IWFM-OPS:
Innovative Approaches to Linking Integrated Hydrologic and Reservoir Systems Analysis Models

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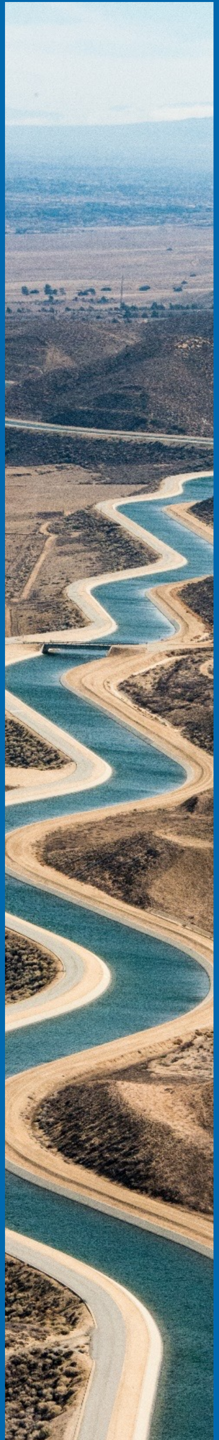
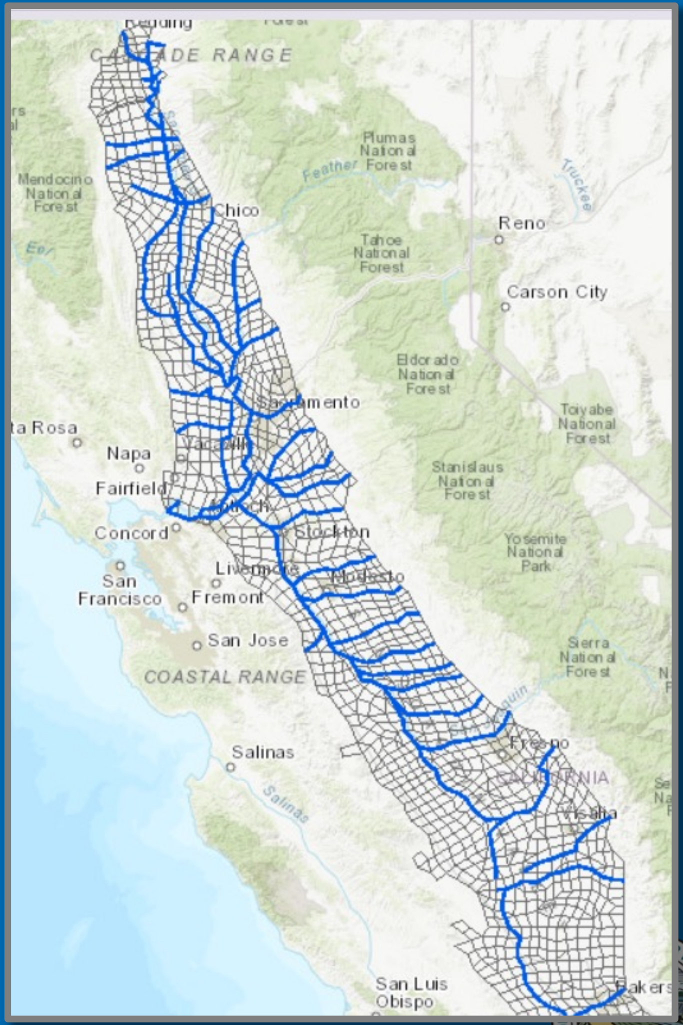
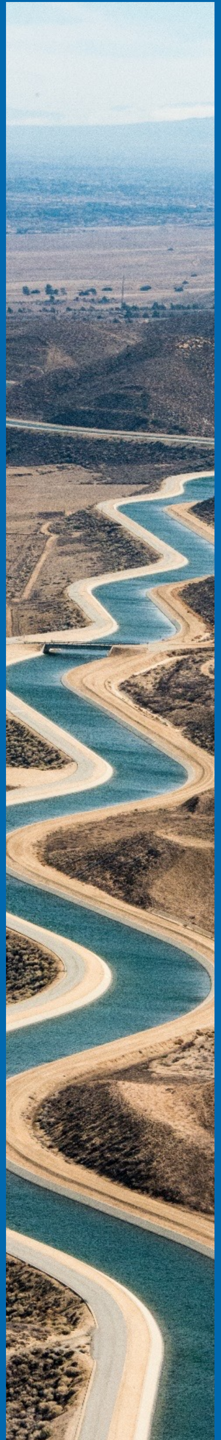


Modeling Platforms

IWFM: **I**ntegrated **W**ater **F**low **M**odel

- Generic integrated hydrologic modeling software
- Simulates water flow within the hydrologic cycle
- Calculates agricultural and urban water demands; uses stream diversions and groundwater pumping to meet the demands
- Notable applications: C2VSimCG, C2VSimFG, local models to assist development of GSPs

