CALIBRATION OF STELLA AND HEC-5 MODELS FOR A.C.F. BASIN

Yongqing Yu[1], Dave Hawkins[2], Steve Whitlock[3] and Owen McKeon[4]

AUTHORS: [1] Environmental Engineer, [2] Program Manager, [3] Principal Engineer, [4] Principal Engineer, Water Resources Planning Unit, Georgia Environmental Protection Division, Water Resources Management Program, Floyd Tower East, Suite 1358, 205 Butler Street, SE, Atlanta, Georgia 30334
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Abstract: The HEC-5 and STELLA models were developed for the Apalachicola, Chattahoochee, and Flint (ACF) river basin by the Army Corps of Engineers at Mobile, Alabama and by the University of Washington. These models will be used to evaluate alternative strategies for water resources management through the year 2050. As originally developed, these models do not produce matching results. This paper discusses the differences between the models. After the models were calibrated, the simulation results are very similar.

INTRODUCTION

The "Alabama, Coosa, Tallapoosa (ACT) and Apalachicola, Chattahoochee, Flint (ACF) Comprehensive Water Resources Study" has been underway since 1991. This study addresses the availability of water and anticipated long-term water needs, as well as the potential ramifications of various water management options on multiple interests in the two basins.

Two of the most important tools being developed are: the System Thinking Experimental Learning Lab Application (STELLA) model and the HEC-5 model. These models will be used to evaluate different operational rules and alternatives for both the ACT and ACF basins. The STELLA model was developed on a monthly time step. Due to its longer simulation time step, flexibility, and utility, the STELLA model will be used to screen operational rules (such as hydropower production schedule, reservoir elevation and instream flow target), and water demand priorities, and to identify valid alternatives. Then HEC-5 models will be used to explore and verify the practicality of alternatives identified by STELLA.

Since the reservoirs were designed and are operated for multiple objectives, tradeoffs between objectives will be analyzed with the models. Allocation formulae, essentially dividing the waters of these basins between the states, will be based , in part, on the model results. However, the initial model results differed from each other, introducing uncertainty in the process of alternatives screening and verification. For example, about 10 ft difference in Lake Lanier elevation was observed during portions of the simulation. In order to utilize the models as planned, model verification and calibration was necessary.

CASE STUDY AND DATA

In order to compare the monthly time step STELLA model with the daily time step HEC-5 model, a common set of model objectives and operating conditions was established. After changing the most recent input file from the HEC-5 Existing Conditions model released by the Army Corps of Engineer in Mobile to reflect the objectives of the alternative, HEC5AEM was executed for the entire 55 year period from 1 January 1939 to 31 December 1993. The STELLA model was run with similar operational rules. Selected comparisons of results are described below.

COMPARISON AND CALIBRATIONS

Lake Lanier

Figure 1 shows the Lake Lanier elevation sequence for a 15 month time period to show sample results. It is obvious that STELLA consistently releases less water than HEC-5 because the STELLA model elevations are higher. One of the reasons for this

