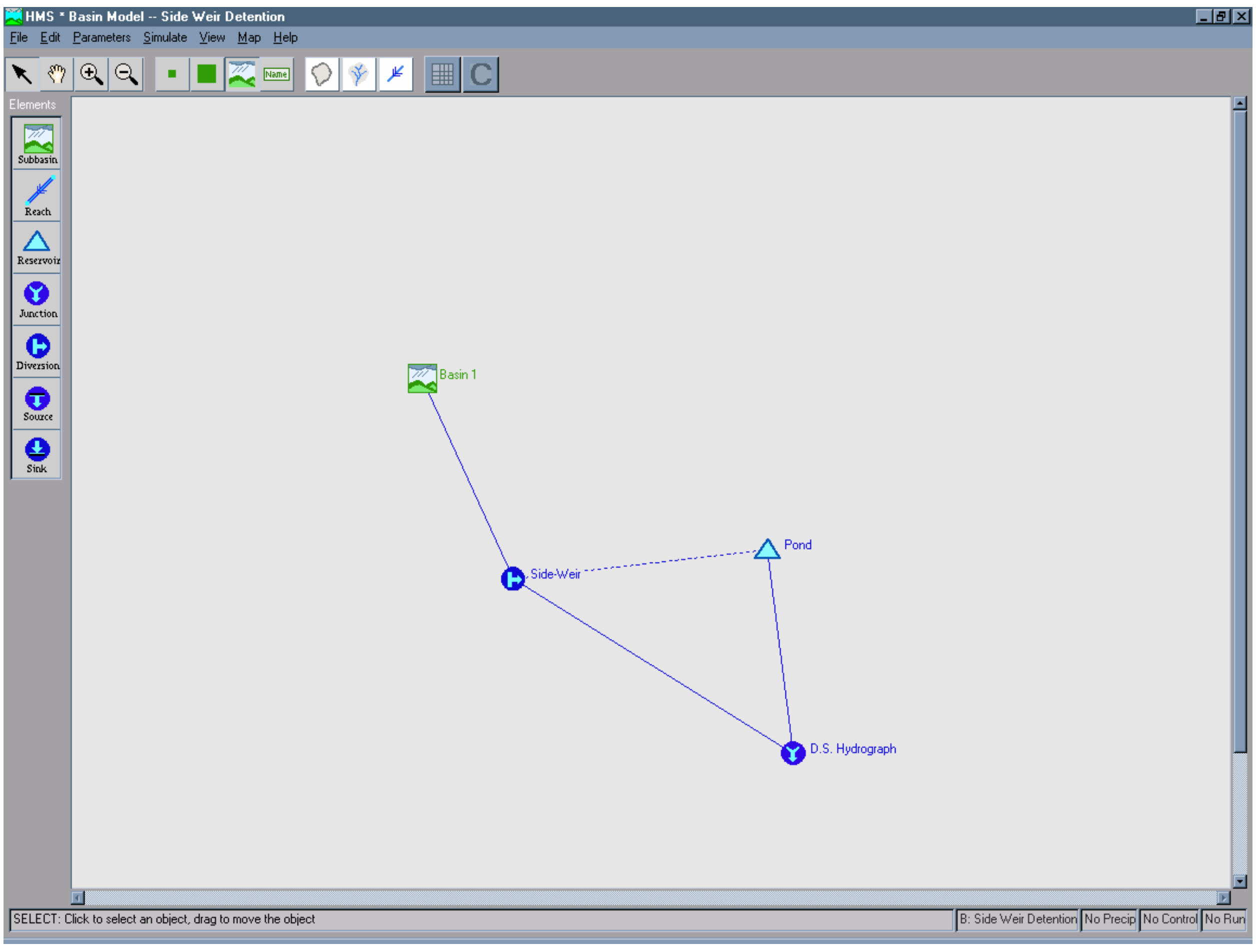
Recommendation for:
Analyzing Side-Weir Detention with HEC-HMS
(Revised 02/13/2002)

<u>Goal:</u> To provide a means of analyzing side-weir detention facilities with minimal computations outside of the HEC-HMS program.

<u>Recommended Procedure:</u> The following steps outline a procedure that provides a reasonable and adequate solution to analyzing these types of facilities in HEC-HMS.

1. Set up an HEC-HMS model configuration similar to Figure 1. The inflow hydrograph (Basin 1) will be connected downstream to a diversion (Side-Weir). The diverted flow will be connected to a reservoir (Pond) and the remaining flow will be connected downstream to a junction (D.S. Hydrograph). The diverted flow will act as the inflow into the reservoir which will be connected downstream to the junction (D.S. Hydrograph).

Figure 1: HEC-HMS Model Schematic



2. Based on known data (construction drawings, design calculations, or field measurements), determine a diversion relationship based on the discharge in the receiving stream and a "free overflow" relationship for the spillway based on water surface elevations in the "receiving" stream. Depending on the shape of the spillway, one of the two following equations should be used:

- Rectangular Spillway: $Q = CLH^{1.5}$

- Trapezoidal Spillway: $Q = C\left(LH + zH^2\right)\sqrt{H}$

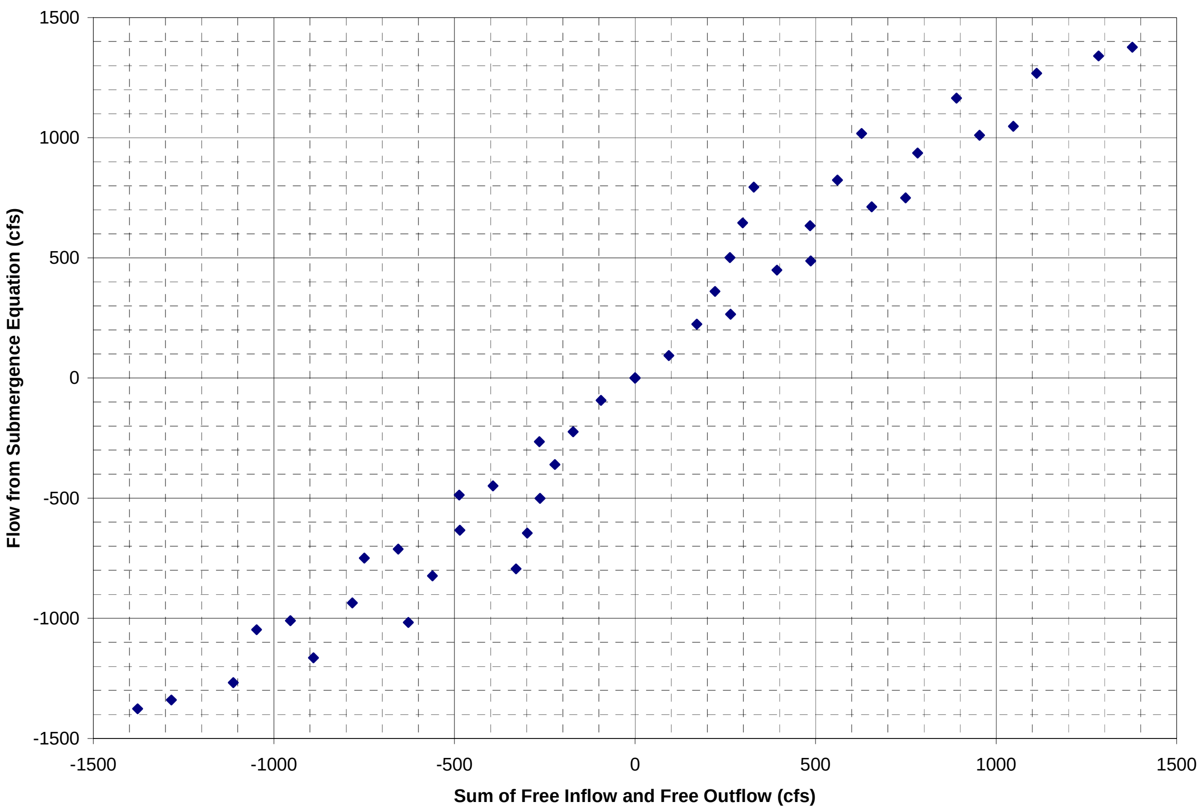
Where, C is the weir coefficient, L is the crest length [feet], H is the head above the crest [feet], and z is the side slope [z:1]. Since there is an assumption of free overflow for this procedure, there is no need to consider weir submergence. Additionally, the volume which can be diverted into the basin should <u>not</u> be limited.