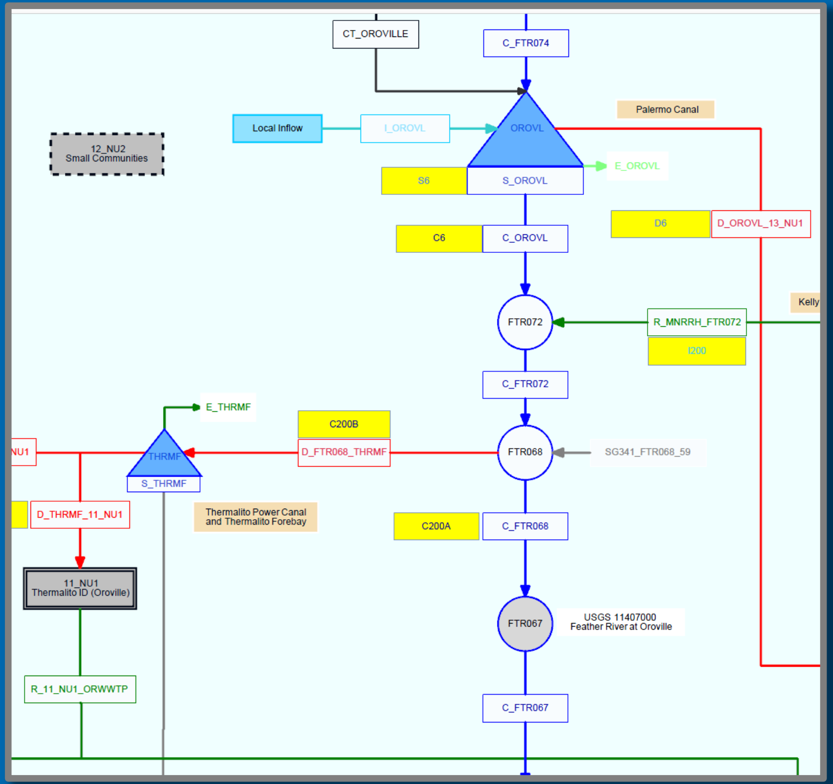




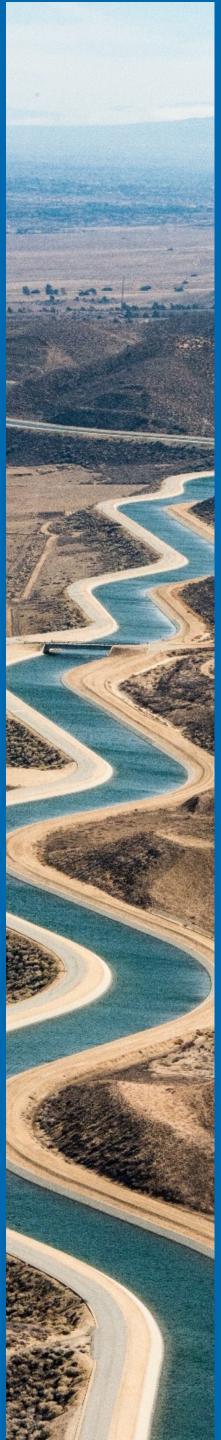
Modeling Platforms

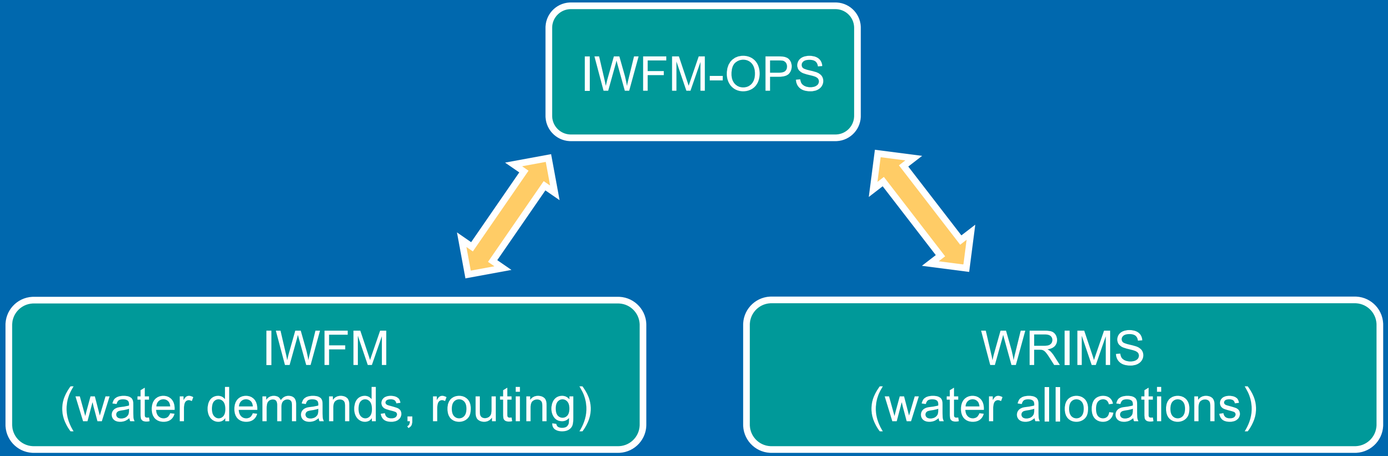
WRIMS: **W**ater **R**esources **I**ntegrated **M**odeling **S**ystem

- Generic reservoir systems and water allocation analysis software
- Simulates reservoir operations and water allocations under physical, legal and operational constraints
- Network-flow-programming based simulation
- Incorporates a flexible language interface (WRESL) to define the mathematical model
- Notable applications: CalSim 2, CalSim 3, CalLite

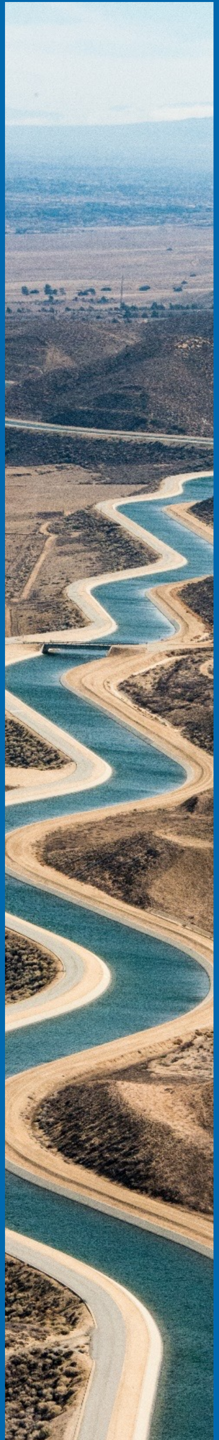


IWFM-OPS: Wrapper for IWFM and WRIMS





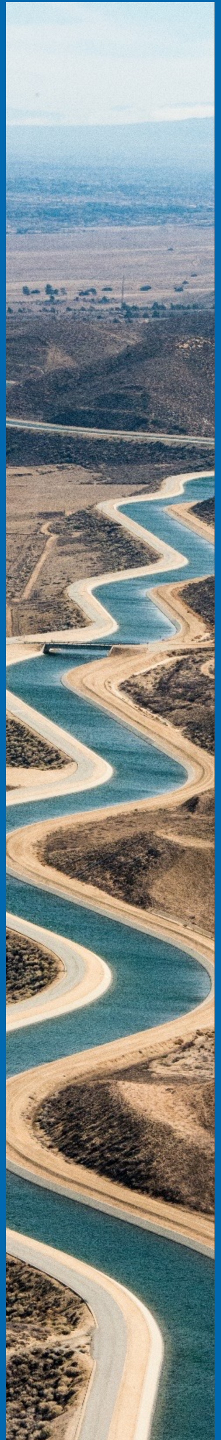
- Coordinates calculations, data passing, and iterations between IWFM and WRIMS
- Complete streamlining and consistency between IWFM and WRIMS models
- Tries to make modelers' work easier
- Full functionality of both IWFM and WRIMS engines are retained



Modeling with IWFM-OPS

Basics

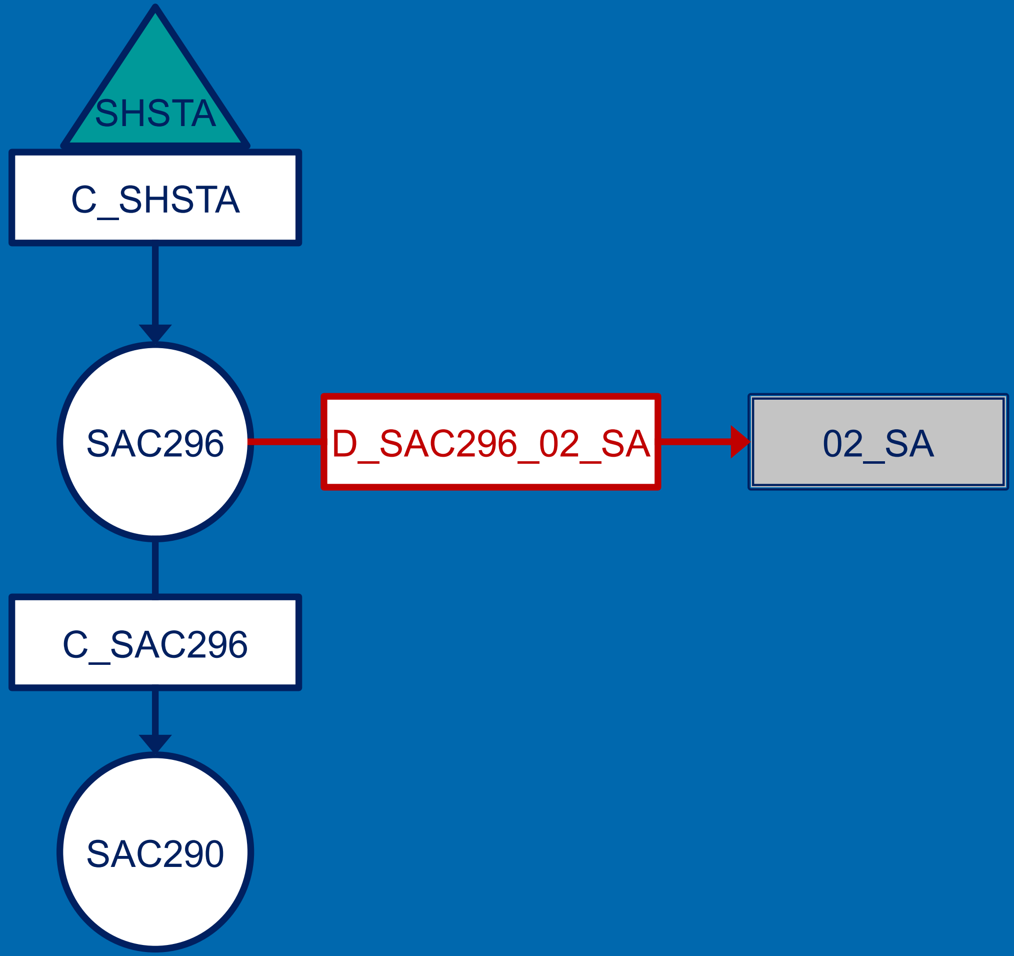
- Initial step: Development and calibration of an IWFM model; all physical system definition (stratigraphy, stream network, diversion and bypass locations, etc.) and flow routing are done in the IWFM model
- Next step: Development of the IWFM-OPS model; build WRIMS model on top of the IWFM model to simulate operations and decision making
- All system-related information must be defined in the IWFM model; e.g. cannot introduce a diversion or stream node in WRIMS model which doesn’t exist in the IWFM model

