RECLAMATION
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Assessing Spatially Distributed Temperatures for Water Suitability and Habitat

Better representation of temperature processes leads to increased accuracy and higher confidence.

What Is The Problem?

Reclamation dam operations need to meet specified temperatures for dam discharges or downstream river reaches, based on habitat and biological criteria on many rivers. Thus, managers need to have accurate forecasts and models of how water and power operations might influence temperatures.

To predict how dam releases will affect downstream river habitat, we must understand the temperature variations in river features such as tributaries and agricultural returns, gravel pits, ground water upwelling, side channel activation, streamside vegetation, and topographical shading. Flows and temperatures within these features behave differently than that in the main channel and are not captured in the existing low-order models. Existing tools based on low-order modeling show river temperatures as a simple line with limited spatial distribution of flow and temperature inputs and poorly represent the physics of the river processes.

What Is The Solution?

This Science and Technology Program project improves the representation of spatial features that affect temperature to better model temperatures for a river. We developed a temperature model into the existing two-dimensional (2D) hydraulic model (SRH-2D). This model is spatially distributed, so it incorporates temperature data both across the river surface and below the surface. A multidimensional representation provides a more complete description of temperature impacts using the same dimensions as are significant for biology. Spatially distributed sources of heat and cooling (ground water, solar, wind, vegetation) are directly transferable to the model and do not require grouping by reach.

The new model takes the existing thermal modeling to a new level— tributary and agriculture returns, side channel activation, and channel spills can be modeled based on their physical processes. Physical processes modeled include solar radiation, terrain and vegetation shade, atmospheric radiation, water back radiation, heat exchange between water and river bed, as well as water surface evaporative and conductive losses.

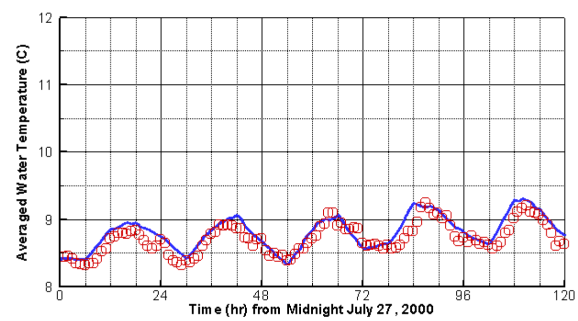
Accurate flow hydraulics eliminates the need for abstract travel time coefficients and flow routing parameters. In lateral splits, such as gravel pits or side channels, flow moves at different speeds along the different paths, and heats or cools at different rates as a result. The difference in flow velocities between the river centerline and banks is also captured, eliminating calibration for cross-section averaging.

Who Can Benefit?

The new model can help planners identify zones in the river that will retain acceptable temperatures even when overall river temperatures might be undesirable or when "hot spots" persist in spite of good average temperatures. Representing these physical processes better also leads to simpler model formulation, increased accuracy, and higher confidence. Thus, this model can benefit river managers who have the need to project downstream temperatures for operational consideration or environmental concerns.

Where Have We Applied This Solution?

We verified the model using test cases with analytical solutions and with data from the McKay Creek downstream of the McKay Dam, Oregon.



Comparison of temperature near McKay Dam from 7/28 through 8/1/2000; solid line: simulated; circles: measured.

Future Development Plans

We are further developing and applying the 2D temperature model to the Methow River, in Washington, to predict the stream temperature and its impact to the salmonid population. We are also applying the model to the San Joaquin River to address temperature issues around gravel pits. Once the model is verified through these further studies, we plan to publish the model on our web site for public use.

For More Information

Lai, Y.G. and D. Mooney, (2009). "On a Two-Dimensional Temperature Model: Development and Verification," ASCE World Environmental and Water Resources Congress, Kansas City, Missouri, May 17-21, 2009.

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Collaborators

Reclamation's Mid Pacific Region and the Science and Technology Program