3. Based on similar known data as above, develop an elevation vs. storage vs. outflow relationship for the reservoir (again, it should be based on free overflow in the spillway and free flow through any low level drains). The initial condition should be set so that inflow equals outflow (i.e., the reservoir should be considered empty at the beginning of the time base). It is noted that version 2.1.1 of HEC-HMS modifies the elevation data for the reservoir after the first run. This is not crucial once the storage vs. outflow relationship for the reservoir has been established. However, it is recommended that the latest version of HEC-HMS (version 2.1.3) be utilized. This "glitch" does not occur in version 2.1.3.

<u>Assumptions:</u> Two critical assumptions are made with respect to this procedure.

- The effects of submergence on the spillway can be replicated by adding "free flow in" to "free flow out" (similar to vector addition). This assumption was checked for head differentials of up to 3.0 feet and the results of the comparison of this assumption with the submerged weir equation are illustrated in Figure 2.

Figure 2: Comparison of Submergence Effects



- All low level outlets have backflow prevention (i.e., flapgates or tideflex valves) which permit flow only in the positive direction out of the basin. If this is not the case for a particular basin, there may be some inflow into the basin from these outlets which will need to be accounted for in the diversion rating curve. It is recommended that the free flow condition continue to be applied in these circumstances.

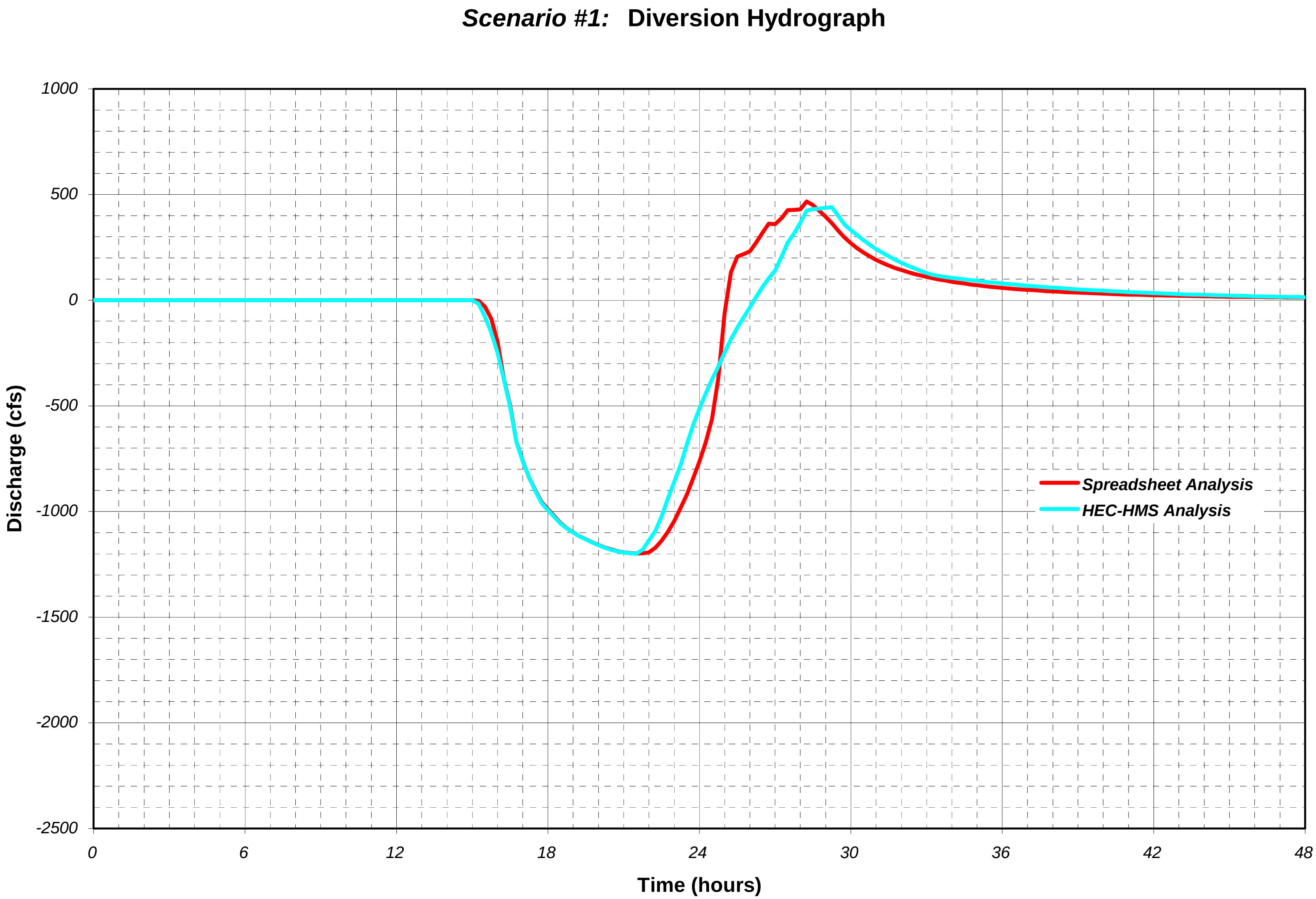
Testing Procedure: In order to understand how the side-weir should function, a spreadsheet was set up for four different scenarios. A description of these scenarios follows.

