An Evaluation and Improvement of Post-Wildfire Hydrology Analysis using HEC-HMS

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HEC

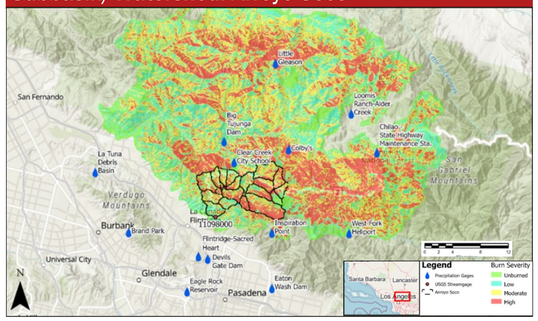
POST-WILDFIRE FLOOD RISK MANAGEMENT

US Army Corps of Engineers®

Project Goal

Develop an effective methodology for modeling post-wildfire hydrology using the Green and Ampt infiltration loss method.

Subbasin/Watershed: Arroyo Seco



Step 1: Estimate initial Green & Ampt parameters for pre-wildfire hydrology using gSSURGO data and Table B-2 (Highway Drainage Design Manual, ADOT, 2014).

Table B-2 Green and Ampt Parameters Based on Texture for Miscellaneous Soils

Texture	Conductivity (in/hr)	Suction (in)	Moisture Content		
			Wilting Point (dry)	Field Capacity (normal)	Saturated
Sand	2.00	0.29	0.021	0.059	0.411
Loamy sand	1.61	0.60	0.030	0.073	0.339
Sandy loam	0.74	2.97	0.058	0.144	0.384
Gravelly sandy loam	0.49	4.71	0.058	0.144	0.384
Loam	0.19	8.19	0.110	0.238	0.390
Gravelly loam	0.13	9.15	0.110	0.238	0.390
Sandy clay loam	0.11	9.49	0.167	0.259	0.393
Silt	0.08	10.03	0.047	0.281	0.369
Extremely gravelly loam	0.08	10.03	0.110	0.238	0.390
Very gravelly loam	0.08	10.03	0.110	0.238	0.390
Silt loam	0.08	10.03	0.124	0.297	0.405
Silty clay Loam	0.04	10.80	0.204	0.370	0.456
Clay loam	0.04	10.80	0.204	0.336	0.429
Gravelly clay	0.01	11.42	0.296	0.423	0.478
Sandy clay	0.01	11.42	0.251	0.360	0.424
Silty clay	0.03	11.00	0.277	0.421	0.504
Clay	0.01	11.42	0.296	0.423	0.478
Rock	0.01	11.42	0.296	0.423	0.478
Unknown texture	0.01	11.42	0.296	0.423	0.478

Subbasin	Soil Texture	Ksat (inch/hr)	Suction (inch)	Moisture Content
AS100_Sub	Sandy Loam, unknown	0.53	3.78	0.34
AS150_Sub	Sandy Loam, unknown	0.49	3.73	0.35
AS200_Sub	unknown	0.32	4.30	0.37
AS250_Sub	Sandy Loam, unknown	0.49	3.76	0.35
AS300_Sub	Sandy Loam, unknown	0.56	3.56	0.34
AS350_Sub	Sandy Loam, unknown	0.55	3.49	0.34
AS400_Sub	Sandy Loam, unknown	0.52	3.67	0.35
AS420_Sub	bedrock	0.05	4.24	0.37
AS450_Sub	Sandy Loam, unknown, bedrock	0.57	3.48	0.34
AS500_Sub	unknown, bedrock	0.29	4.35	0.37
AS550_Sub	gravelly loam, bedrock, unknown	0.15	5.35	0.35
AS600_Sub	sandy loam	0.74	2.98	0.33
AS640_Sub	Bedrock, sandy loam	0.48	3.45	0.34
AS660_Sub	bedrock, gravelly loam	0.04	5.30	0.35
AS680_Sub	gravelly loam, sandy loam	0.38	6.65	0.30
AS700_Sub	sandy loam, gravelly loam	0.58	4.63	0.31
AS720_Sub	sandy loam	0.74	3.00	0.33
AS740_Sub	bedrock, sandy loam, gravelly loam	0.23	4.83	0.34
AS760_Sub	Bedrock, sandy loam	0.20	3.98	0.36
AS800_Sub	bedrock, sandy loam	0.50	3.44	0.34
AS850_Sub	bedrock	0.01	4.30	0.37
AS900_Sub	bedrock, sandy loam	0.40	3.59	0.35