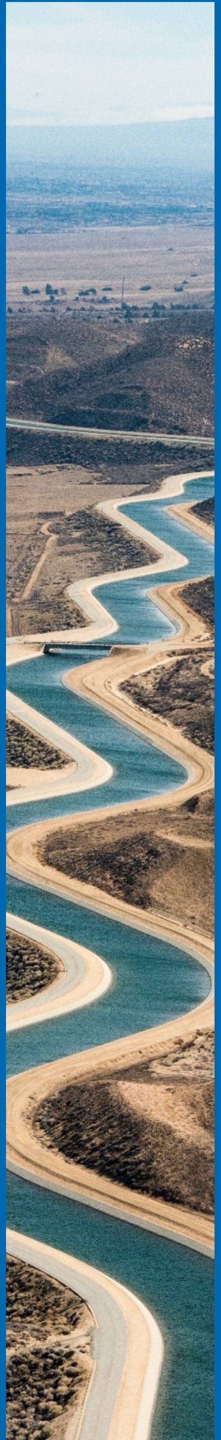


Modeling with IWFM-OPS

Use of keywords

WRIMS Representation





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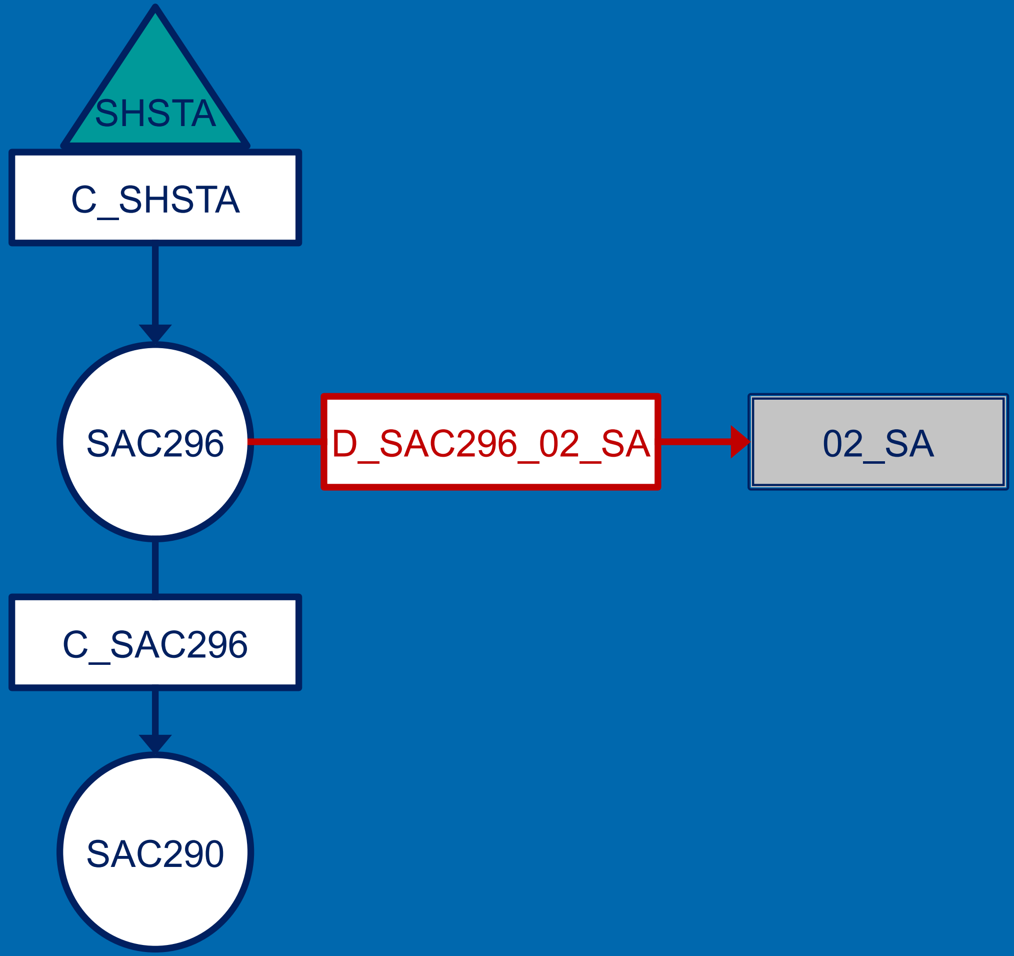
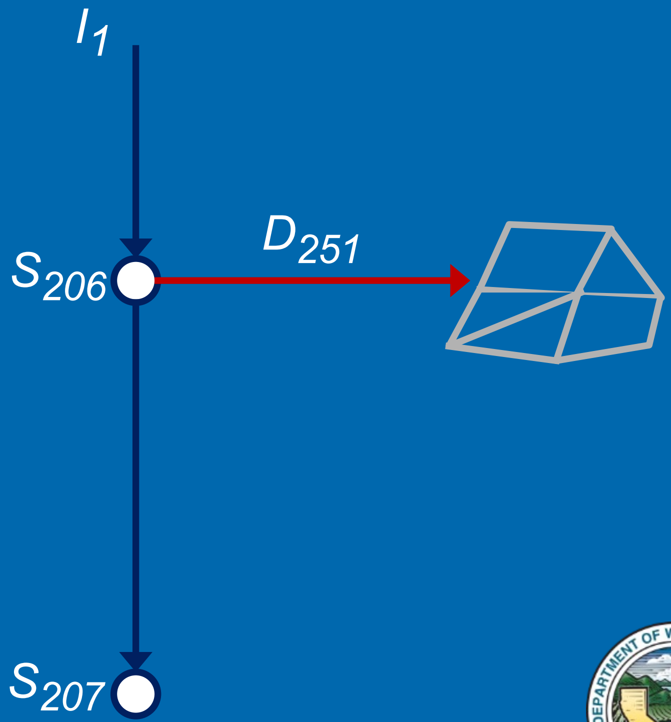
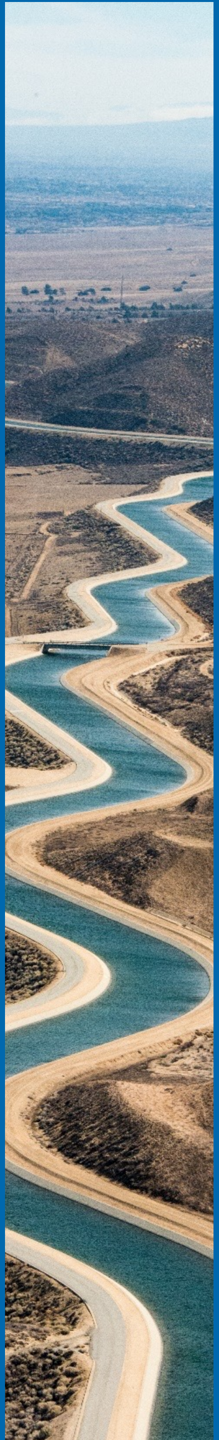