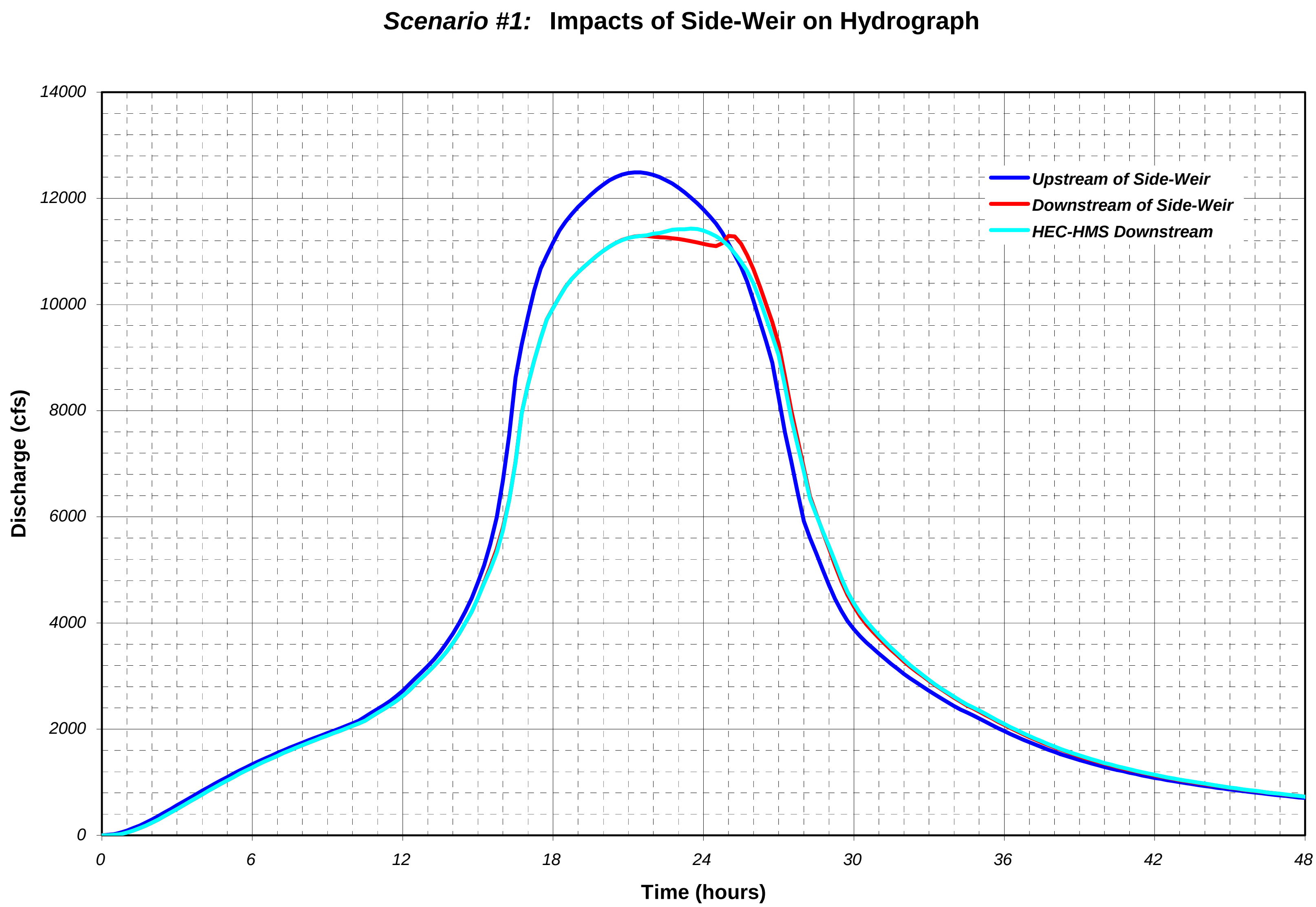
> *Scenario #1:* The E500-01-00 detention basin located along White Oak Bayou converted to a side-weir facility capable of storing up to 735 acre-feet at elevation 97.0. The spillway crest (set at elevation 93.0) was optimized to a length of approximately 38 feet and had 6:1 side slopes.
>
> *Scenario #2:* The crest length of the E500-01-00 spillway from the previous scenario was modified to 100 feet.
>
> *Scenario #3:* An artificial model was set up for a small drainage area (3.02 square miles) and a side-weir facility capable of storing up to 1000 acre-feet at elevation 112.0. The spillway crest (set at elevation 109.0) was optimized to a length of approximately 168 feet and had 6:1 side slopes.
>
> *Scenario #4:* A 36-inch low-level outlet was added to the previous scenario with the invert set at elevation 102.0.

Test Results: The attached graphs illustrate the reasonableness of using the described procedure for modeling side-weir detention facilities. In general, the spillway hydrographs, the downstream combined hydrographs, and the stage hydrographs from HEC-HMS produced reasonably similar hydrographs when compared to a more detailed spreadsheet analysis using quasi-unsteady flow methods.

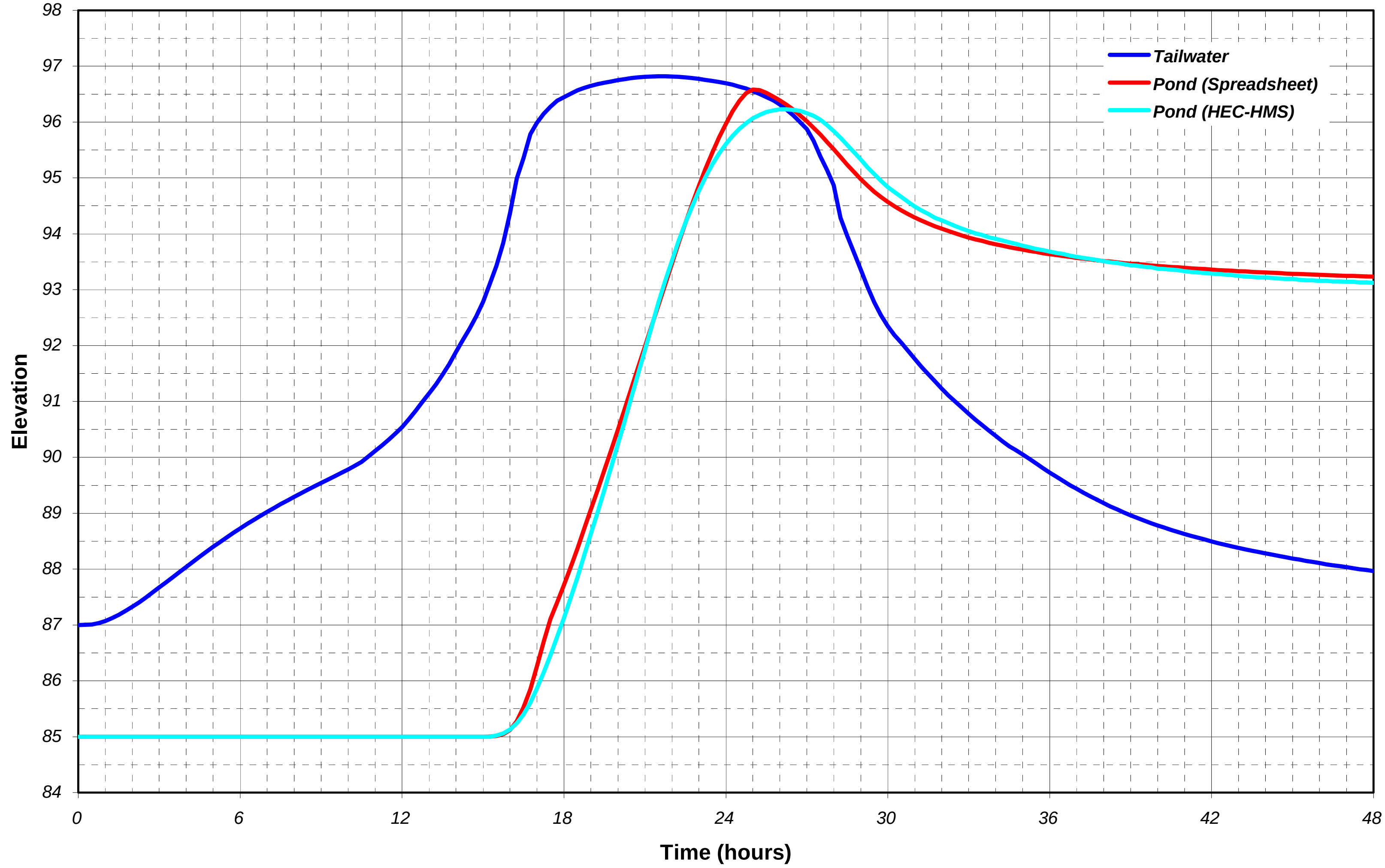
Final Notes: This procedure appears to adequately model the effects of side-weir detention on hydrographs. It may be used in preliminary design of such facilities, but should not be used in final design. An unsteady flow model or spreadsheet analysis is recommended for final design of these types of facilities to ensure the ability of the facility to meet project goals.

