

Implementation of the Sacramento Soil Moisture Accounting Model for Douglas County, Colorado

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Through a cooperative program between the Urban Drainage and Flood Control District and Douglas County in 2014, Water & Earth Technologies, Inc. (WET) implemented the Sacramento Soil Moisture Accounting (SSMA) rainfall-runoff model to provide operational forecasts of streamflow on East Plum Creek. The SSMA was implemented for East Plum Creek with the lower forecast point being co-located at the USGS streamgage upstream of the Haskins Gulch confluence near Castle Rock. The ALERT gaging station #2820 is coincident with a USGS stream gage.

The SSMA model is a native component within the NovaStar5 base station software application used by UDFCD. The ALERT monitoring network provides real-time rainfall input to the model. NovaStar5 can run the SSMA at different time steps ranging from 15 minutes to 6 hours.

The SMA is a conceptual, lumped parameter model that provides a simplified representation of the physical runoff process. The fundamental concept in the SSMA is that the soil column has two soil zones; an upper zone and a lower zone. The first represents the upper soil layer and interception storage while the lower zone represents the bulk of the soil column and ground-water storage. Within both zones there is tension water capacity and free water capacity. Tension water is held tightly to soil particles and can only be depleted as evapotranspiration. Free water can move both horizontally and vertically through the soil profile. Free water can be depleted by evapotranspiration or drained as surface runoff, interflow, percolation and ground-water base flow.

The SSMA employs a unit hydrograph which converts runoff generated from the model into instantaneous discharges. Together the SSMA and unit hydrograph models are used to simulate and forecast hydrologic stream conditions.

The SSMA was selected for three reasons: 1) It is implemented at very low cost because it is native to the currently running NovaStar5 base station software, 2) It is a continuous simulation model that tracks soil moisture conditions through time and 3) A regional parameter set was obtained from the National Weather Service (NWS). The NWS also uses the SSMA to prepare river basin forecasts across the U.S.

In Colorado, the NWS runs the SSMA for the South Platte River basin out of its Missouri Basin River Forecast Center (MBRFC). The NWS forecast point nearest our basins of interest is Plum Creek at Sedalia (see map). The SSMA parameter set utilized by the MBRFC for Plum Creek at Sedalia was applied directly to our implementation of the SSMA for East Plum Creek above Haskins Gulch without alteration. The Plum Creek at Sedalia MBRFC forecast point has a tributary area of 275 square miles. East Plum Creek at Haskins Gulch drains 116 square miles (Figure 1).

The primary input to the SSMA is basin rainfall. Basin rainfall, in this case, is derived from the real-time ALERT monitoring network using a predetermined set of Thiessen station weights to generate a mean areal precipitation time series representative of each sub-basin. The modeled basins and the ALERT gage locations are shown on the map below. Station weights are assigned within NovaStar5 which then generates the basin average rainfall time series and supplies this time series to the SSMA.