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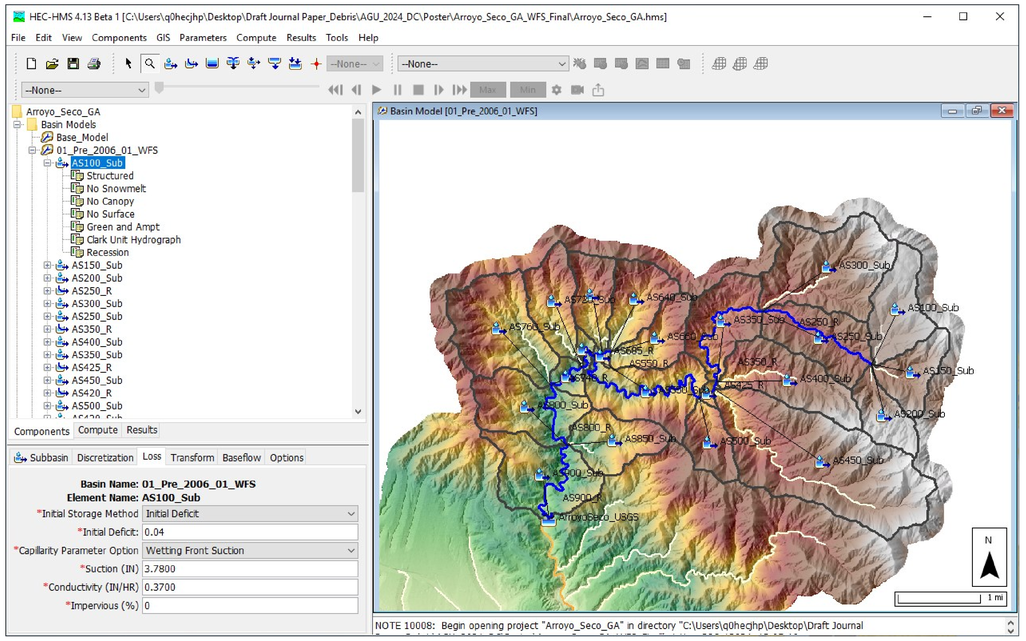
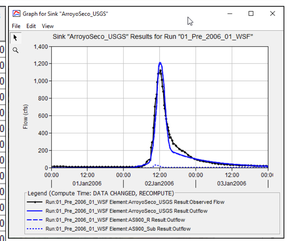
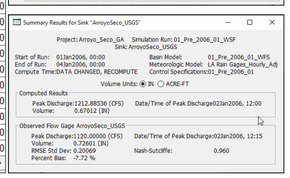
Step 2: Calibrate the pre-wildfire hydrology model using the precipitation and flow gage data.



