Attachment 12—Hydrology Modeling

Hydrologic simulation models, such as RiverWare, are essentially mass balance models operating within a rule-based framework to simulate hydrologic interactions between water sources and their uses. Maintaining a water balance assures that the sum of inflows less the sum of outflows equals the change of storage within the basin. Water inflows consist of historic stream flows. Outflows consist of water flowing across the downstream basin boundary (Gunnison River at the confluence with the Colorado River at Grand Junction), Gunnison Tunnel diversions, Redlands Power Canal diversions, and consumptive use (crops, domestic use, natural vegetation, evaporation, etc.). Water storage consists of the water within basin reservoirs. In the Gunnison River model only unnatural (man-induced) hydrologic effects are explicitly modeled. The model uses with the historic inflows and ungaged, gains and losses to river reaches. Starting from this basis eliminates the need to model natural hydrologic processes such as rainfall/runoff. Thus, precipitation falling on natural vegetation, consumptive use by natural vegetation, runoff of excess precipitation, evaporation from the free water surfaces of rivers, etc. is assumed to be reflected in the inflows. Therefore reach gains and losses are not modeled. Likewise, it is assumed that precipitation runoff from man-affected areas (agricultural lands, cities, etc.) is not significantly different from natural conditions to warrant explicit modeling treatment. Thus, the inflows for the simulated water balance of the Gunnison River Basin consist of the historic inflows, stream reach gains. The outflows consist of the man-affected (gaged) flow of the Gunnison River at the confluence with the Colorado River, depletions including consumptive irrigation, domestic use and net (in excess of natural) evaporation from manmade reservoirs.. The change in storage is reflected in the difference between beginning and ending reservoir content. The effects of soil water storage for irrigated lands are incorporated into the historical streamflow and stream reach gains and losses and are not explicitly modeled. The RiverWare model of the Gunnison River Basin operates on a daily time-step, simulating the flow at every gaging station. The model separates reservoir operations into 3 time periods: January-March, April-July, and August-December. Basic daily inputs to the model are: historic Blue Mesa inflows, both actual and unregulated; historic side inflows to Morrow Point and Crystal; Gunnison Tunnel diversion; and various downstream gains computed from actual gage data. Other data provided as input to the model includes forecasted inflow and tunnel demands for each forecast period.

Forecast data, both reservoir inflow and tunnel demand, is for the current forecast period and can be input on any day; generally on the first day of the month and then on the fifteenth if available. Forecast data for the last month of the forecast period generally has to be adjusted (sometimes daily) to reflect the improved accuracy which occurs at the end of the forecast period. The model determines remaining forecasted inflow and demand by subtracting the inflows or demands to date from the most recent forecast data available. Remaining minimum canyon demands, which include trout spawning and incubation flows, are computed at various times in the model since these demands are dependent upon flows that occur during the model run.

Based on forecasted inflows, forecasted demands (Gunnison Tunnel and Black Canyon requirements), and storage or release of storage, a volume of water that should be released before the end of the forecast period is determined. This volume is generally referred to as the operation volume. Operation volume is converted to a daily flow rate (cfs) and added to the required downstream releases to compute the desired total release. Actual releases equal this desired release unless policy or physical constraints are triggered. Required downstream releases include tunnel diversion and canyon requirements. Canyon requirements include a minimum flow of 300 cfs and the flow needed to minimize impacts to the spawning and incubation of brown and rainbow trout.

Constraints which may be applied to the computed release include ramping rates in the Black Canyon, flood control decisions both at Blue Mesa and Delta, and powerplant limitations.

At Blue Mesa, the daily release is set to be "Canyon Requirement + Gunnison Tunnel Demand-Side Inflow to Crystal and Morrow Point + Crystal Operation Release". Blue Mesa daily release may be reset by other constraints:

-If the desired Blue Mesa release results in Blue Mesa exceeding its maximum content, release is increased.
-Blue Mesa release is reduced if flow at Delta exceeded 14,000 cfs on the previous day.
-Blue Mesa release adjusted if ramping rates (either up or down) in the canyon are exceeded.
-Blue Mesa release is increased if the minimum brown or rainbow trout spawning or incubation flow, or the minimum canyon flow of 300 cfs is not met. (can occur due to tunnel diversions changing.)
-During Jan-Mar release are limited so that all releases at Crystal go through the powerplant.
-Blue Mesa release will be increased, subject to downstream ramping criteria, if with the current rate of fill, Blue Mesa would have less than 2 feet of storage space remaining at the end of 9 days. Release is the minimum of 6,000 cfs or the release which would result in having 2 feet of storage space remaining.
-If high fall releases are anticipated, June and July flows may be increased. This provides for additional power generation and more stable canyon flows.

In general, Crystal Reservoir release is equal to the Blue Mesa release plus side inflows occurring between Blue Mesa and Crystal.

Operation of the Aspinall Unit to provide peak flows at Whitewater also requires forecasting the time of peak runoff for the North Fork of the Gunnison River, in an attempt to allow releases from Crystal Dam to match the North Fork's peak. The required timing of the peak release from Crystal Reservoir was adjusted to closely approximate the timing of the North Fork peak, occurring during the last two weeks in May, with the assumption that this level of accuracy in predicting

the peak could be reproduced in future operations. For the proposed action modeling, releases to attempt to reach the peak target are made for up to 9 days.

The model in its present configuration represents the best science available to assess the impacts of baseline and proposed operations on various the endangered fish of the Gunnison River.