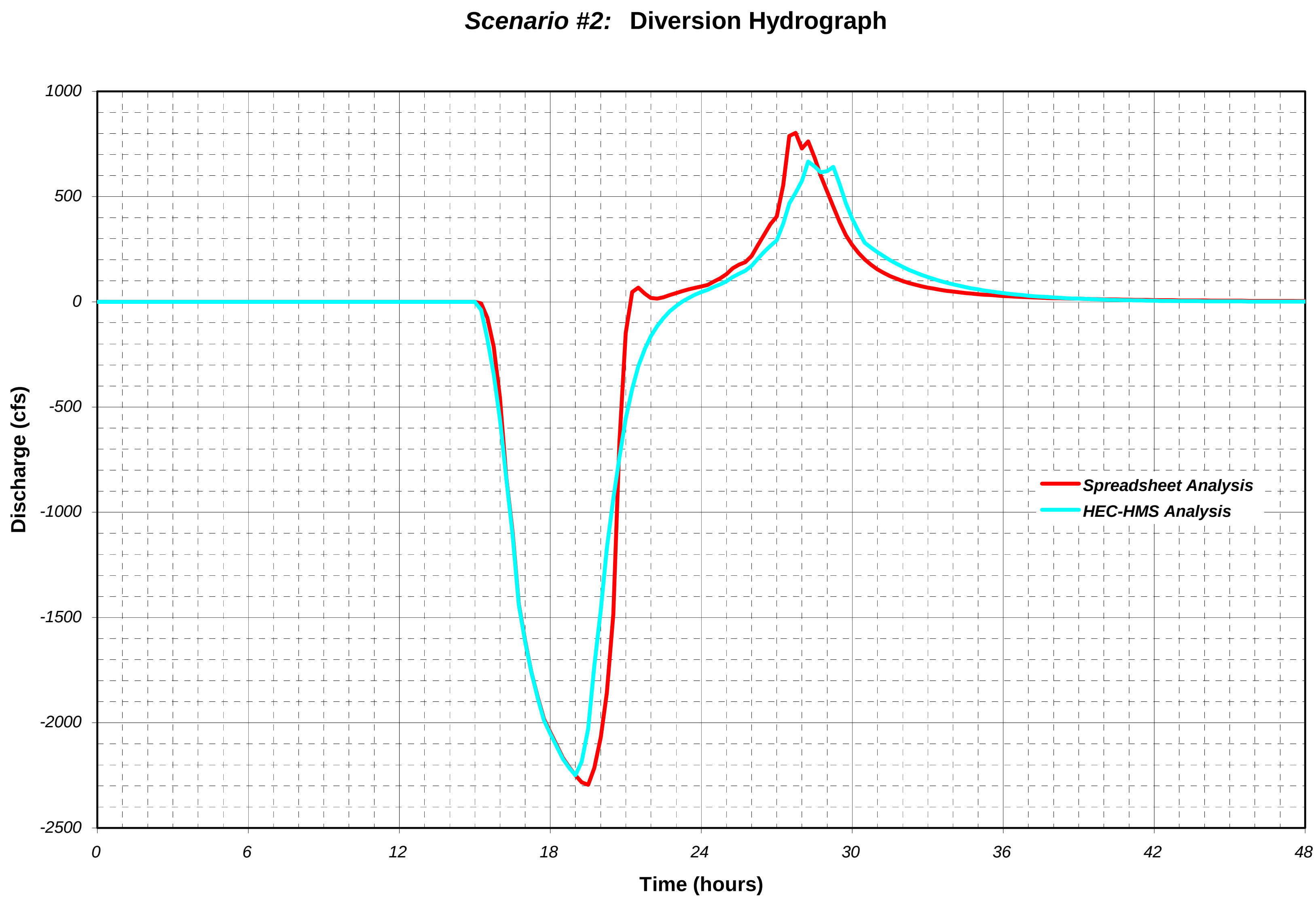
Committee Resolution: Use the procedure described above. The spreadsheet analyses are included on an attached diskette.


Scenario #1: Diversion Hydrograph
1000
500
0
-500
-1000
-1500
-2000
-2500
Discharge (cfs)
0
6
12
18
24
30
36
42
48
Time (hours)
Spreadsheet Analysis
HEC-HMS Analysis