Subbasin	Initial Storage Method	Initial Deficit	Initial Content	Saturated Content	Capillarity Parameter Option	Suction (IN)	Sorptivity (IN/√HR)	Conductivity (IN/HR)	Impervious (%)
AS100_Sub	Initial Deficit	0.04			Wetting Front Suction	3.78		0.37	0
AS150_Sub	Initial Deficit	0.04			Wetting Front Suction	3.73		0.34	0
AS200_Sub	Initial Deficit	0.04			Wetting Front Suction	4.3		0.22	0
AS300_Sub	Initial Deficit	0.04			Wetting Front Suction	3.56		0.39	0
AS250_Sub	Initial Deficit	0.04			Wetting Front Suction	3.76		0.34	0
AS400_Sub	Initial Deficit	0.04			Wetting Front Suction	3.67		0.36	0
AS350_Sub	Initial Deficit	0.04			Wetting Front Suction	3.49		0.39	0
AS450_Sub	Initial Deficit	0.04			Wetting Front Suction	3.83		0.46	0
AS500_Sub	Initial Deficit	0.04			Wetting Front Suction	4.35		0.2	0
AS420_Sub	Initial Deficit	0.04			Wetting Front Suction	4.66		0.06	0
AS640_Sub	Initial Deficit	0.04			Wetting Front Suction	3.8		0.38	0
AS660_Sub	Initial Deficit	0.04			Wetting Front Suction	5.83		0.06	0
AS600_Sub	Initial Deficit	0.04			Wetting Front Suction	3.28		0.59	0
AS550_Sub	Initial Deficit	0.04			Wetting Front Suction	5.35		0.11	0
AS680_Sub	Initial Deficit	0.03			Wetting Front Suction	7.32		0.3	0
AS720_Sub	Initial Deficit	0.04			Wetting Front Suction	3.3		0.59	0
AS700_Sub	Initial Deficit	0.04			Wetting Front Suction	5.09		0.46	0
AS760_Sub	Initial Deficit	0.04			Wetting Front Suction	3.98		0.14	0
AS740_Sub	Initial Deficit	0.04			Wetting Front Suction	4.83		0.16	0
AS800_Sub	Initial Deficit	0.03			Wetting Front Suction	3.78		0.4	0
AS850_Sub	Initial Deficit	0.04			Wetting Front Suction	4.73		0.04	0
AS900_Sub	Initial Deficit	0.04			Wetting Front Suction	3.95		0.32	0





Guidance Table for Post-Wildfire Hydrology

Post-Fire Parameters For the 1st year after fire	1 st Year Actual Range For G&A (Wet Condition)				
	Min	1Q Percentile	Median	3Q Percentile	Max
Moisture Deficit Values	0.12	0.08	0.07	0.021	0.001
Sorptivity Multiplier	0.94*(Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value)	0.91*(Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value)	0.91*(Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value)	0.84*(Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value)	0.75*(Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value)
Wetting Front Suction Multiplier	0.94[2] * (Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value) [2]	0.91[2] * (Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value) [2]	0.91[2] * (Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value) [2]	0.84[2] * (Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value) [2]	0.75[2] * (Pre-Fire Moisture Deficit Value/Post-Fire Moisture Deficit Value) [2]
Hydraulic Conductivity Multiplier	1.91	1.23	0.87	0.46	0.14

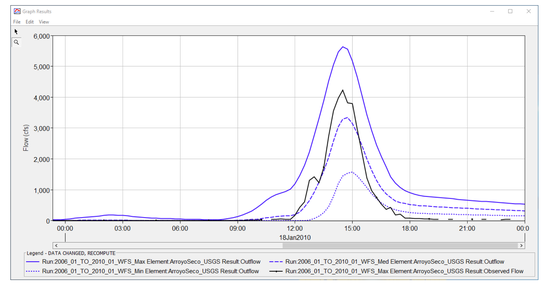
Step 3: Prepare Post-Wildfire Hydrology Model using the guidance Table