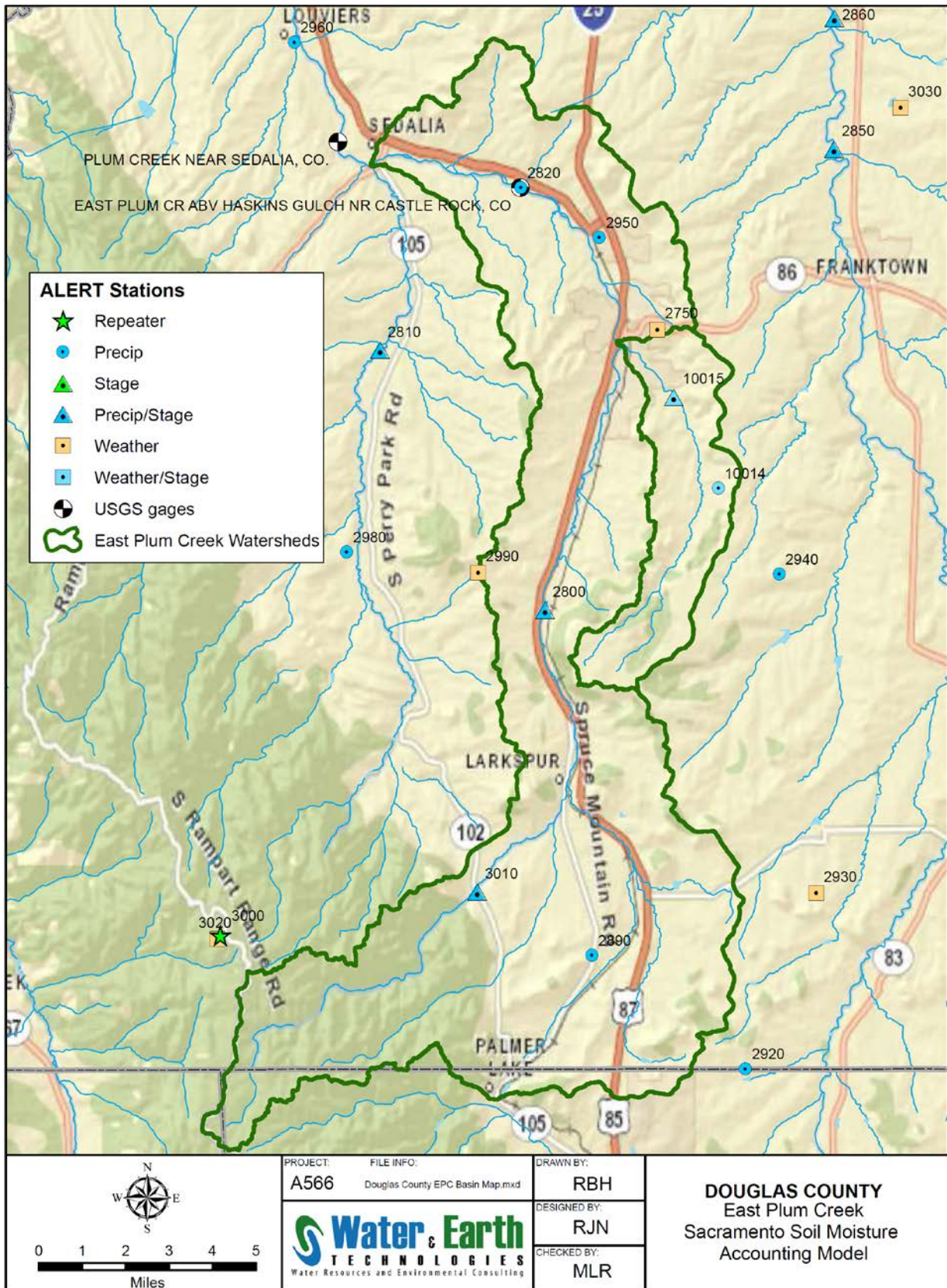


Figure 1. Plum Creek Watershed Map

July 12, 2014

The first real test of the SSMA occurred on July 12, 2014. Heavy rainfall began in the late afternoon and persisted into the evening during a 3-hour storm with rain totals exceeding two inches in the East Plum Creek watershed (Figure 2).