IWFM Representation

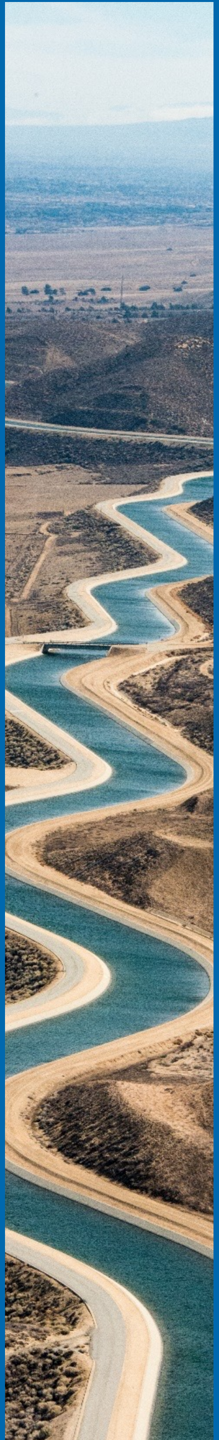




Modeling with IWFM-OPS

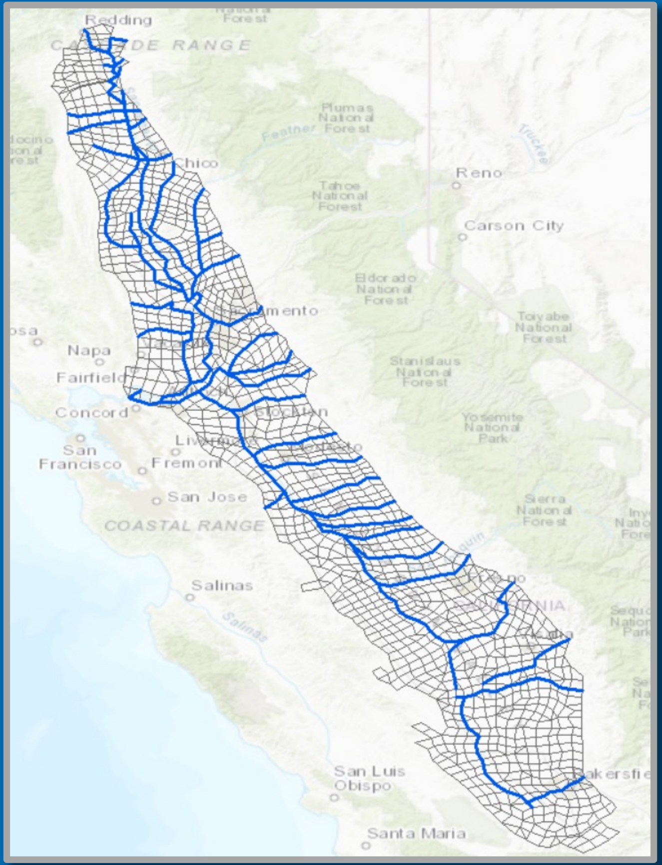
Use of keywords

- Must use IWFM numbering convention in naming state and decision variables (SVARs and DVARs) in WRESL code
  - Stream flow: *C_xxx* (e.g. *C_356* instead of C_SAC296)
  - Diversion: *DIV_xxx* (e.g. *DIV_251* instead of D_SAC296_02_SA)
  - Diversion requirement: *DIV_REQ_xxx* (e.g. *DIV_REQ_251;* this is the demand computed by IWFM and served by diversion 251)
  - Stream boundary inflow: *I_xxx* (e.g. *I_1* instead of C_SHSTA)
  - Bypass flow: *BYPS_OUT_xxx* (e.g. *BYPS_OUT_11*)
- Corresponding SVARs and DVARs are automatically generated for WRIMS



Modeling with IWFM-OPS

Auto-generation of stream flow continuity equations for WRIMS



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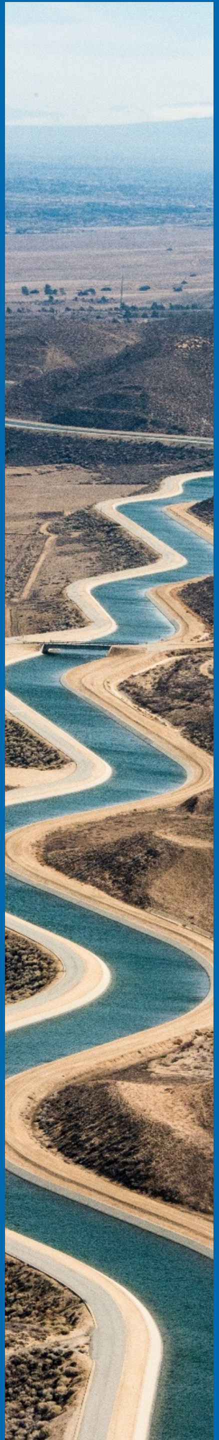

