

APPENDIX C –

Provisional Inflow Data Development

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The current methodology for developing model inflow data does not lend itself well to frequent updates that will be necessary for real-time position analysis. The current methodology requires a large amount of input gage data (using 15 active gages); impairments from reservoir operations, water supply, wastewater returns, and agricultural withdrawals; correction to negative inflows that could otherwise cause model infeasibility; and scaling of gains to ensure that filled-in data for gages with missing data preserves the known volume of flow at downstream gages. Obtaining impairment data alone (which are necessary to unimpair the gage flows) is the most time-intensive part of the updating process.

HydroLogics has developed a simplified, *provisional* procedure that will enable weekly or monthly updates to be made, later overridden by periodic annual updates using the current methodology. It is meant to provide a representative inflow to key points in the basin, most notably Falls Lake, which is central to real-time management of the basin. The calculations for the provisional update are handled automatically within the GUI upon entry of data as shown on the Update Record tab.

To simplify the update as much as possible, the procedure eliminates the need for most impairments and the concern over negative inflows that could lead to model infeasibility. The assumption is that most of the net impairments (withdrawals – discharges) in the basin are small and occur within a reach and therefore are not likely to have much effect on the natural inflow.

As an example, the Neuse River gages (e.g., Clayton, Goldsboro, and Kinston) are significantly affected by the operation of Falls Lake upstream. However, by computing the gains between Falls Lake (using measured releases) and Clayton, Clayton and Goldsboro, and Goldsboro and Kinston, the effect of the Falls Lake operation is removed. Only the net impairments within those reaches affects the natural inflow, and as long as the net impairments are small, it can be assumed that the difference in gaged flows in these reaches is the natural inflow.

Negative inflows can occur at Falls Lake since they are back-calculated from the historic releases. They can also occur when the downstream gage flow is less than the upstream gage flow (which is usually due to time of travel issues). In either case, these only pose a modeling problem if there is not enough water in the river or reservoir to handle them, which is rare. As a precaution, when gains are negative, the model's OCL is used to filter them to maintain model feasibility. Negative inflows to Falls Lake are maintained since reservoir storage is always adequate to handle them.

The simplified procedure is detailed below in the following steps. A list of gages and model inflow nodes is provided in the table and figure at the end of this document. As noted, all calculations are automatically done within the model.

Step 1: Obtain from the USGS web site the daily gage data (cfs) for the following fifteen gages: Eno River at Hillsborough (Hills), Eno River near Durham (Durha), Flat River at Bahama (Flatb), Little River at SR1461 near Orange Factory (Litor), Flat River at Dam near Bahama (Flatd), Little River near Fairtosh (Litfr), Knap of Reeds Creek near Butner (Knapc), Neuse River near Clayton (Clayt), Swift Creek near Apex (Swift), Middle Creek near Clayton (Middl), Little River near Princeton (Litpr), Neuse River near Goldsboro (Golds), Neuse River at Kinston (Kinst), Contentnea Creek near Lucama (Lucam), and Contentnea Creek near Hookerton (Hooke) . These gages are shown in red on the node schematic at the end of the document.

Step 2: Obtain the following additional data for the basin:

Daily elevations in feet for the following six reservoirs: West Fork Eno Reservoir (WFER), Lake Orange, Lake Michie, Little River Reservoir, Beaverdam Lake, and Falls Lake.

Additional daily operations records for Falls Lake from the Army Corp of Engineers (COE): Computed Falls net inflow and total Falls release, both in cfs.

Daily withdrawal data in millions of gallons per day (mgd) for the following two utilities: Hillsborough and Durham.

Daily wastewater discharge by Cary into Middle Creek (SCWRF) in mgd.

Daily precipitation record for Falls Lake in inches.

Step 3: Compute the net evaporation for all reservoirs in the basin using the precipitation data collected above and a monthly evaporation pattern.

Step 4: Unimpair the Hills gage flow by adding back the WFER and Lake Orange change in contents and net evaporation, the Hillsborough withdrawal and an average of other upstream withdrawals. Assign inflows to nodes 010, 050, 060, 080, 100, and 110 based on a drainage area adjustment of the unimpaired Hills flow.

Step 5: Compute the Durha gain by subtracting the Hills gage flow from the Durha gage flow and adding back the estimated impairment in that reach.

Step 6: Set the inflows to nodes 140, 250, 270, and 290 using a drainage area adjustment of the Flatb gage. Set the inflow to node 200 using a drainage area adjustment of the Litor gage.

Step 7: Compute the *unimpaired* gain into Falls Lake and Beaverdam Lake. We are using the COE reported net inflow because it is readily available on its Falls project website.¹

Step 7a: Add back estimated net evaporation to the Falls net inflow. Use Falls net evaporation when Beaverdam is below 249 ft; otherwise add Falls and Beaverdam net evaporation back. Adjust by dividing by 0.95 when the Beaverdam elevation is less than 249 feet. This compensates for the Corps-reported net inflow not including the Beaverdam storage below 249 feet.
Step 7b: Compute the total Falls gain by subtracting from the above value the Flatd flow, Litfr gage flow (both adjusted to the Falls drainage area), the Durha gage flow, and the Knapc gage flow and adding back the impairments in the reach.
Step 7c: Allocate 5% of the gain to Beaverdam and the remaining 95% to Falls.

Step 8: Compute the unimpaired Middl gage flow by subtracting the Cary wastewater return and an estimate of other upstream returns. Set the inflows to nodes 400, 445, 450, and 480 using a drainage area adjustment of the unimpaired Middl gage.

Step 9: Set the inflows to nodes 420 and 440 using a drainage area adjustment of the Swift gage.