Estimated G&A Input Parameters using Guidance Table For Post-Wildfire Hydrology

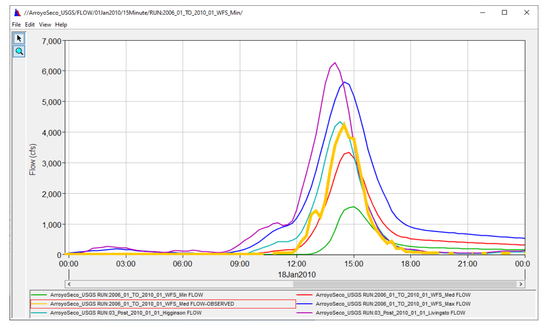
Subbasin	Minimum			Median			Maximum		
	Moisture Content	Suction* (inch)	Ksat (inch/hr)	Moisture Content	Suction* (inch)	Ksat (inch/hr)	Moisture Content	Suction* (inch)	Ksat (inch/hr)
AS100_Sub	0.12	0.37	0.37	0.07	1.03	0.32	0.001	157.00	0.05
AS150_Sub	0.12	0.84	0.84	0.07	1.40	0.30	0.001	157.00	0.09
AS200_Sub	0.12	2.41	2.41	0.07	2.77	0.21	0.001	157.00	0.13
AS250_Sub	0.12	0.37	0.37	0.07	0.98	0.34	0.001	157.00	0.06
AS300_Sub	0.12	0.37	0.37	0.07	1.02	0.30	0.001	157.00	0.05
AS350_Sub	0.12	0.39	0.39	0.07	1.02	0.31	0.001	157.00	0.05
AS400_Sub	0.12	0.47	0.47	0.07	1.04	0.34	0.001	157.00	0.07
AS420_Sub	0.12	0.49	0.49	0.07	1.13	0.40	0.001	157.00	0.08
AS450_Sub	0.12	0.43	0.43	0.07	1.18	0.17	0.001	157.00	0.03
AS500_Sub	0.12	0.45	0.45	0.07	1.26	0.05	0.001	157.00	0.01
AS550_Sub	0.12	0.55	0.55	0.07	1.17	0.33	0.001	157.00	0.07
AS600_Sub	0.12	0.60	0.60	0.07	1.60	0.05	0.001	157.00	0.01
AS640_Sub	0.12	0.40	0.40	0.07	0.95	0.52	0.001	157.00	0.10
AS660_Sub	0.12	0.56	0.56	0.07	1.47	0.10	0.001	157.00	0.02
AS680_Sub	0.12	0.41	0.41	0.07	1.12	0.26	0.001	157.00	0.04
AS700_Sub	0.12	0.52	0.52	0.07	1.05	0.52	0.001	157.00	0.12
AS720_Sub	0.12	0.50	0.50	0.07	1.38	0.40	0.001	157.00	0.06
AS740_Sub	0.12	0.61	0.61	0.07	1.25	0.12	0.001	157.00	0.03
AS760_Sub	0.12	0.64	0.64	0.07	1.44	0.14	0.001	157.00	0.03
AS800_Sub	0.12	0.31	0.31	0.07	0.66	0.35	0.001	157.00	0.07
AS850_Sub	0.12	0.75	0.75	0.07	1.51	0.04	0.001	157.00	0.01
AS900_Sub	0.12	0.64	0.64	0.07	1.28	0.28	0.001	157.00	0.06

* - The maximum suction value is 157 inches.

Estimated Uncertainty Boundary Range for 18 Jan 2010 Event



Step 4: Compare the post-fire hydrology model with SCS-CN methods (Livingston et al. 2005; Higginson & Jarnecke 2007).



Method	NSE	RSR	PBIAS-V
Min (G&A-S)	0.573	0.653	-42.63
Median (G&A-S)	0.803	0.444	28.02
Max (G&A-S)	0.126	0.935	157.08
CN-Higginson & Jarnecke (2007)	0.929	0.267	-22.99
CN-Livingston & others (2005)	0.212	0.888	101.45

Performance Rating	NSE	RSR	PBIAS-Volume
Very Good	0.80 < NSE ≤ 1.00	0.00 < RSR ≤ 0.60	PBIAS < ±5
Good	0.70 < NSE ≤ 0.80	0.50 < RSR ≤ 0.60	±5 ≤ PBIAS < ±10
Satisfactory	0.50 < NSE ≤ 0.70	0.60 < RSR ≤ 0.70	±10 ≤ PBIAS < ±15
Unsatisfactory	NSE ≤ 0.50	RSR > 0.70	PBIAS ≥ ±15

Source: Moriasi, et al. (2007)