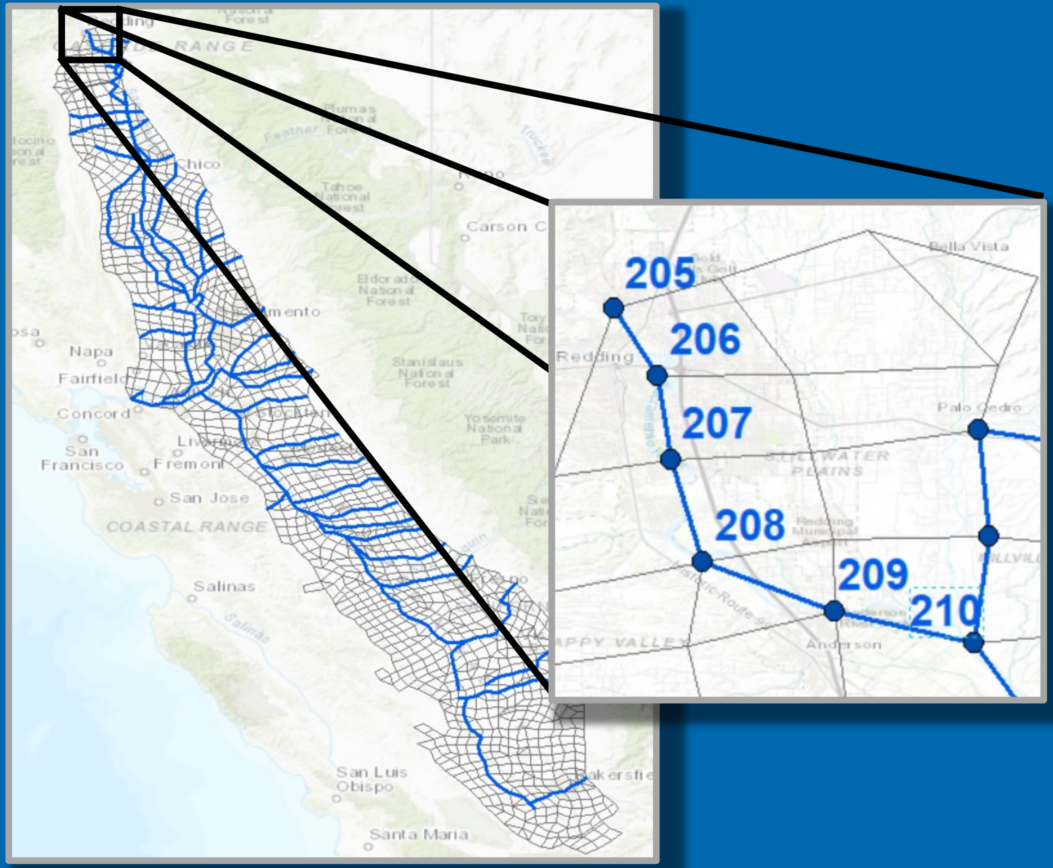

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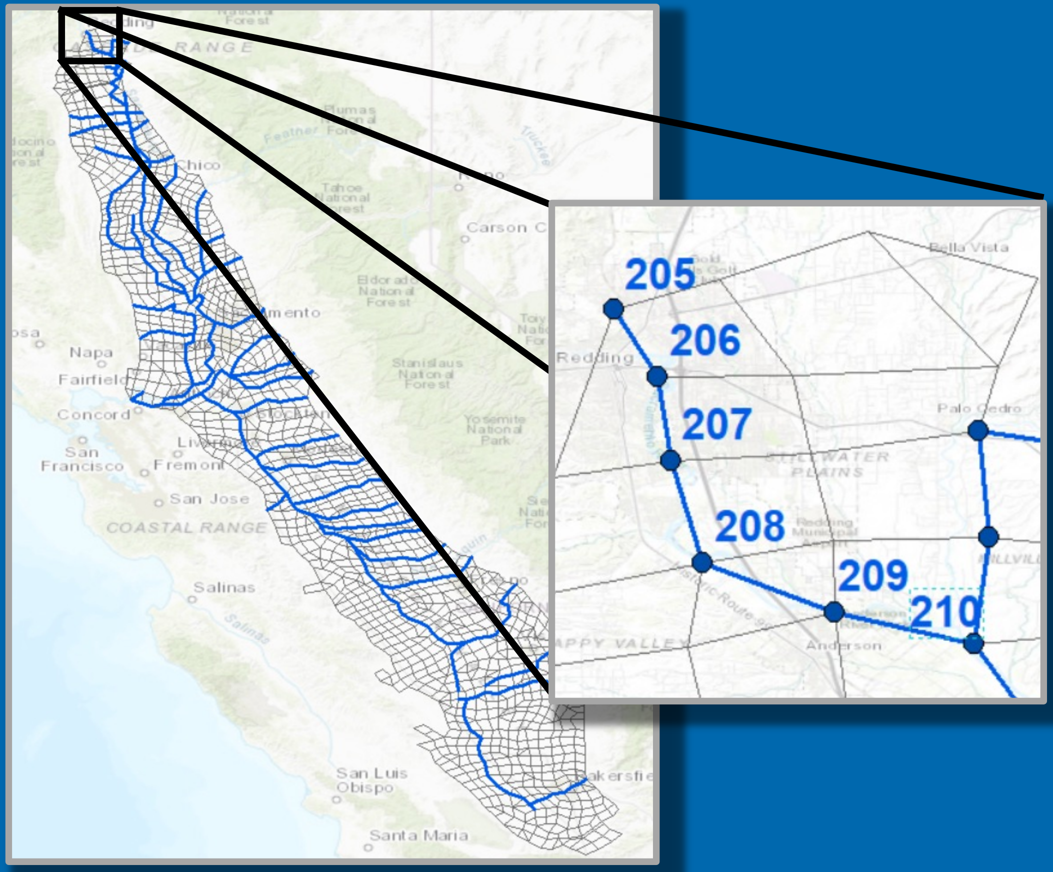
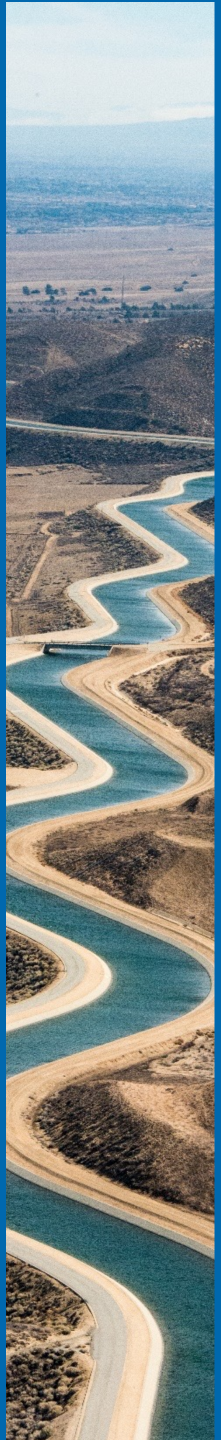
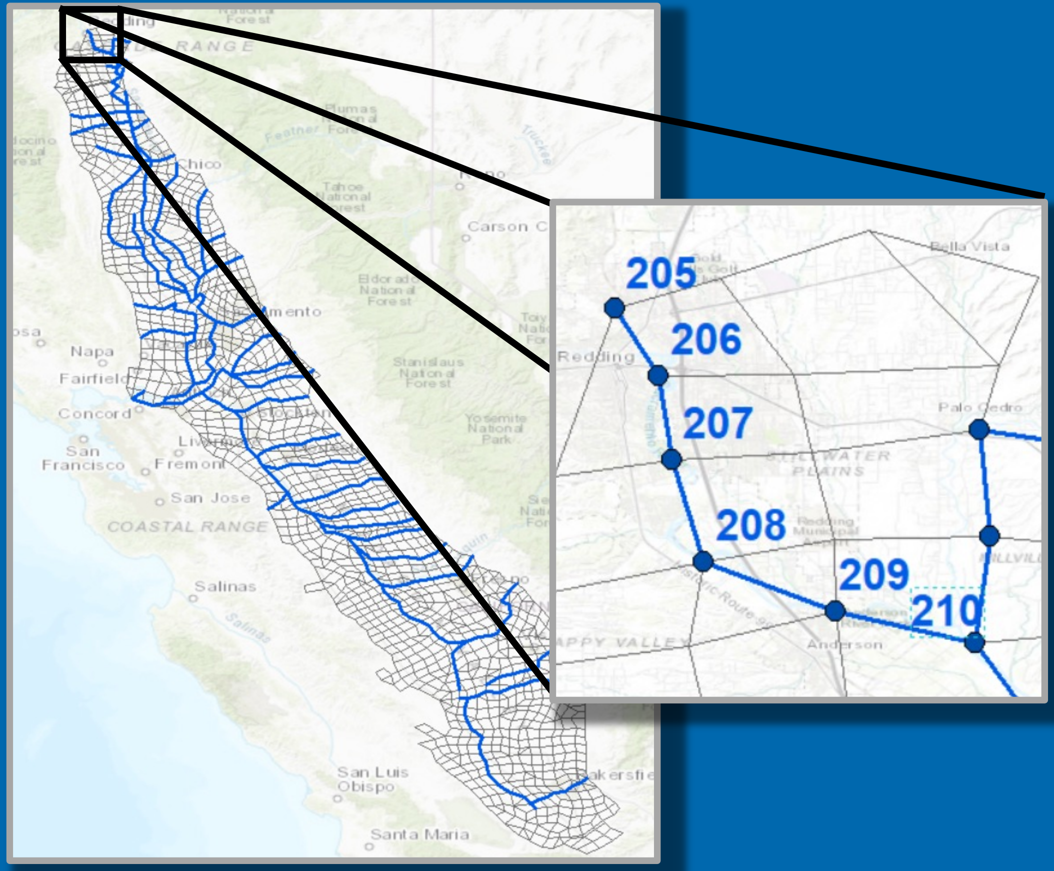


- No operations/constraints defined for reach:
  - ➢ Automatically generates 1 continuity equation for the entire reach
  - ➢ Automatic SVARs (computed by IWFM):
    - Reach net accretion
    - Stream inflow into node 205
  - ➢ Automatic DVARs (computed by WRIMS):
    - Stream flow at node 210