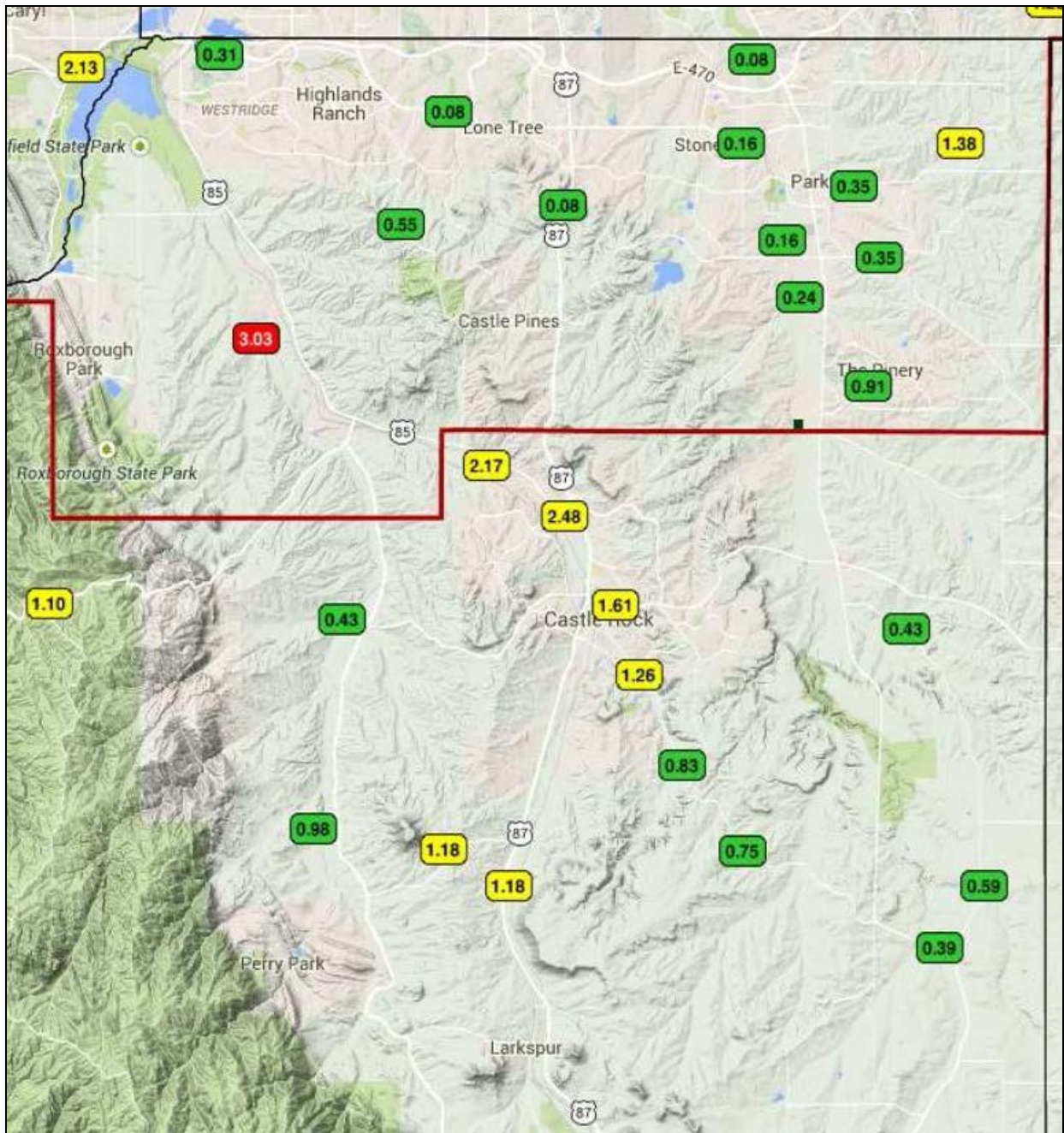


Figure 2. Six Hour Rain Totals for July 12, 2014

Table 1. Peak Rain Accumulation for July 12, 2014

ALERT ID	15 minutes		1 hour		3 hour	
	Time Ending	Total (in)	Time Ending	Total (in)	Time Ending	Total (in)
2820	6:27:45 PM	0.591	6:59:32 PM	1.496	7:55:40 PM	2.165
2950	6:58:45 PM	0.669	7:18:51 PM	1.929	8:23:15 PM	2.480
2750	7:20:48 PM	0.472	7:22:01 PM	1.220	8:21:44 PM	1.614
2990	6:59:35 PM	0.354	7:18:56 PM	0.866	8:48:24 PM	1.181
2800	6:49:25 PM	0.354	7:24:07 PM	0.906	9:05:39 PM	1.181
2890	6:32:30 PM	0.512	6:32:30 PM	0.512	10:06:40 PM	0.787
3010	8:45:12 PM	0.070	9:01:11 PM	0.180	10:11:27 PM	0.350
10014	7:29:53 PM	0.236	7:51:12 PM	0.551	8:27:53 PM	0.827
10015	6:38:10 PM	0.433	7:20:30 PM	0.827	8:26:35 PM	1.260

From a meteorological perspective, deep low level moisture was in place due to thunderstorm outflow boundaries that pushed through during the previous night. Training thunderstorm cells moved over Douglas County prompting NWS to issue Flash Flood Warnings.