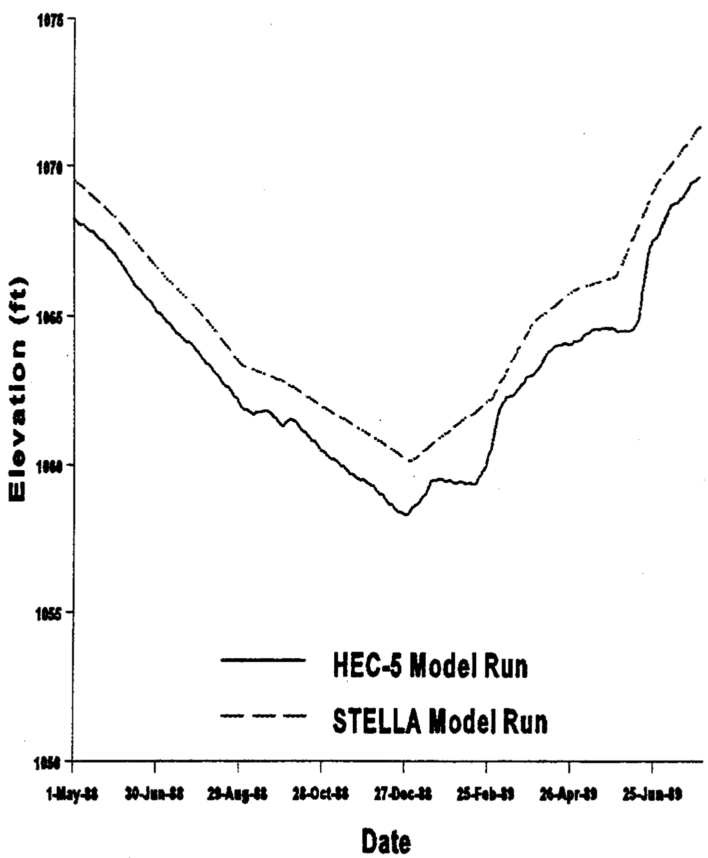

Figure 1. Lake Lanier elevation sequence comparison before calibration

difference is that the STELLA model did not consider the effect of elevation on the energy or power requirement, instead using the penstock capacity to determine water release. To meet the peaking requirement, STELLA releases water at the penstock capacity for the required number of peaking hours. The STELLA variable BUAvgHydro shows this method of calculation. A second reason for the higher elevation is that STELLA does not include the service turbine release during peaking release calculation. In contrast, HEC-5 assumes that the service turbine has a 450 cfs release in addition to the two main turbines, computing total release as 1183.33 cfs ((2 x 8800 + 24 x 450) / 24 = 1183.33). For consistency, the equation was changed in STELLA to the following :

(1) BUAvgHydro = ((PeakingDaysPerWeek x BUPeakHrs) x (BUPenCap+BUMinCont)) / 168 + BUContRel_cfs x (168-BUPeakHrs x PeakingDaysPerWeek) / 168

Here BUPenCap is the calculated peaking release from the energy equation which takes into account the net head and efficiency. The energy equation is defined below:

$$(2) \qquad BUPenCap = \frac{11.85 \times Peaking\ Capacity}{Net\ Head \times Efficiency}$$

Next, BUMinCont, the minimum release from Buford, was checked. Care should be taken to set the value at 450 cfs in both STELLA and HEC-5.

Finally, BUFriSatSunMonCont, was checked. In the equation the value 24 should be 72, which represents the continuous non-peaking hours during the weekend. With these changes, the STELLA model was run again for the same time period and the Lake Lanier elevations were compared. The elevation sequences are plotted in Figure 2 which shows that the two models have very similar results with the described changes.

One more correction is required. In the STELLA model, the top of conservation pool is set to 1076 or 1075 ft. The simulation results show that the elevation is limited to 1075 ft. The reasons for that are: 1) Function LanConsVol limits the elevation to 1075 ft; 2) Function LanBegRuleVol_cfsd limits the elevation to 1075 feet which makes it impossible to simulate the alternative when pool level is higher than the top of conservation pool level during flood. Therefore, function LanConsVol was changed to 1080 ft, LanBegRuleVol_cfsd was changed to 1080 ft, and the corresponding storage volumes were input for these elevations.

In the HEC-5 model, the tailwater elevation vs average daily release function is used to calculate the net head. For the peaking operation, the tailwater elevation should be the elevation corresponding to the peaking release. The penstock capacity is a good estimate of the peaking release for calculating the peaking tailwater elevation. Therefore, tailwater elevation vs average daily release function was replaced by a constant tailwater elevation of 920.5 ft.

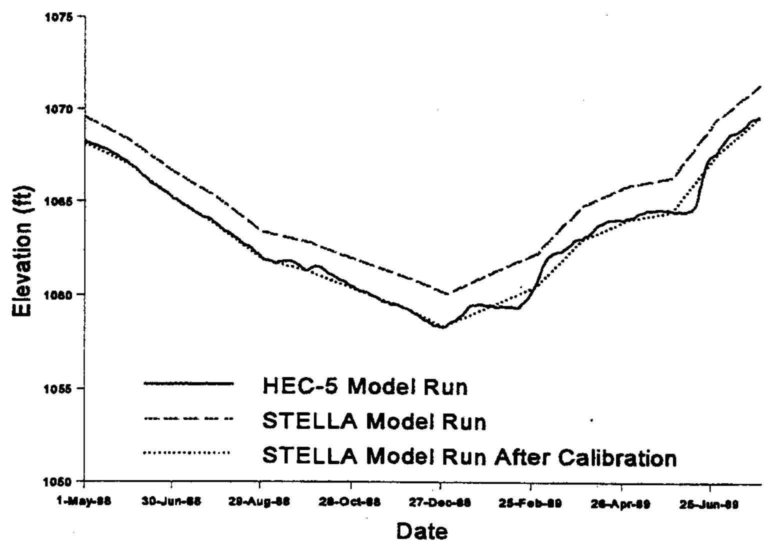

Figure 2. Lake Lanier elevation sequence comparisons

Figure 3 shows the complete Lake Lanier elevation sequence, computed with all the calibration changes, over the 55 year simulation period. The two largest differences are 1.35 ft (first of April, 1977) and 1.34 ft (first of March, 1961) at elevation 1075 ft. The reason for these differences is that the STELLA model does not allow the elevation to go above top of conservation pool. For a monthly model, this is a good assumption because the monthly average release is unlikely to be greater than the maximum flood control release. The HEC-5 model is a daily model, however, and its daily release is limited by the maximum flood control release, which may allow the water level to exceed the conservation pool elevation. For this reason the simulated HEC-5 elevation is higher than the STELLA elevation by as much as 1.35 ft or 1.34 ft at these two times.