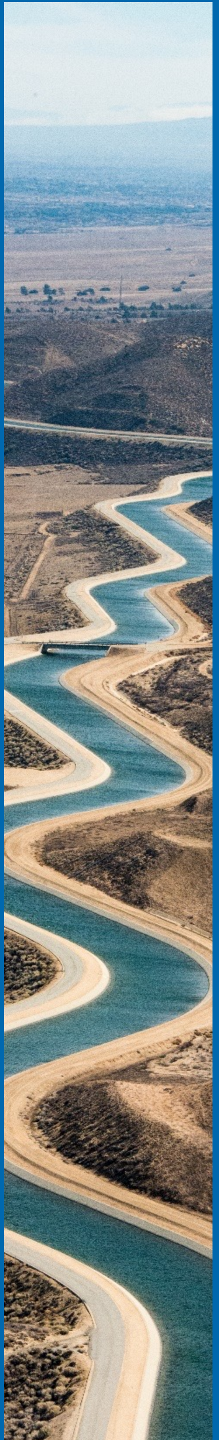


Modeling with IWFM-OPS

Auto-generation of stream flow continuity equations for WRIMS

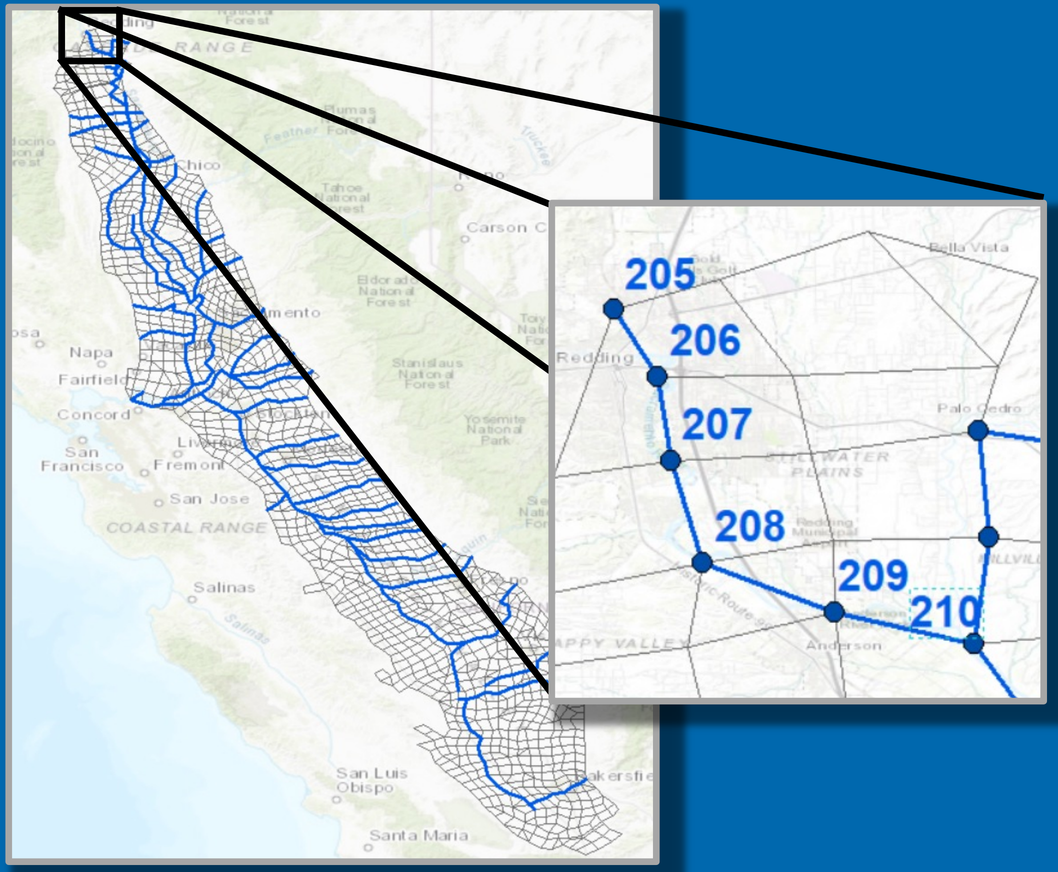


- An operation/constraint defined at node 205 (e.g. minimum flow requirement, diversion requirement, etc.):
  - Automatically generates 2 continuity equations for the reach
    - For node 205
    - For nodes 206-210 combined
  - Automatic SVARs (computed by IWFM):
    - Net accretion to node 205
    - Net accretion to nodes 206-210 combined
  - Automatic DVARs (computed by WRIMS):
    - Stream flows at nodes 205 and 210

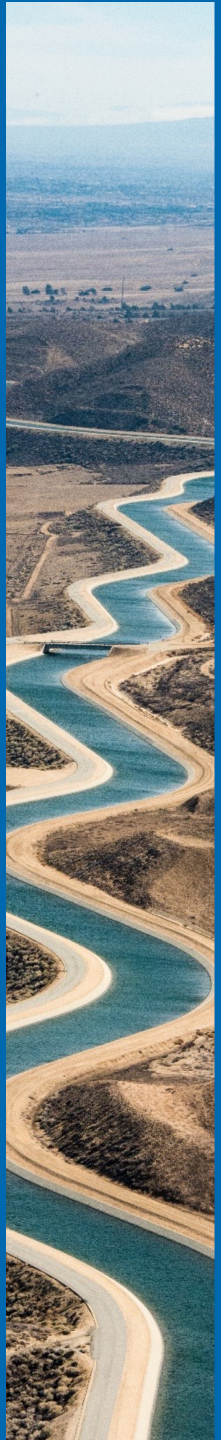


Modeling with IWFM-OPS

Auto-generation of stream flow continuity equations for WRIMS



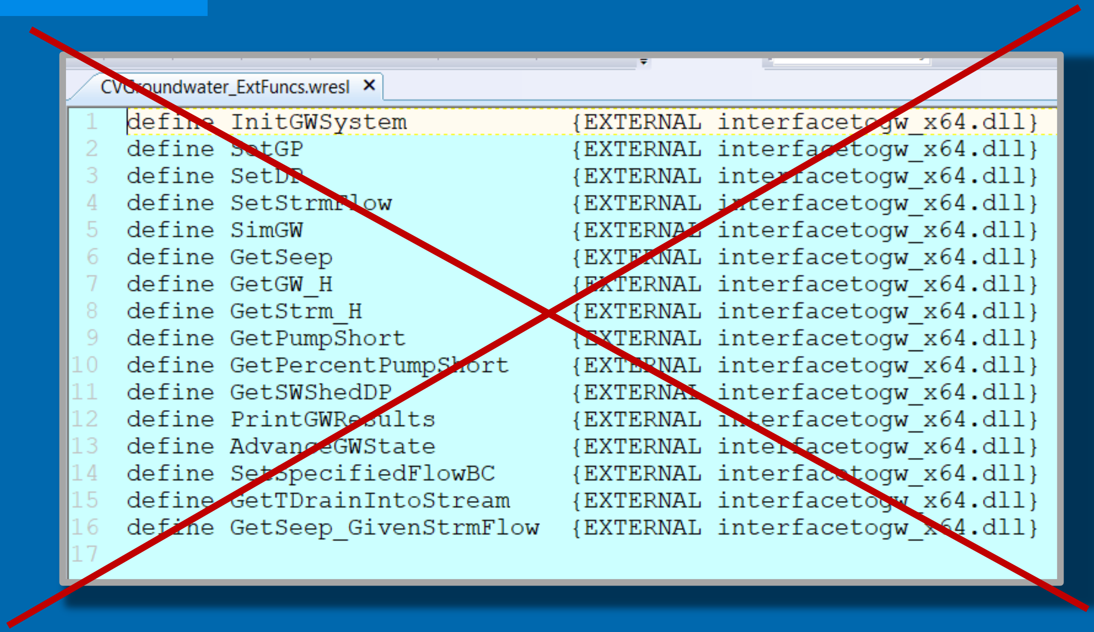
- WRIMS model size (number of SVARs and DVARs) independent of the underlying IWFM model size (number of stream nodes, groundwater nodes, elements)
- Automatically generated stream flow continuity equations, SVARs and DVARs can be different for each cycle