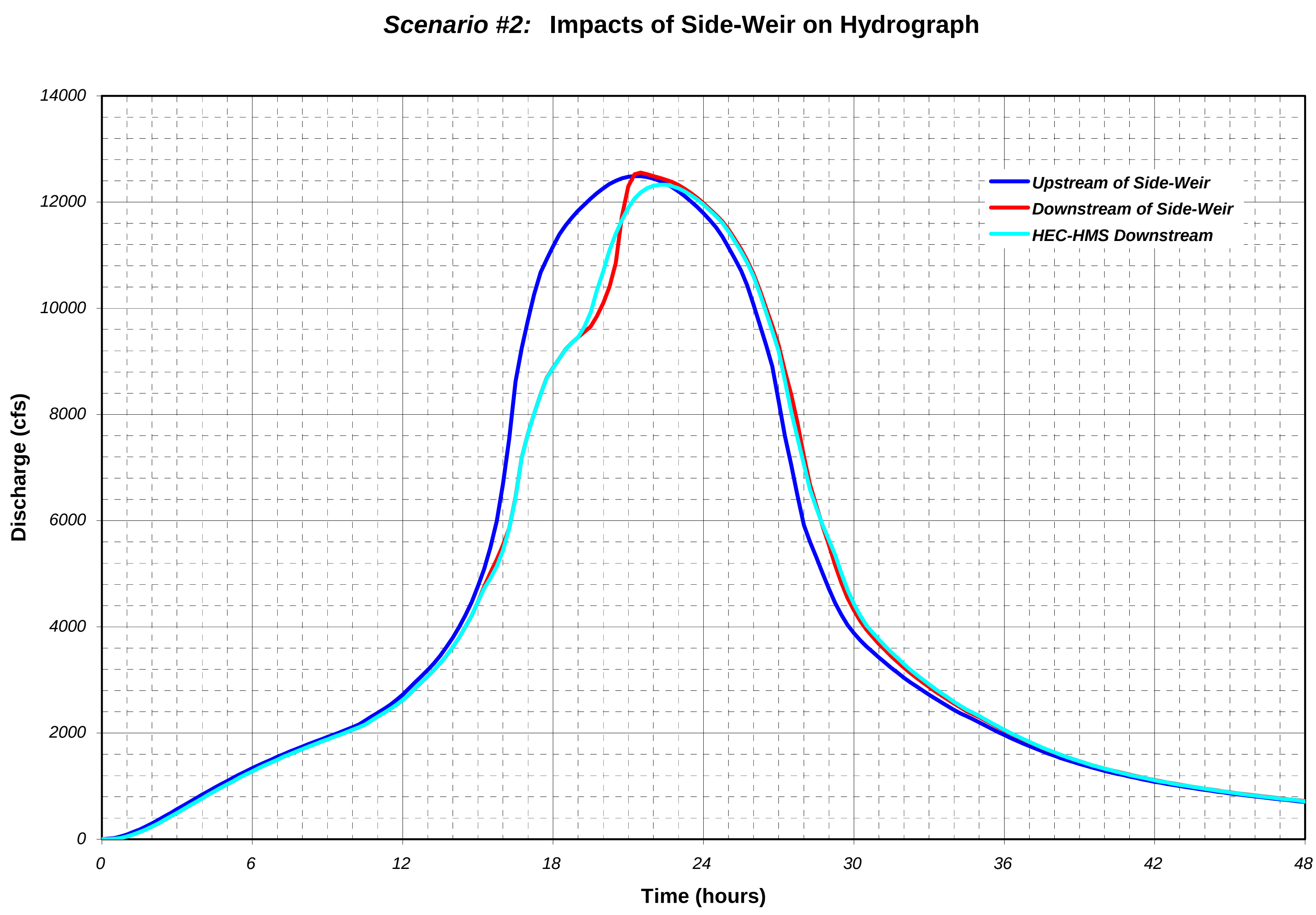

Scenario #1: **Impacts of Side-Weir on Hydrograph**
Discharge (cfs)
14000
12000
10000
8000
6000
4000
2000
0
0
6
12
18
24
30
36
42
48
Time (hours)
Upstream of Side-Weir
Downstream of Side-Weir
HEC-HMS Downstream

