# Appendix 6-E

## Crop Demand Approach

Appendix 6-E contains a technical memorandum focused on providing clarity to the previous and current incorporation of the crop demands (from CropSIM) into the surface water operations model for determining the appropriate approach for handling the monthly demands.

HDR | ONE COMPANY *Many Solutions*℠

# Memo

| | |
|---|---|
| To: COHYST Team | |
| From: John Engel | Project: |
| CC: | |
| Date: December 2015 | Job No: |

RE: Crop Demand Representation in the STELLA Surface Water Model

This memo is focused on providing clarity to the previous and current incorporation of the crop demands (from CropSIM) into the surface water operations model for the purpose of determining the appropriate approach for handling the monthly demands.

## Previous Approach (Annual CropSIM demands)

The approach to incorporating irrigation demands for lands served by surface water canals is documented in *Section 6.6 Operational Rules* of the draft draft documentation (2013). In general, the annual irrigation demand is distributed into constant values for four distinct periods (June 16-30, July, August, Sept 1-10). The distribution of the demands was determined based on inputs from canal operators and to match historic diversion patterns ***and does not match the theoretical crop consumptive use demand determined by CropSIM, nor the distribution used in the demands used for groundwater pumping***.

The following is an example of the approach utilized for July 2003 for the Gothenburg Canal. The computations in STELLA are computed on a daily basis (equal distribution of monthly values), the following is on a monthly basis for simplicity.

**Example: Gothenburg Canal 2003**

1. Annual Demand (2003) for Gothenburg Canal = 21,278 AF
2. This is distributed to the Irrigation Season (June, July, August and September) with the following percentages:

| Month | Percentage | Monthly Demand |
|---|---|---|
| June 16 – 30 | 7.4% | 21,278 AF * 7.4% = 1,575 AF |
| July | 50% | 21,278 AF * 50% = 10,639 AF |
| August | 35.9% | 21,278 AF * 35.9% = 7,639 AF |
| Sept 1-10 | 6.7% | 21,278 AF * 6.7% = 1,426 AF |

The monthly demand is then distributed to a daily irrigation demand.

3. Total Demand at the Head gate for July =
   5,480 AF Seepage + (Net Evap of 1% of Diversion) + 10,640 AF Crop Demand + (Spill 21% of Diversion) = 20,670 AF
4. Total July Diversion computed by STELLA = 20,255 AF
5. Once in the Canal, Diversion is partitioned =
   5,480 AF Seepage + 220 AF Net Evap + 10,640 AF Crop Delivery + **3,915 AF Return**.
   (Diversion, Seepage, Net Evap and Crop Delivery are known and Stella is calculating the Return.)

Utilizing this approach, generally very good agreement was achieved as documented in the draft model calibration documentation from the summer of 2013.

## Current Approach (Monthly CropSIM demands)

At the October 2013 workshop, it was decided by the Sponsor Group to develop irrigation demands on a monthly basis. In April 2014, monthly irrigation demands for lands served by the surface water canals were

complete and approaches for incorporation were discussed amongst the modeling group during the April 8, 2014 conference call. The following describes the agreed upon approach:

**Example: Gothenburg Canal 2003**

1. Monthly Irrigation Demands for lands served by Gothenburg Canal (CropSIM output)

| Month | Demand (AF) |
|---|---|
| Jan | 0 |
| Feb | 0 |
| Mar | 61 |
| Apr | 385 |
| May | 90 |
| Jun | 169 |
| Jul | **6,815** |
| Aug | 9,101 |
| Sep | 2,216 |
| Oct | 28 |
| Nov | 0 |
| Dec | 0 |

2. The irrigation season demands (June, July, August and September) are summed to create an annual irrigation demand (demands outside of this period are neglected and will be passed back to the watershed model as unmet demands). Sum of June, July, August, September irrigation demands = 18,301 AF

Similar to the previous approach, this is distributed over June, July, August and September with the following percentages to develop a monthly irrigation demand at the headgate:

| Month | Percentage | Monthly Demand |
|---|---|---|
| June 16 – 30 | 7.4% | 18,301 AF * 7.4% = 1,354 AF |
| July | 50% | 18,301 AF * 50% = 9,150 AF |
| August | 35.9% | 18,301 AF * 35.9% = 6,570 AF |
| Sept 1-10 | 6.7% | 18,301 AF * 6.7% = 1,230 AF |

The monthly demand is then distributed to a daily irrigation demand.