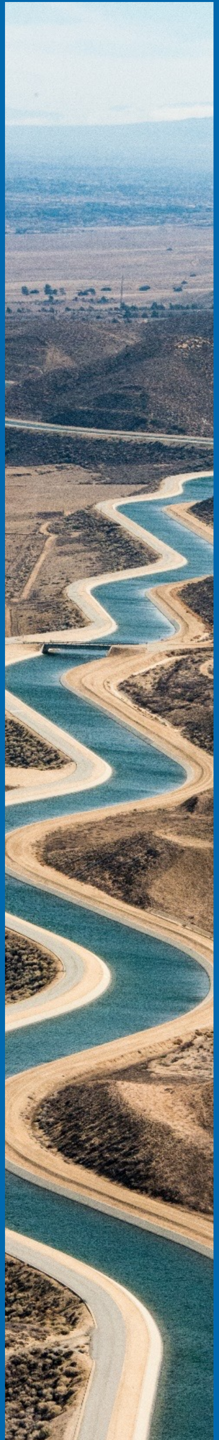


Modeling with IWFM-OPS

Other features

- The logic of IWFM-WRIMS linkage is coded into IWFM-OPS; no need to call external DLL functions from WRESL code





Modeling with IWFM-OPS

Other features

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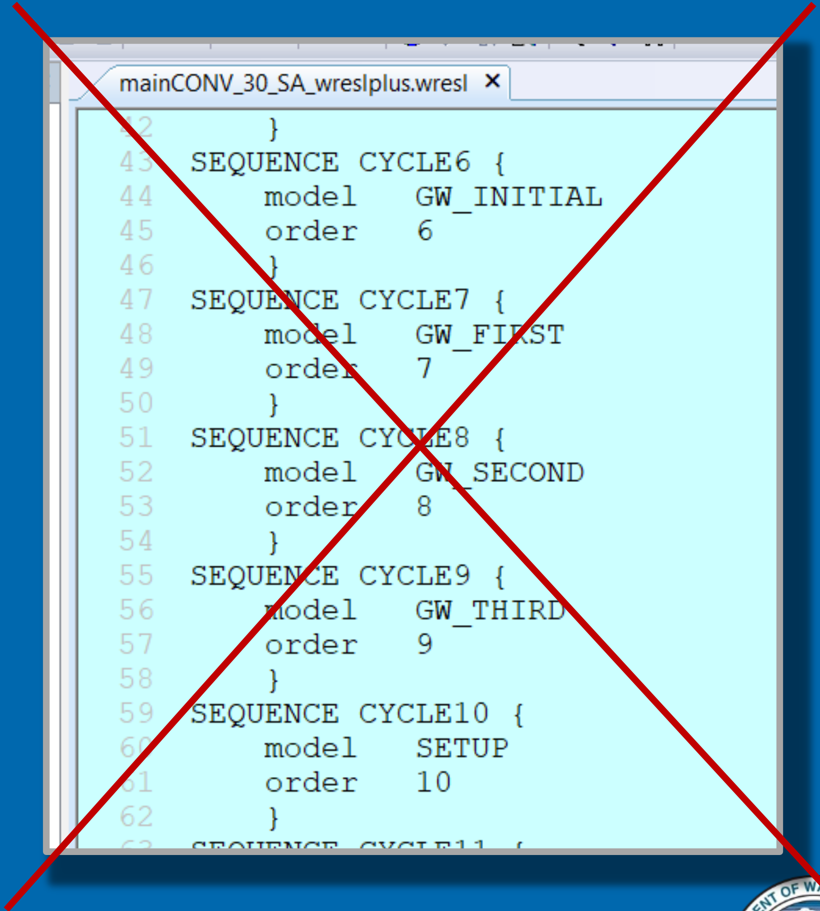
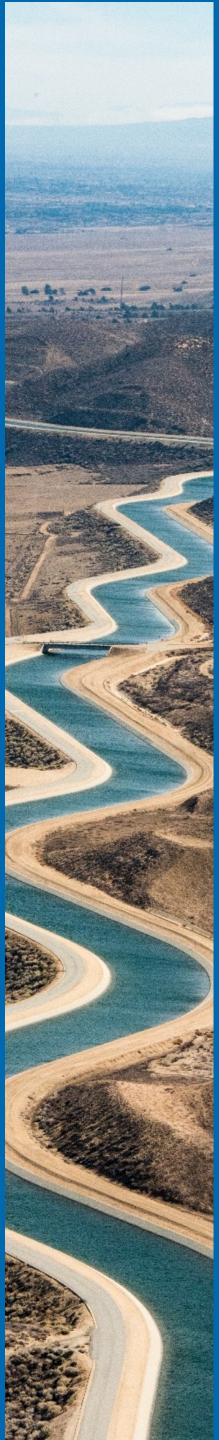
- Number of iterations between WRIMS and IWFM are dynamic to achieve a user-specified convergence criteria





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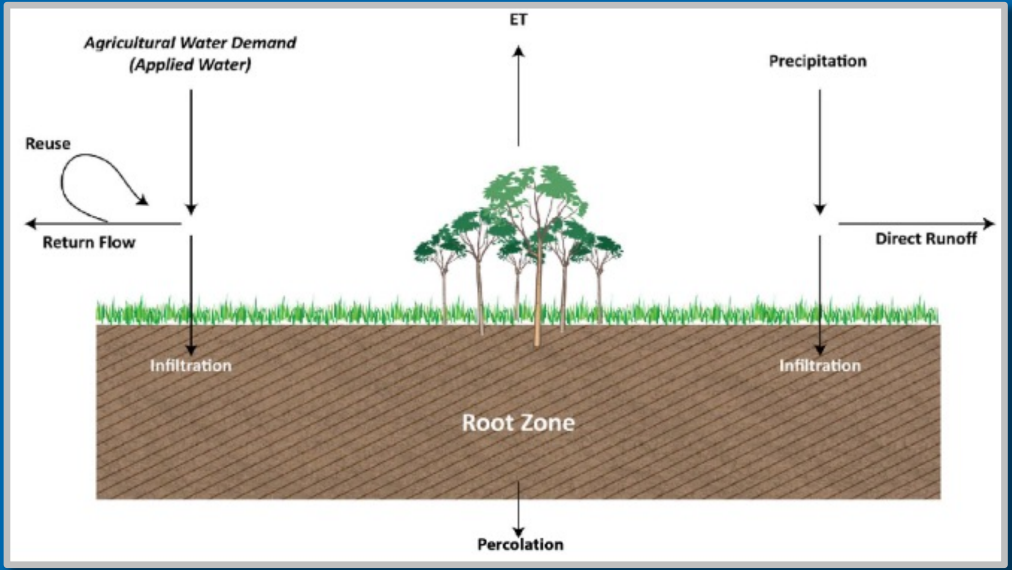
- Water demand computations are dynamic within a model run (efficient simulation of climate change scenarios; opens possibility to dynamically modify crop acreages)