The USGS gage at East Plum Creek above Haskins Gulch recorded a peak discharge of 1,180 cfs at approximately 9:00 PM on July 12, 2014 (Figure 3). The USGS station stopped recording data just before midnight on July 12.

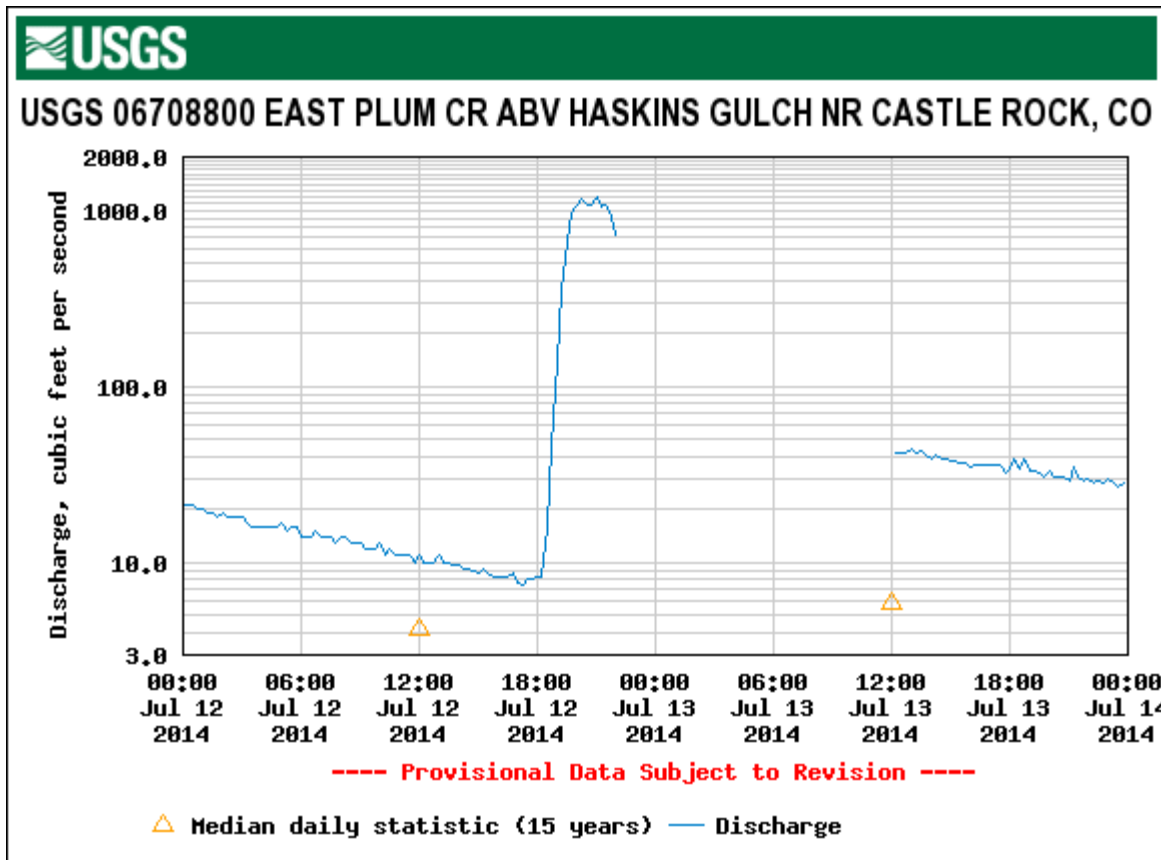


Figure 3. USGS Instantaneous Discharge for July 12, 2014

NovaStar5 runs the SSMA on a 15-minute time step, producing forecasts that extend 90 minutes into the future. The model runs continuously every 15 minutes. The simulated flow forecast (blue line) relative to the measured USGS discharge (green line) for the period July 11 through July 14, 2014 is shown (Figure 4). The basin rainfall (red line) is plotted vertically from the top of the plot. The observed data from the USGS plotted below includes an artificial interpolation for the period of missing measured data. Overall, the NovaStar5 SSMA flow forecast matches the discharge measured by the USGS very well. UDFCD and Douglas County are encouraged by this early success and hope to add alarm and notification functionality to the simulated flow forecast to obtain additional lead-time for emergency responders. UDFCD may also consider further implementations of the SSMA incorporating radar-rainfall estimates as inputs to the model.