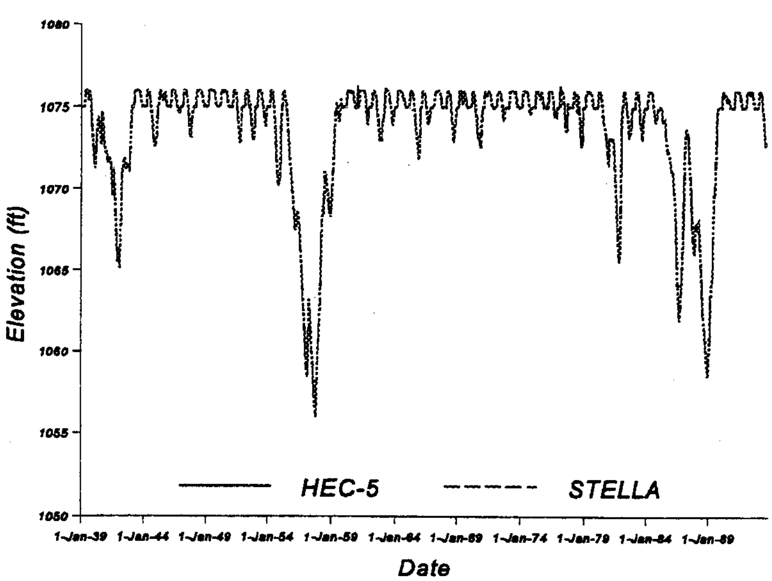

Figure 3. Lake Lanier elevation sequence comparison after calibration for 55 years

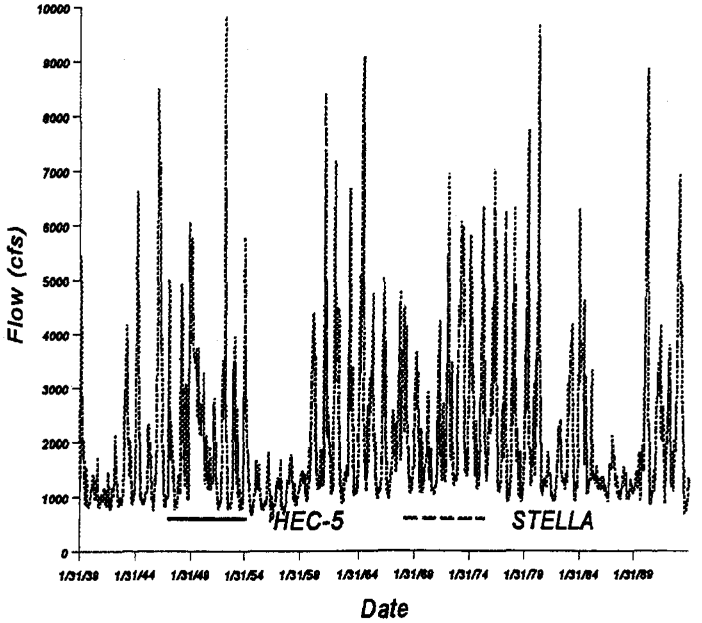

Figure 4. Atlanta gage flow sequence comparison after calibration for 55 years

Atlanta Gage Flow Comparison

Flow at the Atlanta Gage is an important target for the ACF system. Therefore, the monthly average flows were compared for HEC-5 and STELLA. No additional adjustment was made to the STELLA model. The flow sequences match each other closely. The minor differences are caused by the different time steps and probably the different withdrawal and return ratios established for the two models. The HEC-5 model has more control points but the water withdrawal and return ratios were estimated from STELLA. Figure 4 shows the flow comparison at Atlanta Gage.

Blountstown

The West Point reservoir, Columbus gage, W. F. George reservoir, and Lake Seminole lie between the Atlanta gage and Blountstown gage on the Apalachicola river in Florida. The comparisons for each of the above control points show good matches after variable changes were made similar to those described for Lake Lanier. Figure 5 shows excellent agreement for the flow sequences between the STELLA and HEC-5 models at Blountstown. This is a significant test for the model calibration. Because Lake Lanier, West Point, W.F George, and Lake Seminole regulate the flow and change the flow distribution, if any one of the reservoirs is not modeled consistently in STELLA and HEC-5, the Blountstown flow sequences will differ from each other.

CONCLUSIONS

After comparison of the model calibration and results, relatively simple modifications to the STELLA and HEC-5 models yield simulation results which are very similar. At Blountstown, 350 miles below Lake Lanier, the flow sequences match each other closely despite upstream flow regulation by four major reservoirs. Under most operating conditions, it appears that the STELLA model can be confidently used as a screening tool to identify valid alternatives as planned; this will greatly reduce the number of HEC-5 alternatives which must be run in analyzing alternative management options for the ACF basin. There is difficulty only in modeling targets which vary within a single month, such as a short term navigation window or short term reservoir elevation target, because such targets can not be accurately simulated with the monthly time step STELLA model.

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