3. Total Demand at the Head gate for July AF =
   5,480 AF Seepage + (Net Evap 1% of Diversion) + 9,150 AF Crop Demand + (Spill 21% of Diversion) = 18,760 AF
4. July Diversion = 18,420 AF
5. Once in the Canal, Diversion the return is determined based on monthly Cropsim demand =
   5,480 AF Seepage + 200 AF Net Evap + 6,815 AF Crop Delivery + **5,925 AF Return**
   (Diversion, Seepage, Net Evap and Crop Delivery are known and Stella is calculating the Return.)

## Discussion

While the proposed approach to applying a monthly demands that considers operational patterns (reflected by the weighting of diversions) does a reasonable job of matching the actual historic diversion (18,420 AF predicted to 18,610 AF historic) – and corresponds with operator input - applying the corresponding monthly theoretical crop demand from CropSIM to the diversion for crop delivery results in a substantial over prediction of returns (5,925 AF compared to 3,915 AF). This appears to reflect the differences between the timing of operational patterns and theoretical crop consumptive use demands and is likely a major factor in

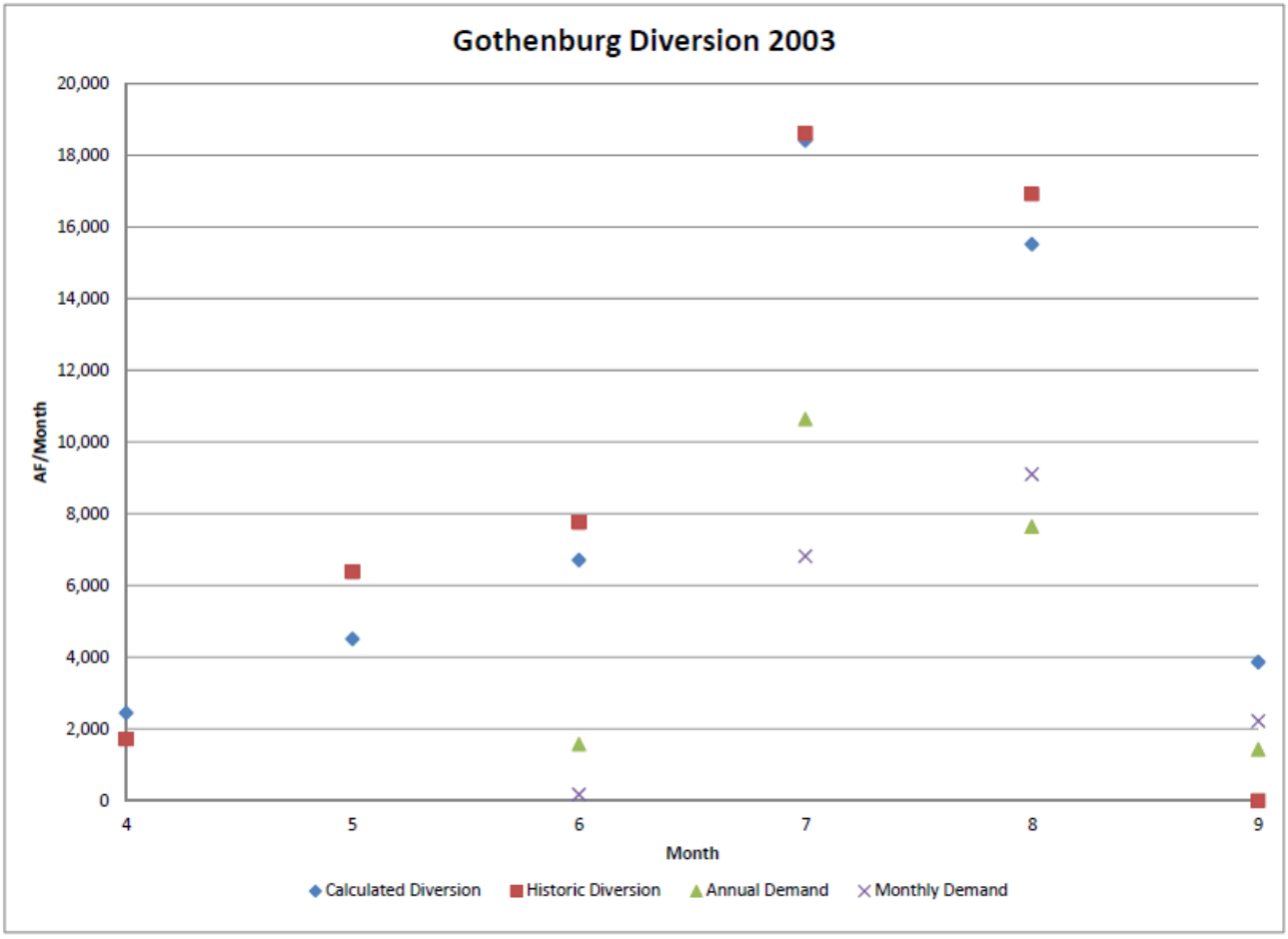
the inability of the integrated model to dry the river during drought periods due to this over prediction of canal return flows.