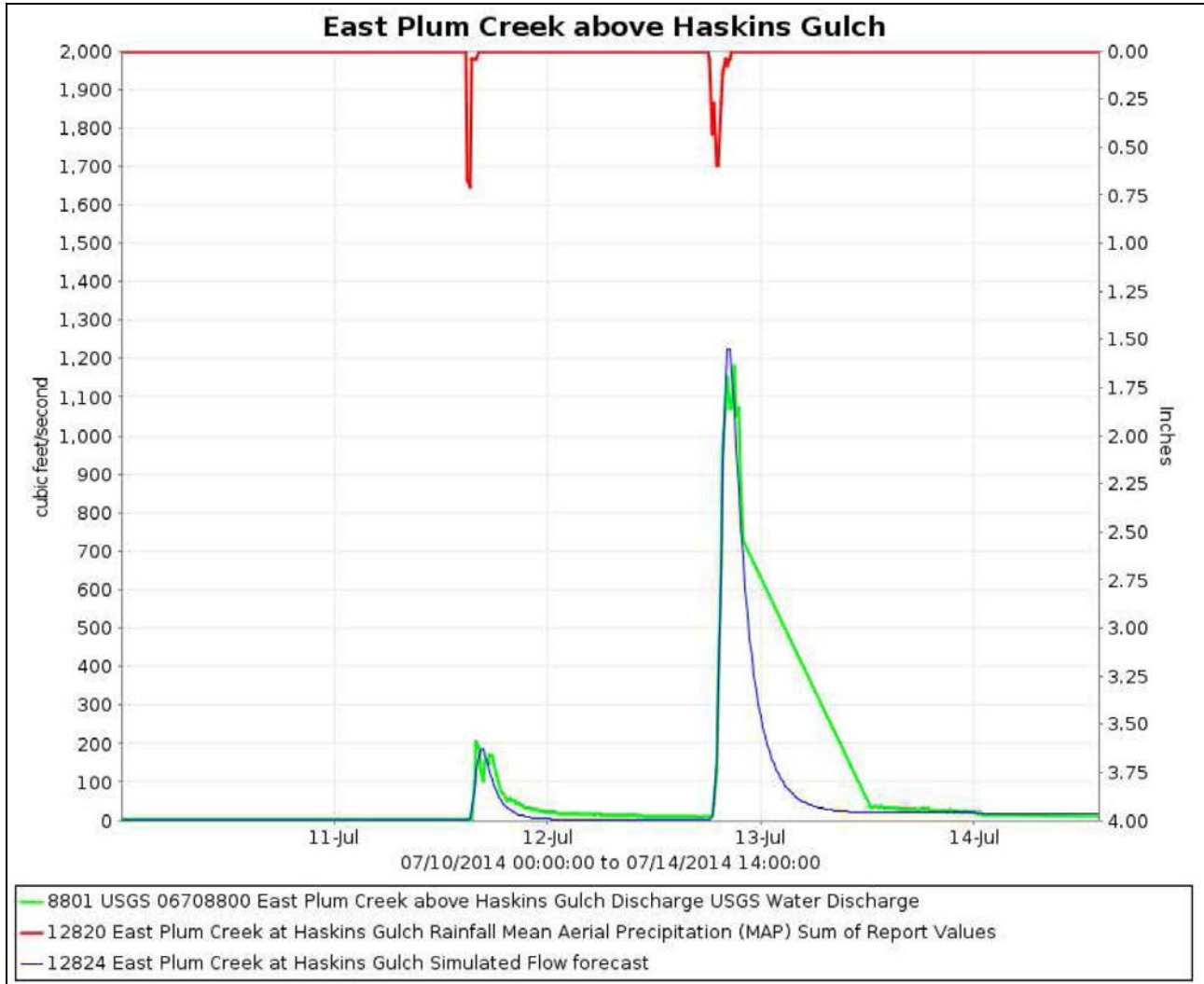


Figure 4. NovaStar5 Simulated Flow Forecast for July 12 Storm