A photograph of a river flowing through a landscape with green shrubs and a clear blue sky. The river is the central focus, winding through the scene. The surrounding vegetation is dense and green, contrasting with the brownish soil of the banks. The sky is a solid, clear blue.

# Assessment of the Restoration Activities on Water Balance and Water Quality at Last Chance Creek Watershed Using Watershed Environmental Hydrology (WEHY) Model

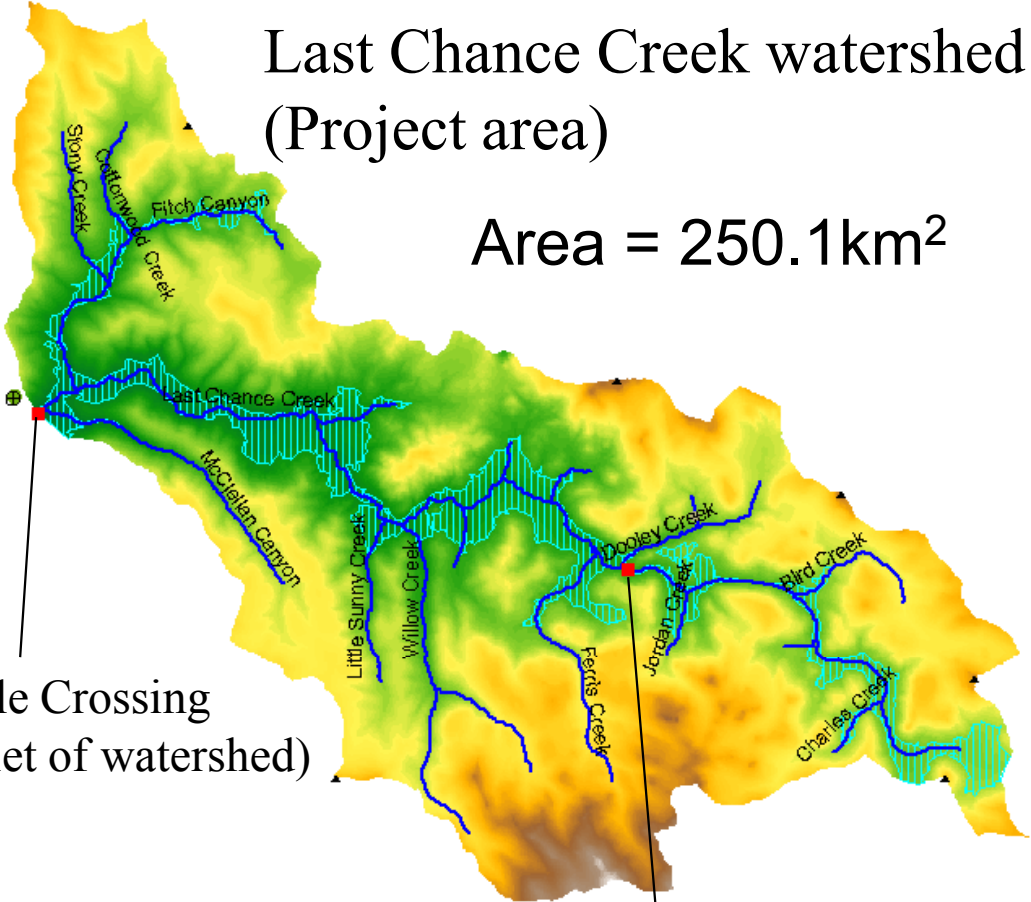
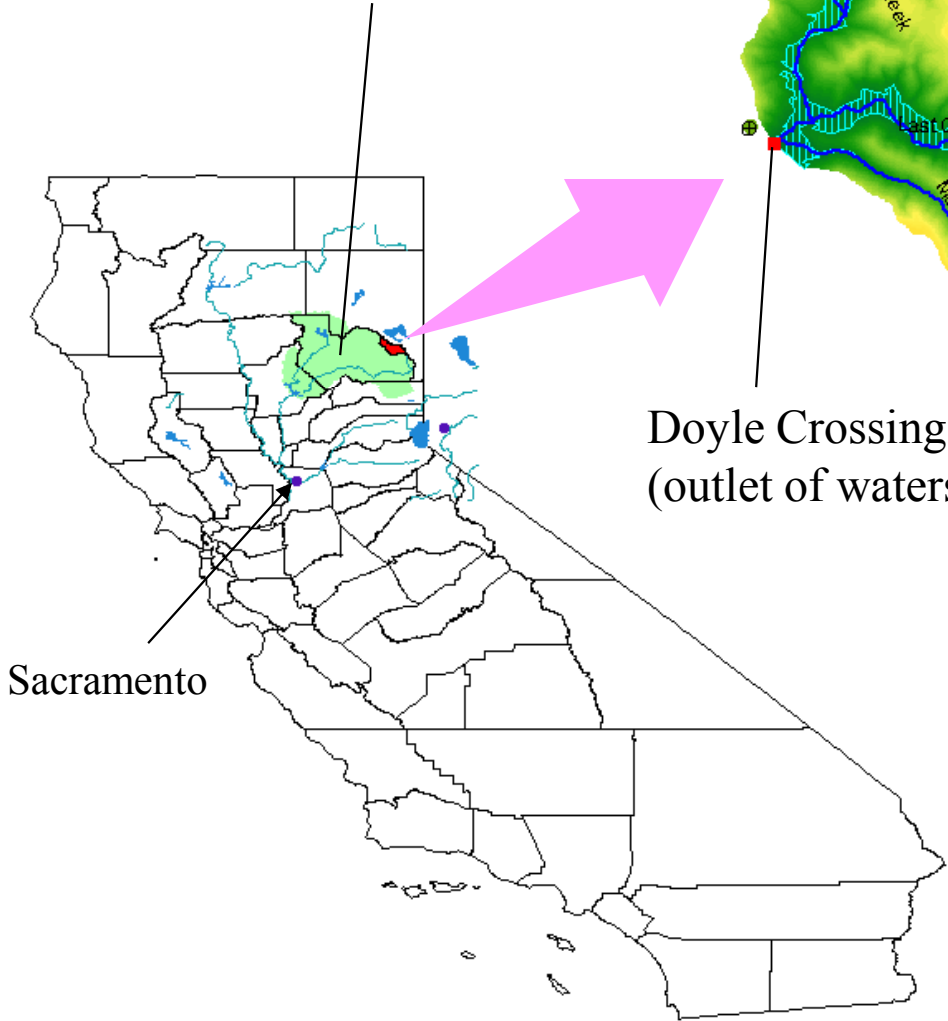
**M.L. Kavvas, Z. Q. Chen, M. Anderson, L. Liang, N. Ohara**  
Hydrologic Research Laboratory,  
Civil and Environmental Engineering, UC Davis