From discussions with operators, peak demand (and delivery) is late June/first week of July – irrespective of actual crop consumptive use demands at that time. Producers are either catching up or trying to get ahead of the expected peak crop demands and heat wave typical of early July because delivery cannot be made in real time (can take 4 to 5 days to make delivery to a parcel). The result is a mismatch between actual crop demands predicted by CropSIM and operator diversion and delivery pattern and consistently occurs at all irrigation canals represented in the model.

The current approach of using a weighted distribution of the cumulative monthly values for the diversion demand to reflect operational characteristics can match the historic diversion pattern with reasonable success (see Figure 1). However, the current approach of applying actual CropSIM demands to determine delivery (as opposed to the weighted demands used in determining the diversion) results in an under prediction of the consumptive use of surface water and corresponding over prediction of return flows to the river.

If the CropSIM monthly demands are used directly (without weighting to reflect operations), consumptive use during the irrigation season will be correct, however the predicted diversion patterns will vary significantly from historic diversion patterns.

**Figure 1 – Gothenburg Canal Diversion and Demand Comparison for 2003**




*Calculated diversion values in Figure are based on current approach using monthly demands.

The current modeling approach produces diversion results that match historical diversions, but the modeling approach impacts two elements of the overall water budget:

1. Correctly representing the consumptive use of the surface water.
2. The role in mismatched delivery demand and crop consumptive use resulting in higher calculated return flows relating to the dry river issues.

**Recommendation**

It is recommended that the previous approach of using the weighted distribution of annual crop demand for diversion and **canal delivery** be utilized with the new monthly crop demands from CropSIM. There would be no change to how the monthly diversion demands are currently handled. Once in the canal, the delivery volume to crops will be determined based on the same weighted distribution of the monthly CropSIM demand used in the diversion demand. This approach will allow the match to historical diversions to be maintained and allow the diversion and delivery to match, eliminating the higher calculated returns.

With the recommended approach, consumptive use during the irrigation season will be maintained, but may vary temporally from the idealized consumptive use predicted by CropSIM. Overall, the timing of crop demands varies year to year by a couple of weeks naturally, and this approach will not compromise the model results when representing an overall water budget of the system.

The following is an example of the recommended approach utilized for July 2003 for the Gothenburg Canal.

**Example: Gothenburg Canal 2003**

1. Monthly Irrigation Demands for lands served by Gothenburg Canal (CropSIM output)

| Month | Demand (AF) |
|---|---|
| Jan | 0 |
| Feb | 0 |
| Mar | 61 |
| Apr | 385 |
| May | 90 |
| Jun | 169 |
| Jul | 6,815 |
| Aug | 9,101 |
| Sep | 2,216 |
| Oct | 28 |
| Nov | 0 |
| Dec | 0 |

2. The irrigation season demands (June, July, August and September) are summed to create an annual irrigation demand (demands outside of this period are neglected and will be passed back to the watershed model as unmet demands). Sum of June, July, August, September irrigation demands = 18,301 AF

Similar to the previous approach, this is distributed over June, July, August and September with the following percentages to develop a monthly irrigation demand at the headgate:

| Month | Percentage | Monthly Demand |
|---|---|---|
| June 16 – 30 | 7.4% | 18,301 AF * 7.4% = 1,354 AF |
| July | 50% | 18,301 AF * 50% = 9,150 AF |
| August | 35.9% | 18,301 AF * 35.9% = 6,570 AF |
| Sept 1-10 | 6.7% | 18,301 AF * 6.7% = 1,230 AF |

The monthly demand is then distributed to a daily irrigation demand.

3. Total Demand at the Head gate for July AF =
   5,480 AF Seepage + (Net Evap 1% of Diversion) + 9,150 AF Crop Demand + (Spill 21% of Diversion) = 18,760 AF
4. July Diversion = 18,420 AF
5. Once in the Canal, Diversion the return is determined based on weighted distribution of the monthly Cropsim demand =
   5,480 AF Seepage + 200 AF Net Evap + 9,150 AF Crop Delivery + **3,590 AF Return**
   (Diversion, Seepage, Net Evap and Crop Delivery are known and Stella is calculating the Return.)