Demand Releases

- Flow requirement on a Control Point represents environmental flows or demand
- Determine releases to meet a downstream flow requirement
- Reservoirs are considered in the order of highest operating level

Rule: MeetLowFlowRequirement(): Execute Low Flow Release Method on computational subbasin and rule sets reservoirs Low Flow Release slots and Outflow slots

Simulation: Objects dispatch and results propagate downstream

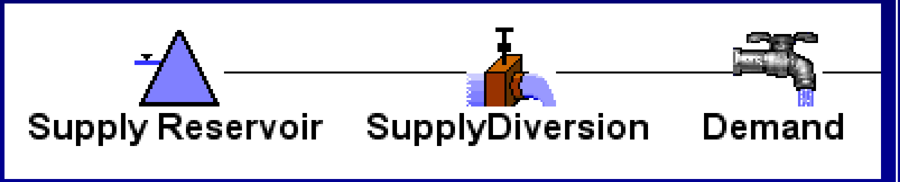


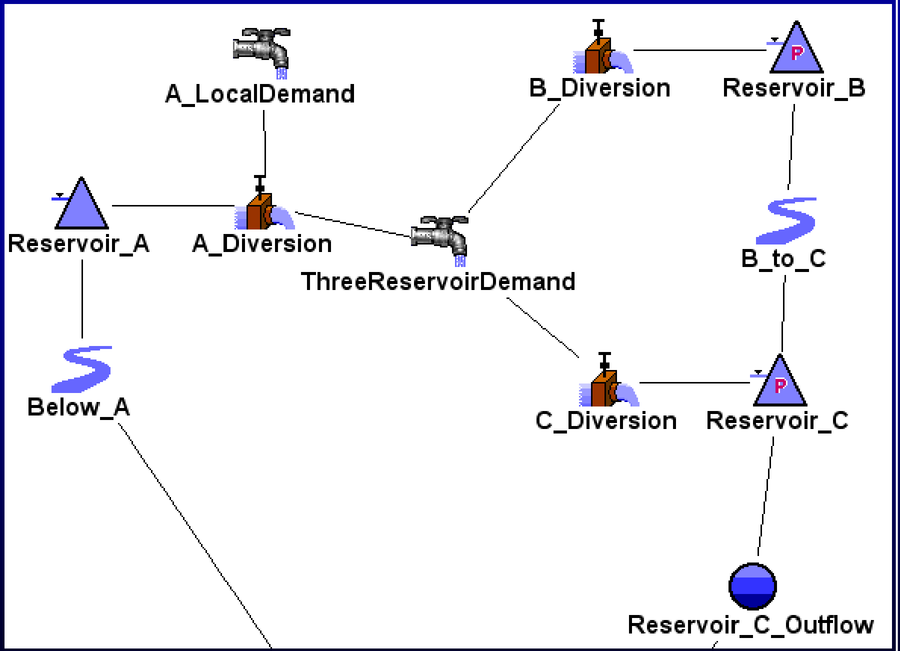
Conservation Operations: Reservoir Diversions

- Water is diverted directly out of a reservoir to meet demands
- Modeled using a Diversion and Water User
- One reservoir can meet many demands
- A demand can be served by many reservoirs

Rule: ComputeReservoirDiversions(): Execute method on subbasin and set Water Users' Incoming Available Water subslots and Diversion objects' Multi Outflow slots

Simulation: Reservoirs, Water Users, and Diversion objects dispatch.





Hydropower

- Make releases to meet energy demand
  - Cannot draw below min power pool or exceed max drawdown
  - Cannot cause additional downstream flooding

Rule: HydropowerRelease(): Prioritizes the reservoirs by relative energy shortage.

  - Loops through each reservoir in the basin and calculates the proposed release to meet the demand.
  - Calculates portion of the proposed release that will not cause additional downstream flooding.
  - Rule sets Res.Outflow

- Simulation: Objects dispatch simulating the effects of the release.

How does this all work together:

- Rules execute in following order once per ts:
  - Surcharge Release } Mandatory Releases
  - Regulation Discharge } Find Empty Space
  - Flood Control Releases } Additional Flood Releases
  - Low Flow / Demand releases } Increase Outflow
  - Reservoir Diversions } Divert water from Res.
  - Hydropower } Increase Outflow

Note, reach diversions and losses happen as objects dispatch.