Scenario #1: Stage Hydrographs

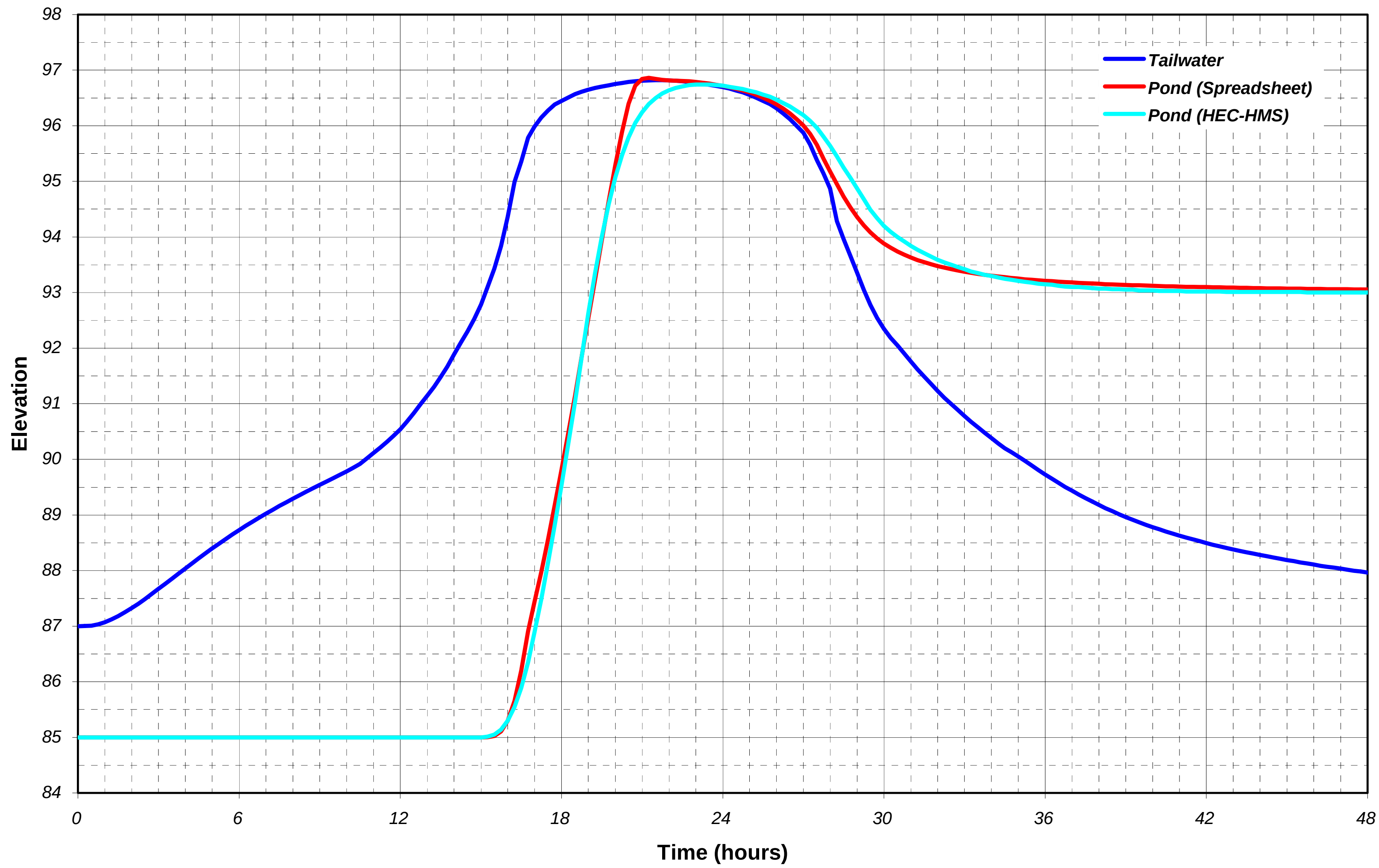


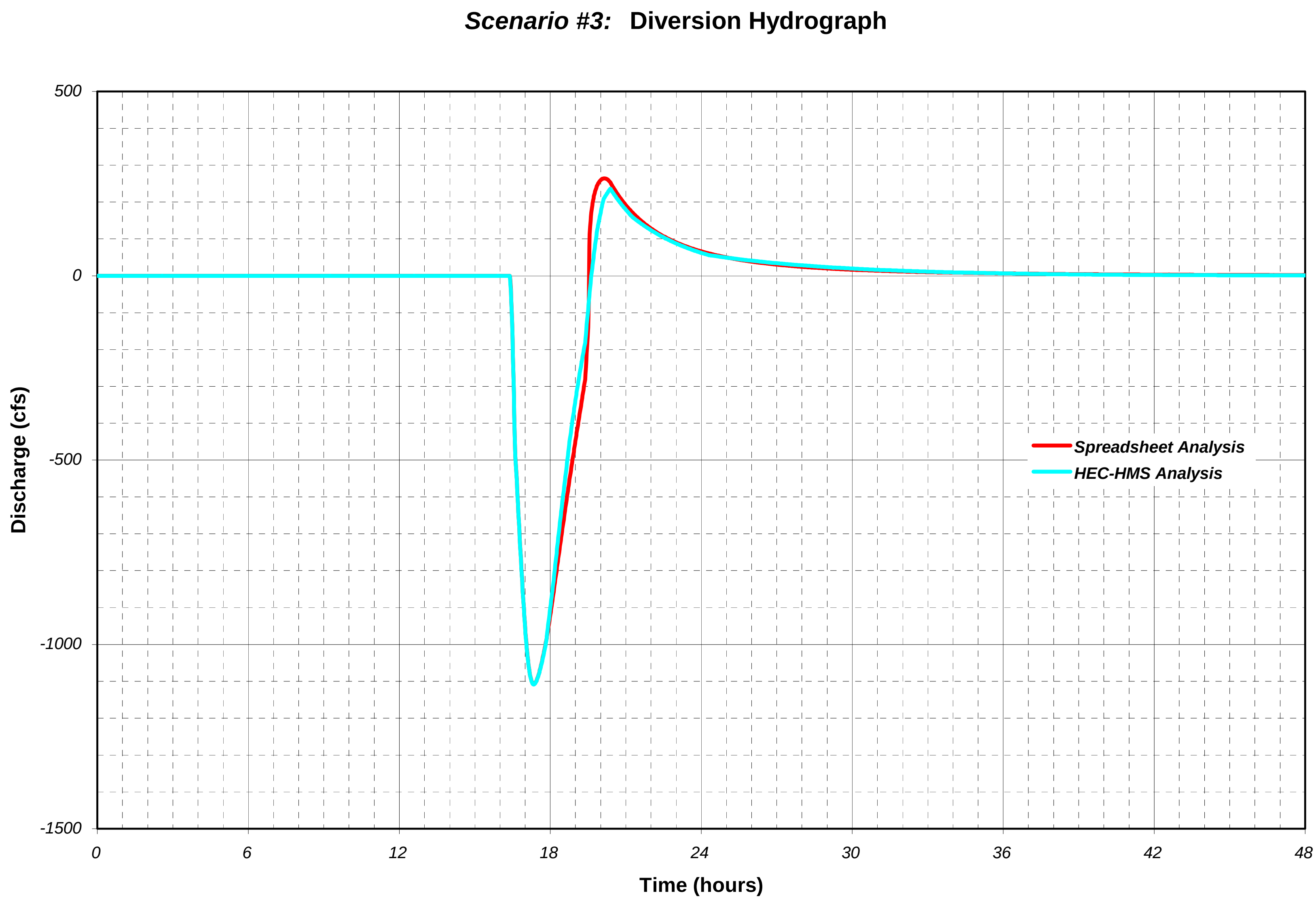


Scenario #2: Diversion Hydrograph
1000
500
0
-500
-1000
-1500
-2000
-2500
Discharge (cfs)
0
6
12
18
24
30
36
42
48
Time (hours)
Spreadsheet Analysis
HEC-HMS Analysis

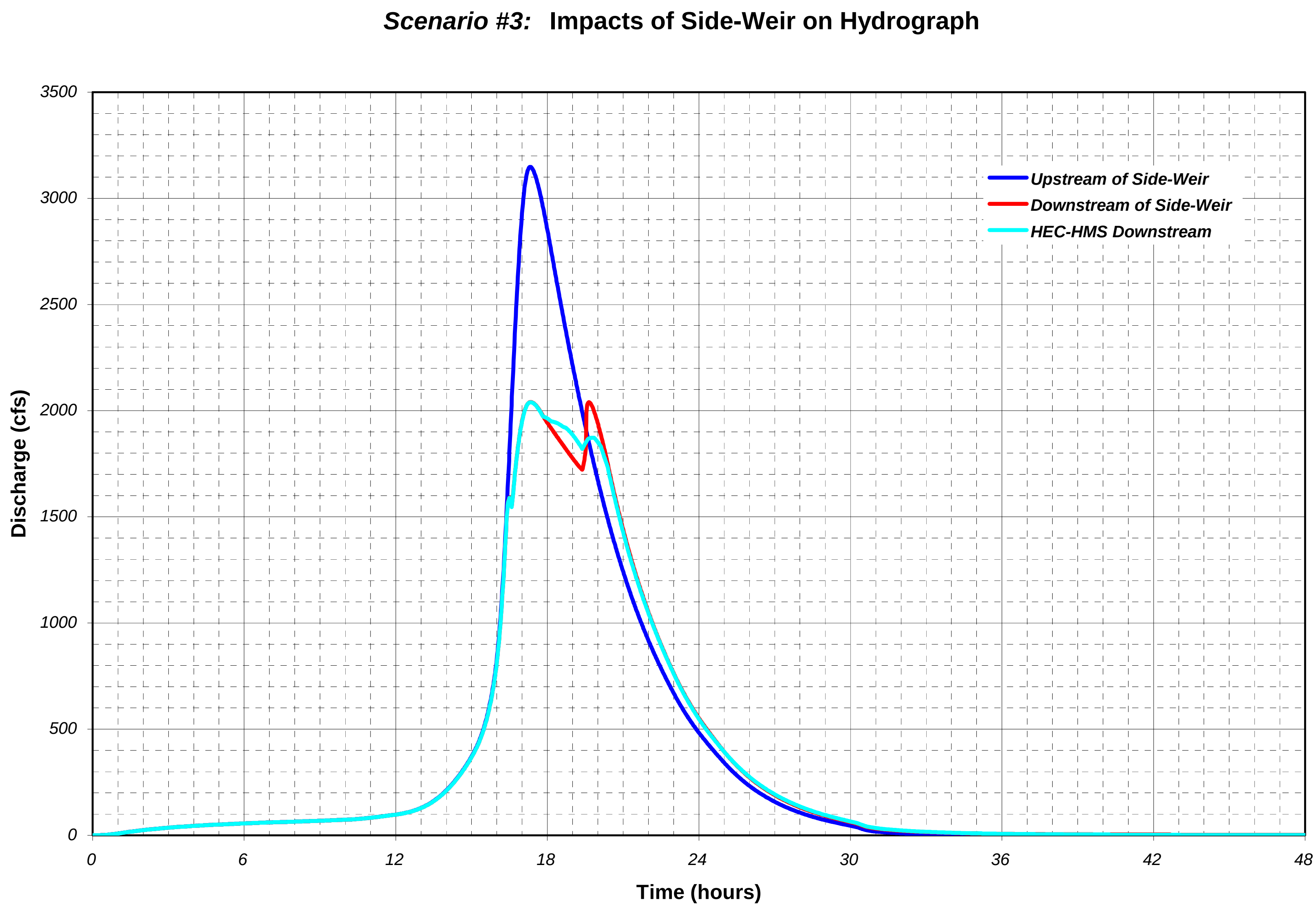

Scenario #2: Impacts of Side-Weir on Hydrograph
Discharge (cfs)
14000
12000
10000
8000
6000
4000
2000
0
0
6
12
18
24
30
36
42
48
Time (hours)
Upstream of Side-Weir
Downstream of Side-Weir
HEC-HMS Downstream