Step 10: Compute the gain at Clayt (node 630) by subtracting from the Clayt gage flow the Falls release, the inflows to nodes 290, 400, 445, and 450, and adding back an estimate of average impairments in this reach.

Step 11: Unimpair the Litpr gage flow by adding back an estimate of average upstream impairments. Set the inflows to nodes 500, 740, and 750 using a drainage area adjustment of the unimpaired Litpr gage.

Step 12: Compute the gain at Golds (node 780) by subtracting from the Golds gage flow the gage flows at Clayt, Middl, and Litpr, the inflows to nodes 420 and 440, and adding back an estimate of average impairments in this reach.

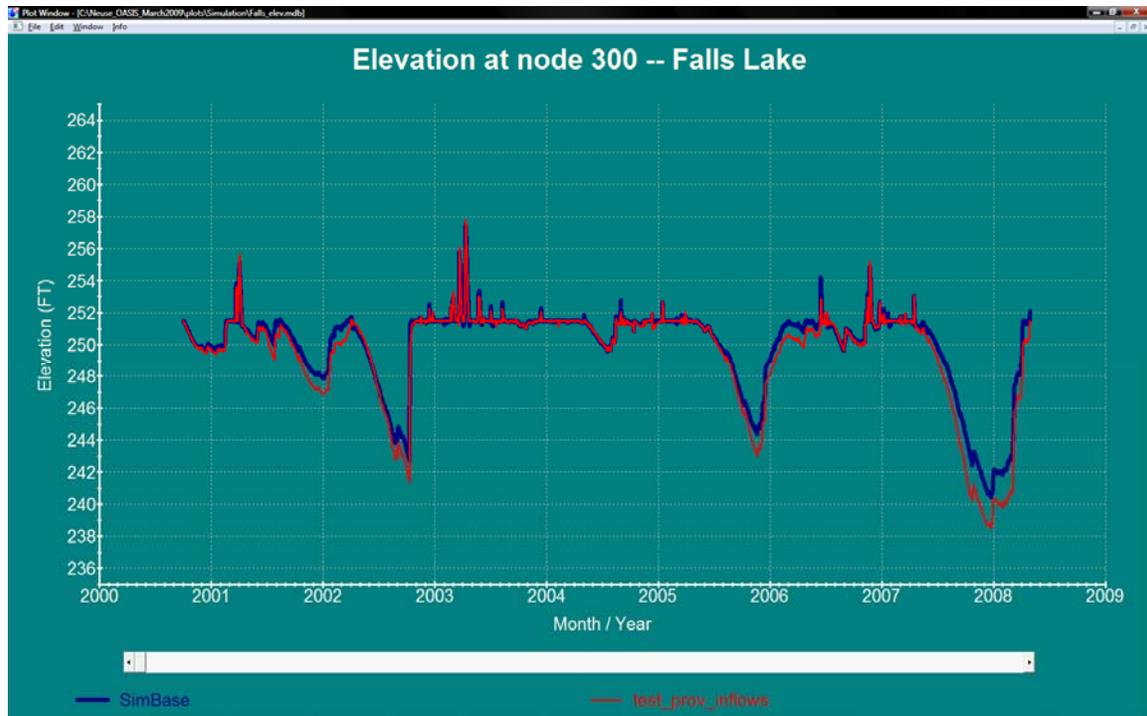
Step 13: Compute the gain at Kinst (node 800) by subtracting from the Kinst gage flow the gage flow at Golds, and adding back an estimate of average impairments in this reach.

Step 14: Compute the gain at Hooke (node 560) by subtracting from the Hooke gage flow the gage flow at Lucam, and adding back an estimate of average impairments in this reach.

Step 15: Set the estimated inflow to node 900 by computing the average basin runoff in cfsm and multiplying by the incremental drainage are between Kinst, Hooke and node 900 (Weyerhaeuser intake).

¹ This differs from our comprehensive inflow approach, where we unimpaired the Clayton gage by taking the COE reported change in contents. In addition, because we use separate stage-storage-area tables for Falls and Beaverdam, if we computed change in storage based on reported elevation, our estimate would differ from what COE used to back-calculate the net inflow.

We assessed the accuracy of these inflows using the Simbase run (with 2004 demands). The simulated elevations for Falls Lake using the simplified (*provisional*) dataset and the current inflow (*finalized*) dataset are plotted below from October 2000 through April 2008. Before 2000, it was not feasible to run the inflow update because the procedure would have to be modified significantly to account for gage and operational data that is not available before then. The red line plots the results of the simplified dataset, while the blue line plots the results of the current dataset.



Overall, simplification of the inflow methodology results in generally lower elevation predictions during drought years. The largest difference occurs during the 2007 drought, when the simplified version produces about two additional feet of drawdown compared to the finalized dataset. The 2001, 2002 and 2005 droughts show a difference of about one foot. By not accounting for effects of the smaller reservoirs in this reach (including Lake Holt) and other impairments, the simplified approach may understate the natural flow. It is not easy to identify what adjustments could be made, if any, to resolve this discrepancy since the number of impairments are so many.

The analysis suggests that the simplified inflow development approach provides representative results, with the caveat that it may underestimate inflow in major droughts. This is a more conservative outcome since drought declarations would be made sooner. The impact of using this approach is diluted by the position analysis methodology—while the current flows are used to condition the forecasts, the forecasts will be based on traces from the entire inflow record from 1930 to present. The more frequent the comprehensive updates to the inflow dataset using the current methodology (say at least every five years), the more accurate the traces will be. The impact of using the simplified

approach can also be lessened by using position analysis in other years of similar gage flow (which are accounted for in the current methodology). For example, if next year's gage flows are similar to 2002 flows, a position analysis can be run with the simplified approach using next year's starting date and these results can be compared to a position analysis using 2002 as a starting date.

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