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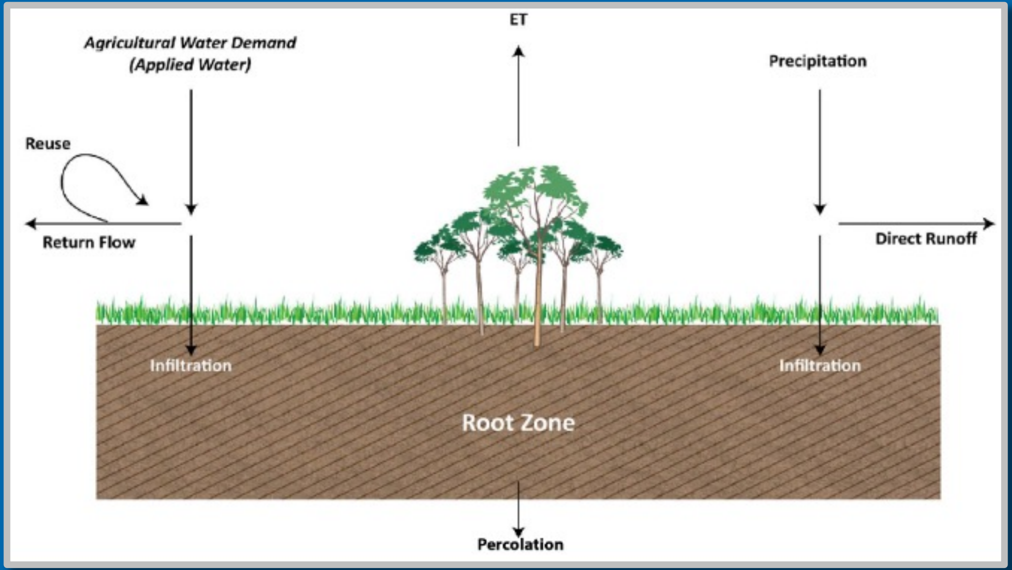
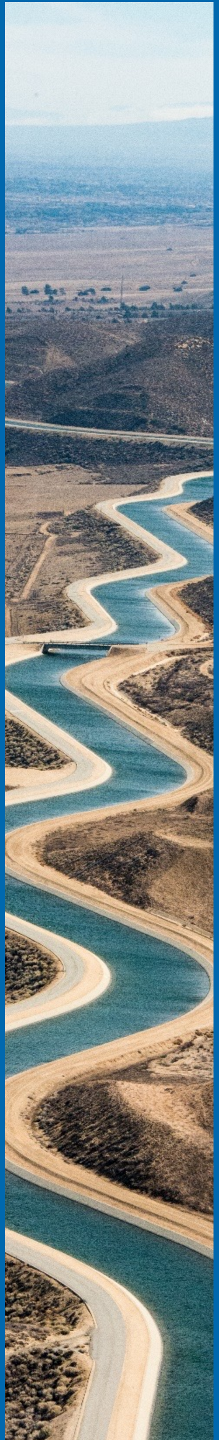
Other features

- The logic of IWFM-WRIMS linkage is coded into IWFM-OPS; no need to call external DLL functions from WRESL code
- Number of iterations between WRIMS and IWFM are dynamic to achieve a user-specified convergence criteria
- Water demand computations are dynamic within a model run (efficient simulation of climate change scenarios, opens possibility to dynamically modify crop acreages)
- Allows gradual building of the WRIMS model

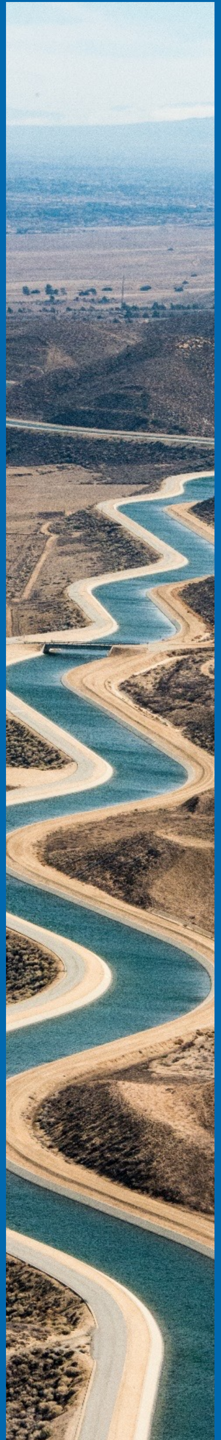




Modeling with IWFM-OPS

Other features

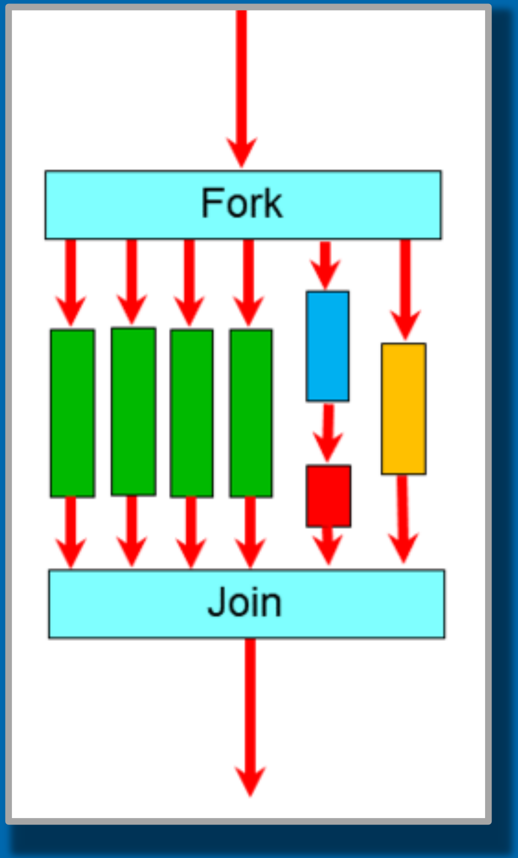
- Ability to forecast future water demands to guide monthly reservoir operations

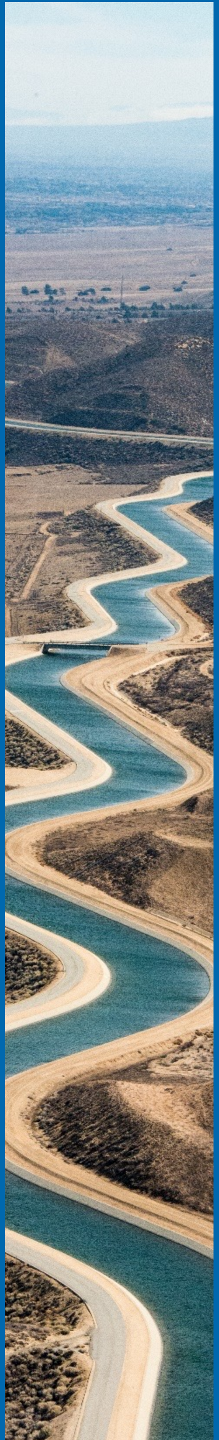


Modeling with IWFM-OPS

Other features

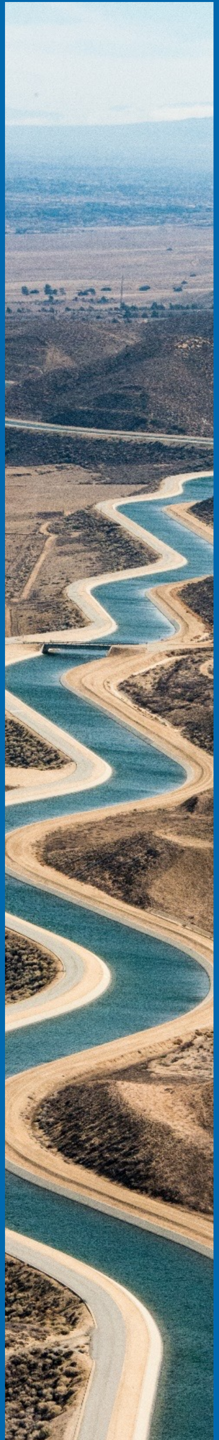
- Ability to forecast future water demands to guide monthly reservoir operations
- Implemented parallel processing to decrease runtimes





Future Developments

- Additional work to speed-up convergence between IWFM and WRIMS models
- Link IWFM-OPS to WRIMS GUI
- Incorporate the ability to impose groundwater-related goals and constraints
- Incorporate agricultural-production-type models to simulate crop acreages under future climate, legal, operational and economic settings



Questions?