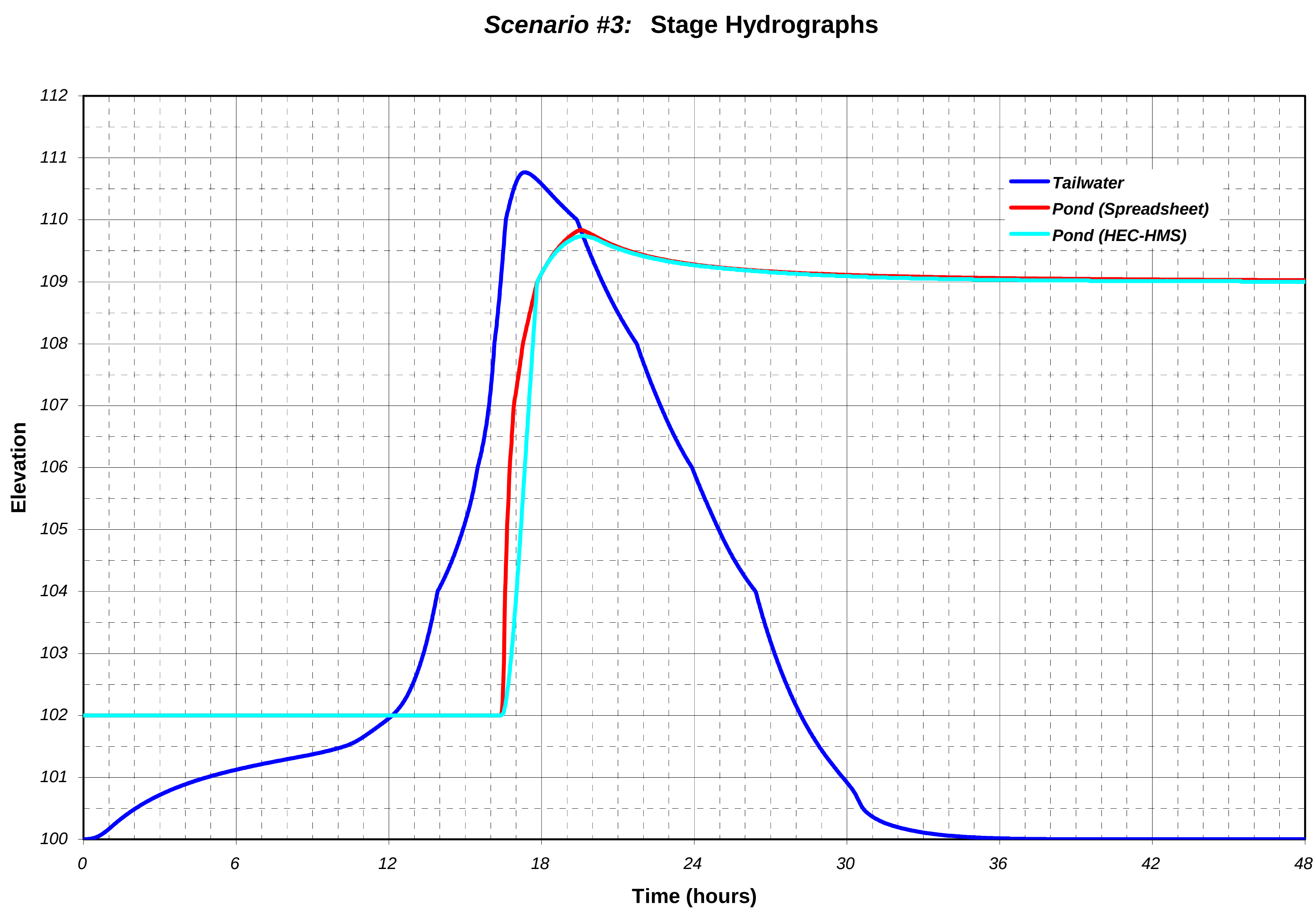
Scenario #2: Stage Hydrographs



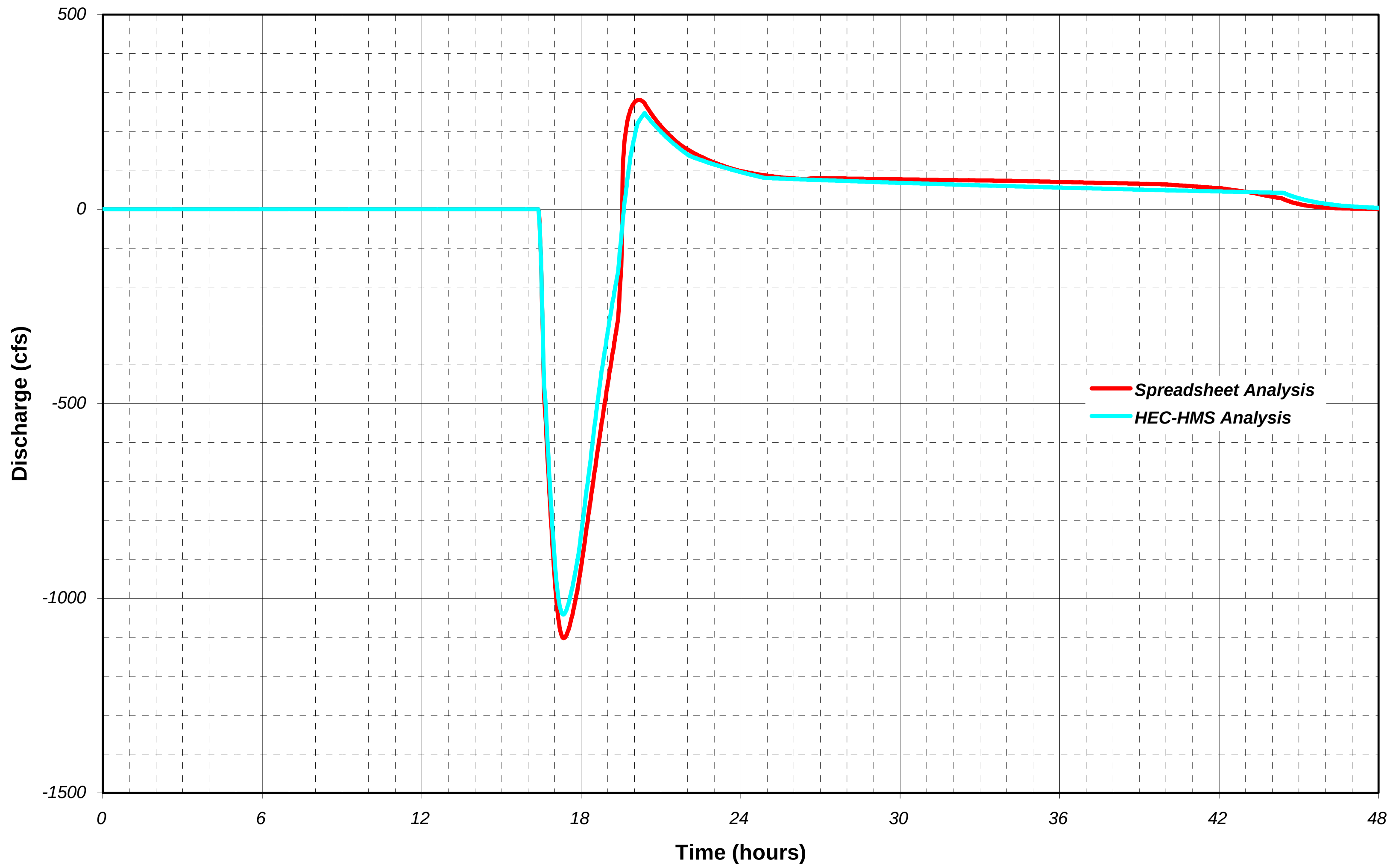


Scenario #3: Diversion Hydrograph
500
0
-500
-1000
-1500
Discharge (cfs)
0
6
12
18
24
30
36
42
48
Time (hours)
Spreadsheet Analysis
HEC-HMS Analysis