Recent Enhancements

- Calculation of incremental flows from cumulative – see previous presentation
- Iterative Mode MRM / Yield Study
  - Integer Index Slots
  - Yield Study Algorithms
  - Presented in detail later

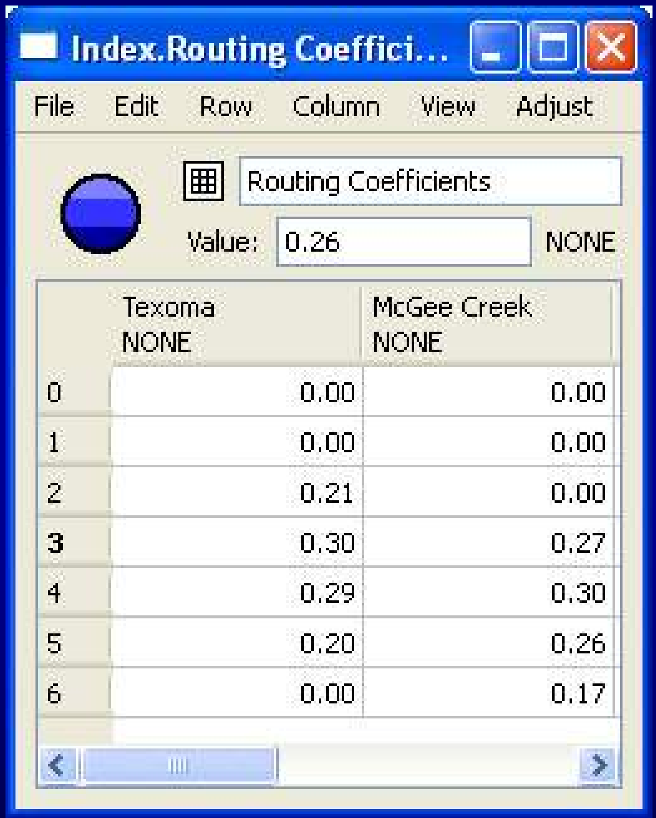
Alternative Routing

- During high flow periods, overbank flow causes invalid routing coefficients.
- New Reach routing method: Variable Step Response
- Reach uses Inflows to select step coefficients

	0 cfs --- NONE	80000 cfs --- NONE	150000 cfs --- NONE
0	0.1111	0.1112	0.0743
1	0.2964	0.2965	0.2162
2	0.2963	0.2966	0.2558
3	0.1646	0.1648	0.1879
4	0.0768	0.0769	0.1181
5	0.0329	0.0330	0.0686
6	0.0134	0.0134	0.0379
7	0.0053	0.0051	0.0203
8	0.0020	0.0017	0.0106
9	0.0008	0.0006	0.0055
10	0.0003	0.0002	0.0027
11	0.0001	0.0000	0.0012
12	0.0000	0.0000	0.0006
13	0.0000	0.0000	0.0003

Alternative Routing – USACE methods

- USACE methods also needed to be enhanced
- Flood control uses slots on CP to specify how water routes from each res to a given CP
- These were static – now they are generated at each timestep



Alternative Routing - USACE methods

- Methods added to Computational Subbasin to specify objects of interest and methods to CP to hold slots
- On each CP, the method searches upstream and uses
  - start of timestep flows and
  - coefficients on reaches

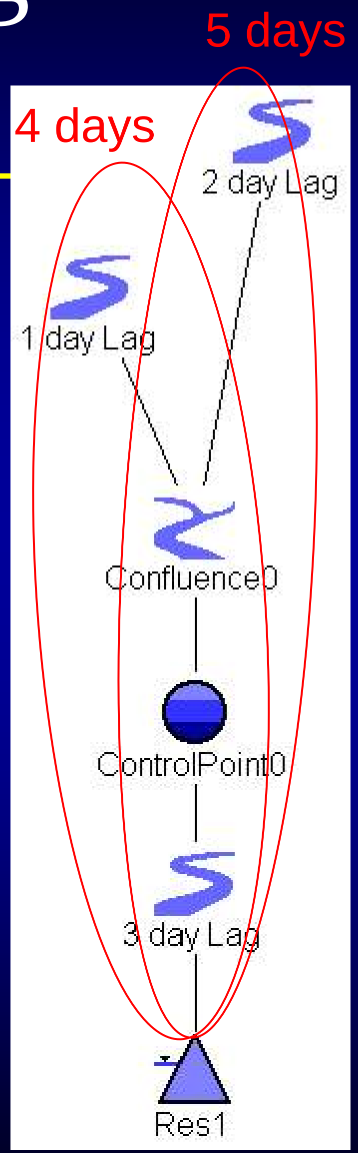
  to create aggregate coefficients from a CP to each upstream Reservoirs
- New coefficients are stored on temp slots

Alternative Routing – Flood Control Modifications

- Flood Control function now uses temp aggregate coefficients in all calculations
- Note, in simulation the reaches still use the coefficients based on inflows – conservation of mass

Initialization for Routing - Background

- USACE methods required that all objects can solve on first timestep
- Because of routing, user has to input pre-simulation data. Difficulties include:
  - Time consuming to calculate number of timesteps needed
  - Which slots need data?
  - Time consuming to enter data
- Hard to move model forward in time
- Approach: New method on Computational Subbasin "Initialize Flow Slots for Routing"