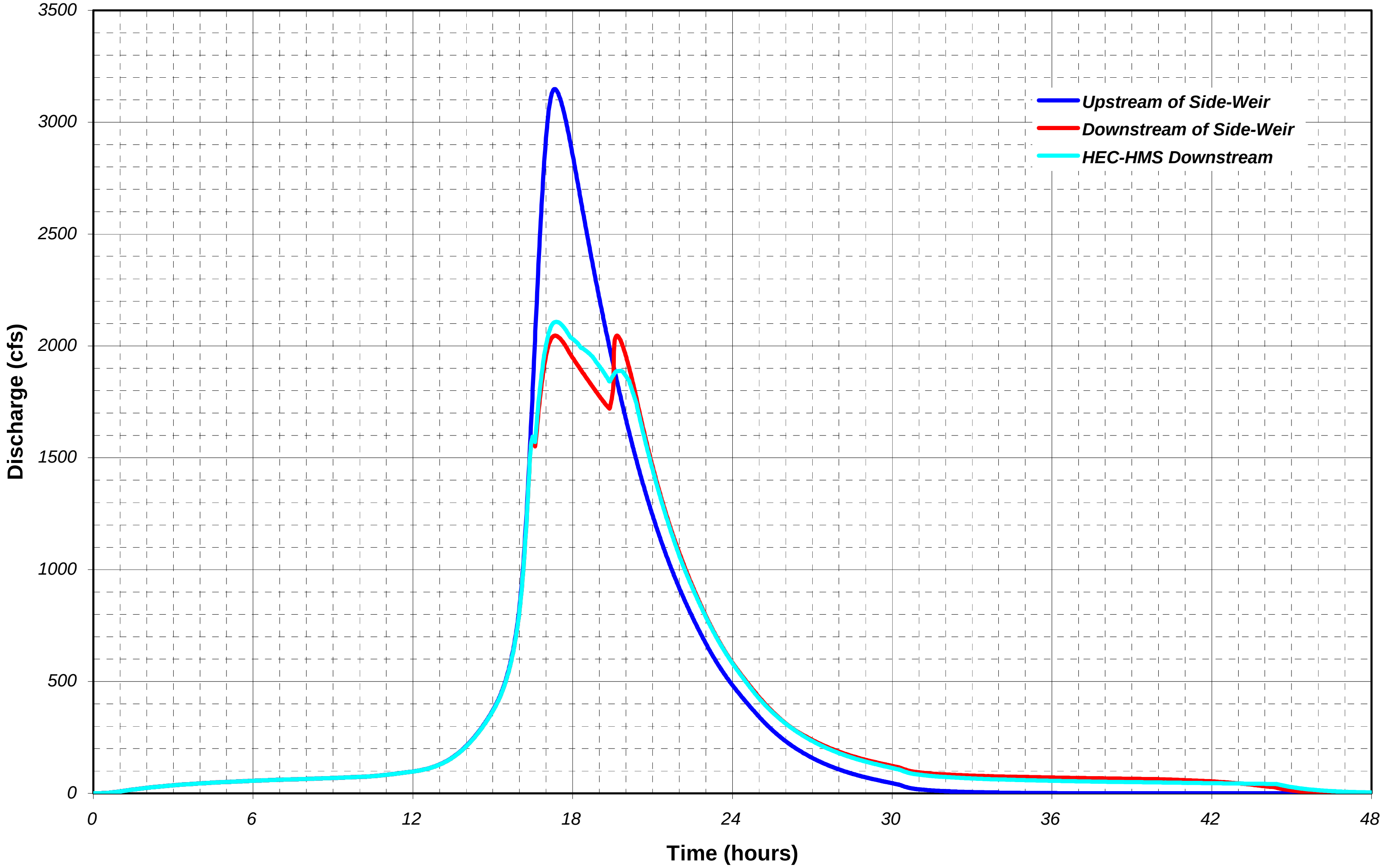

Scenario #3: Impacts of Side-Weir on Hydrograph
Discharge (cfs)
3500
3000
2500
2000
1500
1000
500
0
0
6
12
18
24
30
36
42
48
Time (hours)
Upstream of Side-Weir
Downstream of Side-Weir
HEC-HMS Downstream

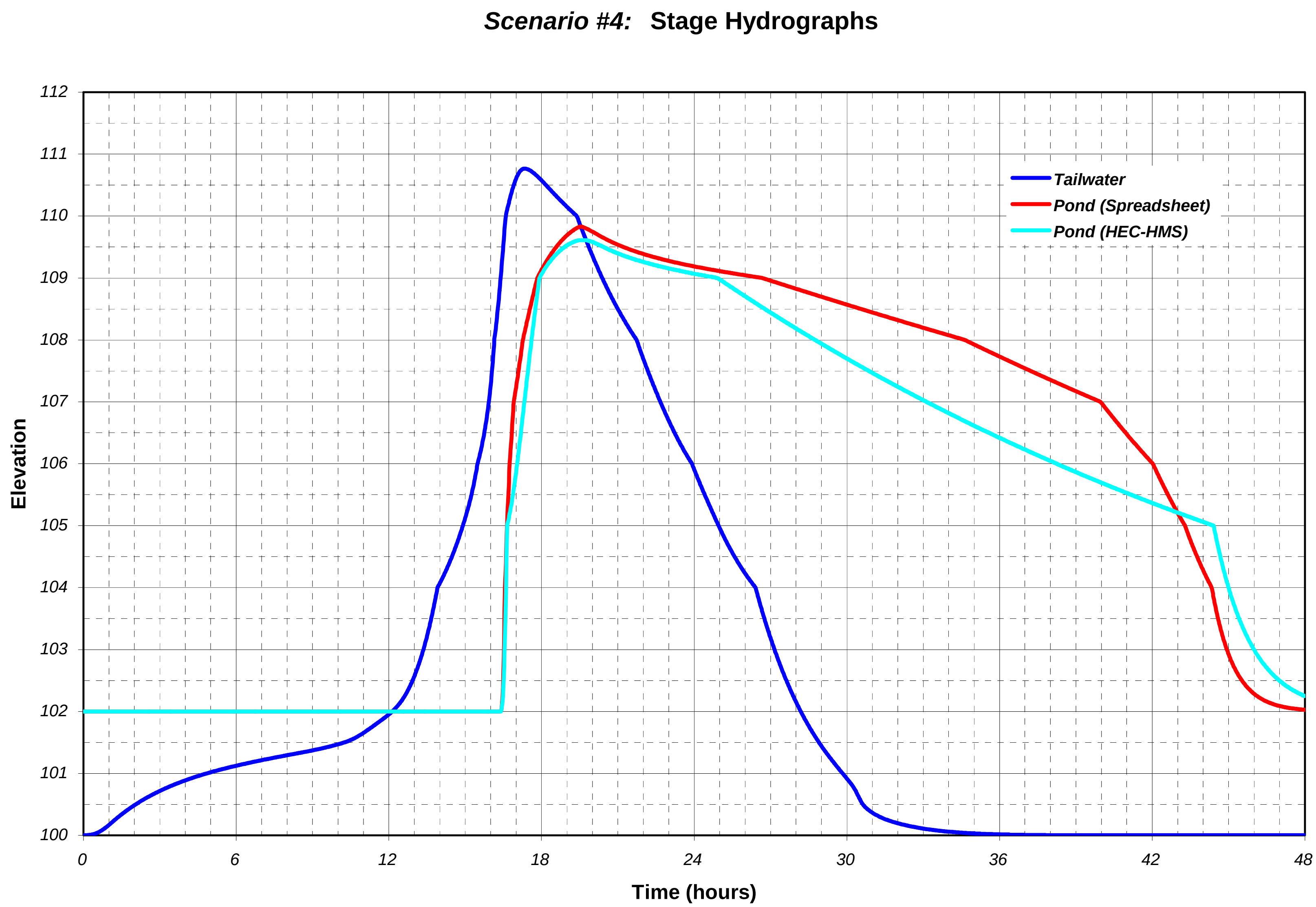

Scenario #3: Stage Hydrographs
Tailwater
Pond (Spreadsheet)
Pond (HEC-HMS)
Elevation
112
111
110
109
108
107
106
105
104
103
102
101
100
0
6
12
18
24
30
36
42
48
Time (hours)

Scenario #4: Diversion Hydrograph



Scenario #4: Impacts of Side-Weir on Hydrograph





Scenario #4: Stage Hydrographs
Elevation
112
111
110
109
108
107
106
105
104
103
102
101
100
0
6
12
18
24
30
36
42
48
Time (hours)
Tailwater
Pond (Spreadsheet)
Pond (HEC-HMS)