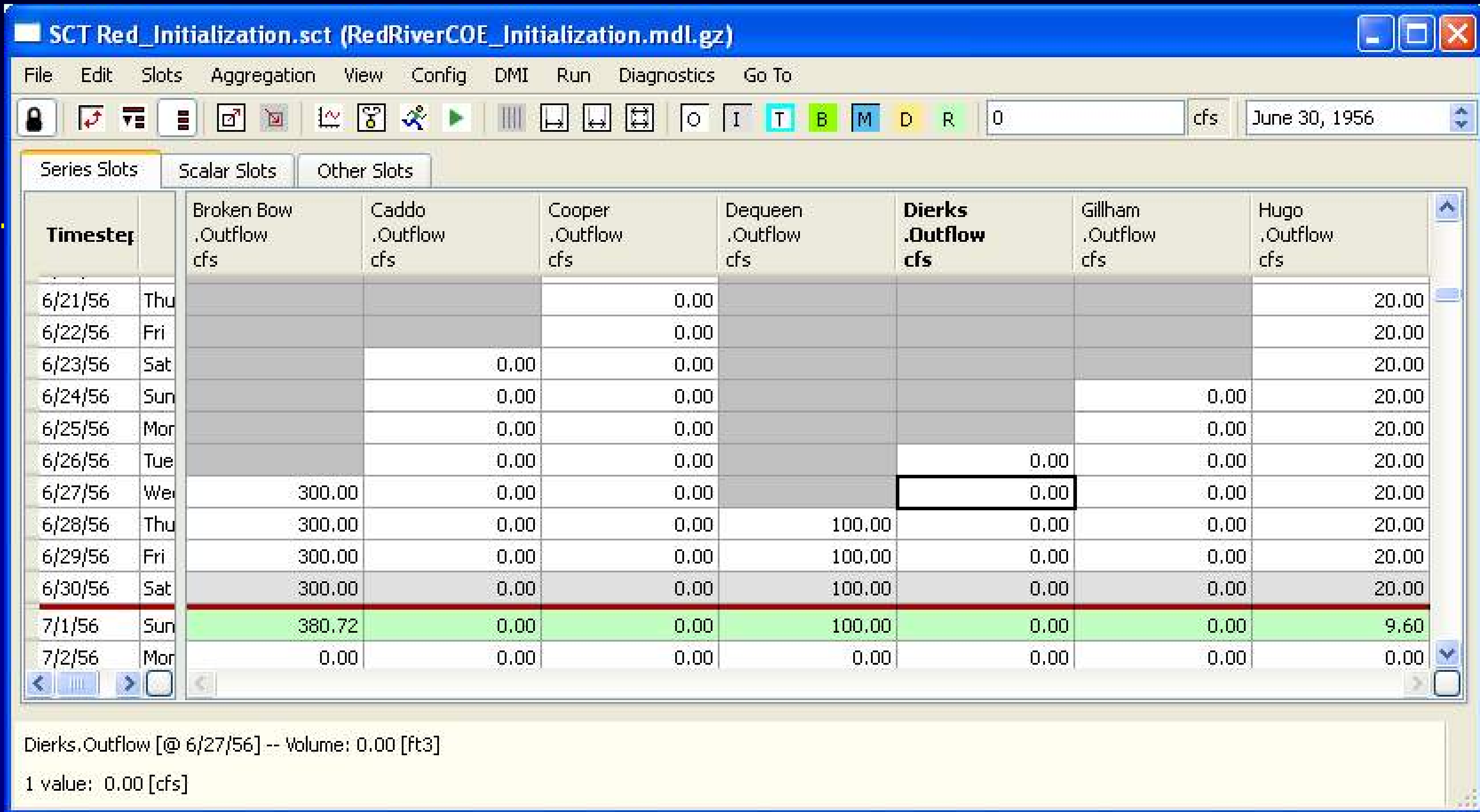
Initialization steps

RiverWare searches through the subbasin and determines:

1. Slots that need to be set:
   - Reach, Confluence, Gage, Agg Reach: Inflows (if not linked)
   - Reservoir, Inline Power, Pipeline and Inline Pump: Outflows (if linked)
   - Reach: Local Inflows, Diversion, and Return Flows (if linked)
2. Number of pre-simulation timesteps required for each object.slot of interest. Each object searches routing reaches downstream to bottom of subbasin. E.g. 3 day lag = 3 timesteps

Initalization steps (cont.)

3. The value to set on each slot. User methods are available to backcast:
   - Zero
   - Initial Value - First user input
4. Finally, the method sets the value on the slot



- Multiple subbasins can be defined
  - Backcast a value for certain object.slots (e.g. Res.Outflow)
  - Assume a value of zero for others (e.g. Reach.Local Inflow)

Upcoming Enhancements

- Performance work
- Export/Import plot configurations
- Post processing to create monthly reports
- Create formatted printable text file of objects, methods, tables, notes in model
- Clear values imported by DMI
- Extend riverwareDB for data objects
- User Guide for USACE methods