**J. Wilcox, L. Mink, T. Benoit**  
Feather River CRM

# Last Chance Creek watershed (Project area)

Area = 250.1km<sup>2</sup>

## Feather River Basin



Doyle Crossing  
(outlet of watershed)

Million \$ Bridge

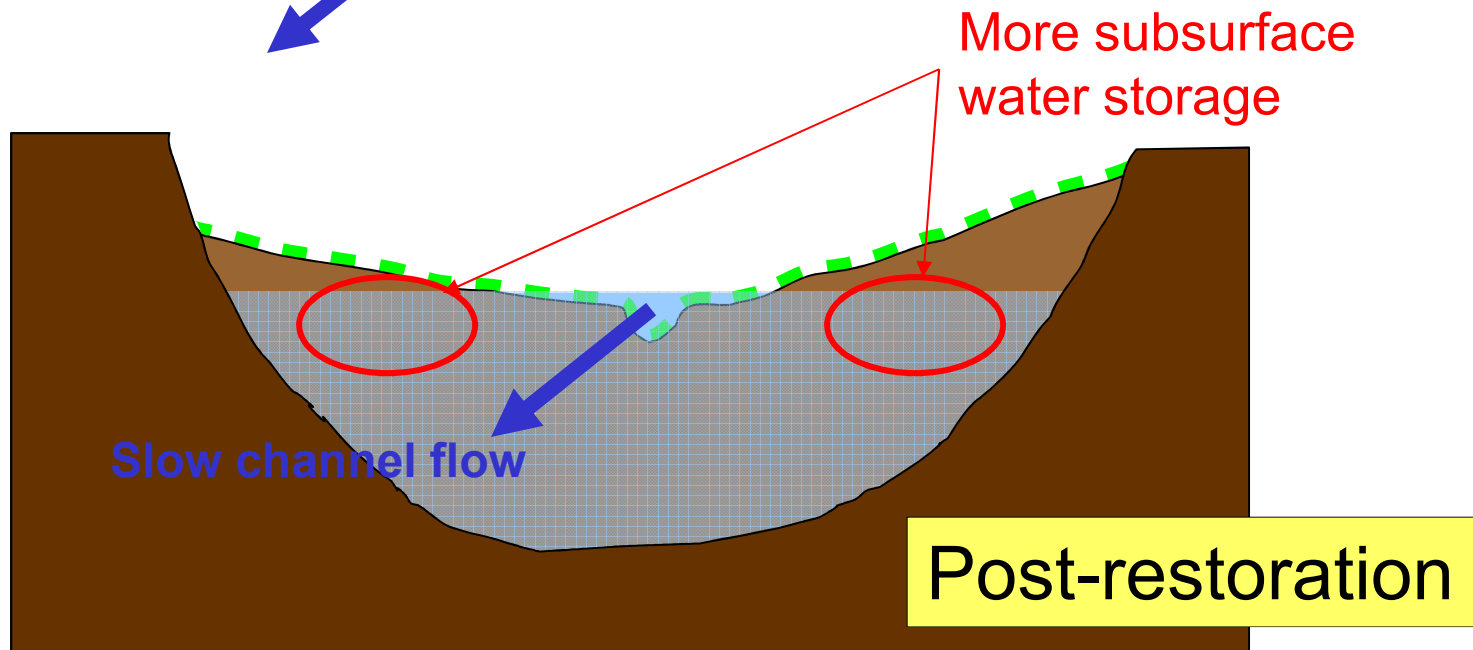
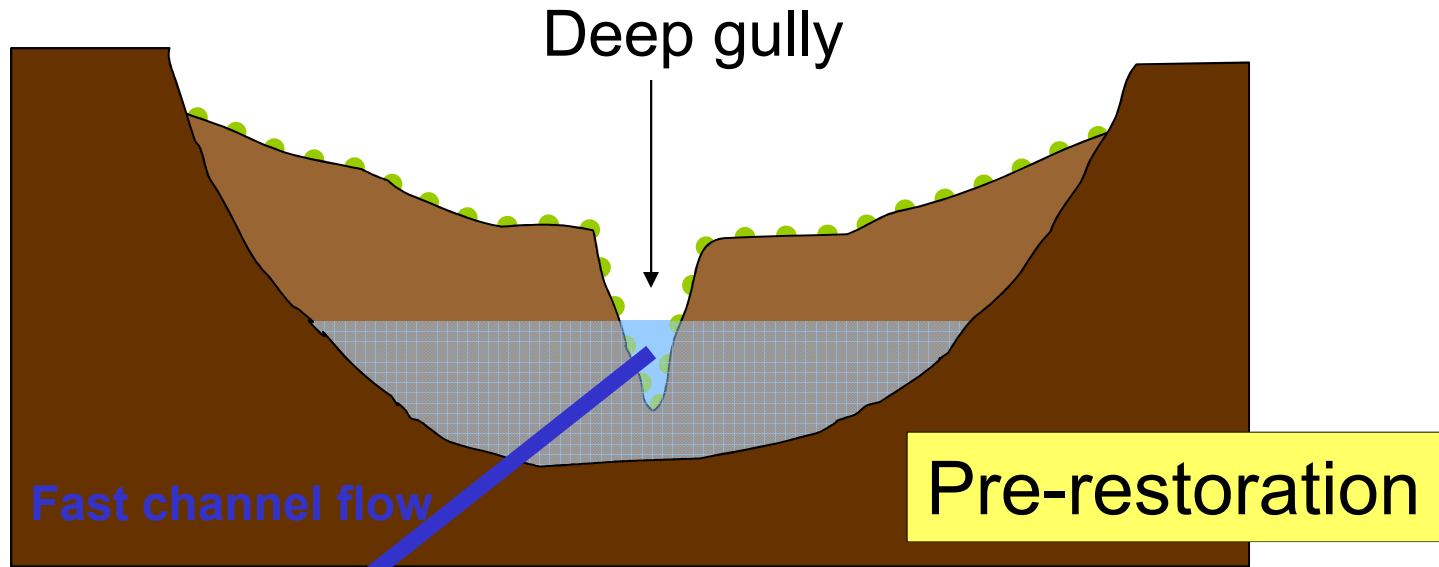
Slom Creek  
Cottonwood Creek  
Fitch Canyon  
Last Chance Creek  
McClellan Canyon  
Little Sunny Creek  
Willow Creek  
Ferts Creek  
Jordan Creek  
Dooley Creek  
Bird Creek  
Charles Creek



← Pre-restoration  
condition  
(May 5, 2002)  
The deep gully due to  
instream erosion induces  
low groundwater level.

Post-restoration →  
condition  
(July 29, 2004)  
The deep gully was filled,  
and a shallow channel  
was dug nearby.





# **ISSUES TO ASSESS FOR RESTORATION ACTIVITIES IN THE LAST CHANCE CREEK WATERSHED**

1. How does the restoration affect flood flows?
2. How does the restoration affect flows during the summer months?
3. How does the restoration affect the groundwater storage within the watershed?
4. How does the restoration affect sediment discharge from the watershed to downstream?

# **Use of a Watershed Model in NPS Studies**

Watershed model provides a tool for watershed evaluation

to help

protect and restore source areas for

water supply and flood control

and

to reduce NPS substance releases from these areas.

Model can identify source areas (sediment, nutrients, groundwater recharge, runoff)

Model can evaluate potential restoration activities for effectiveness at any watershed

Model can assess any land use/management scenarios

WEHY (Watershed Environmental Hydrology) Model

is a

physically-based, spatially-distributed

continuous simulation model

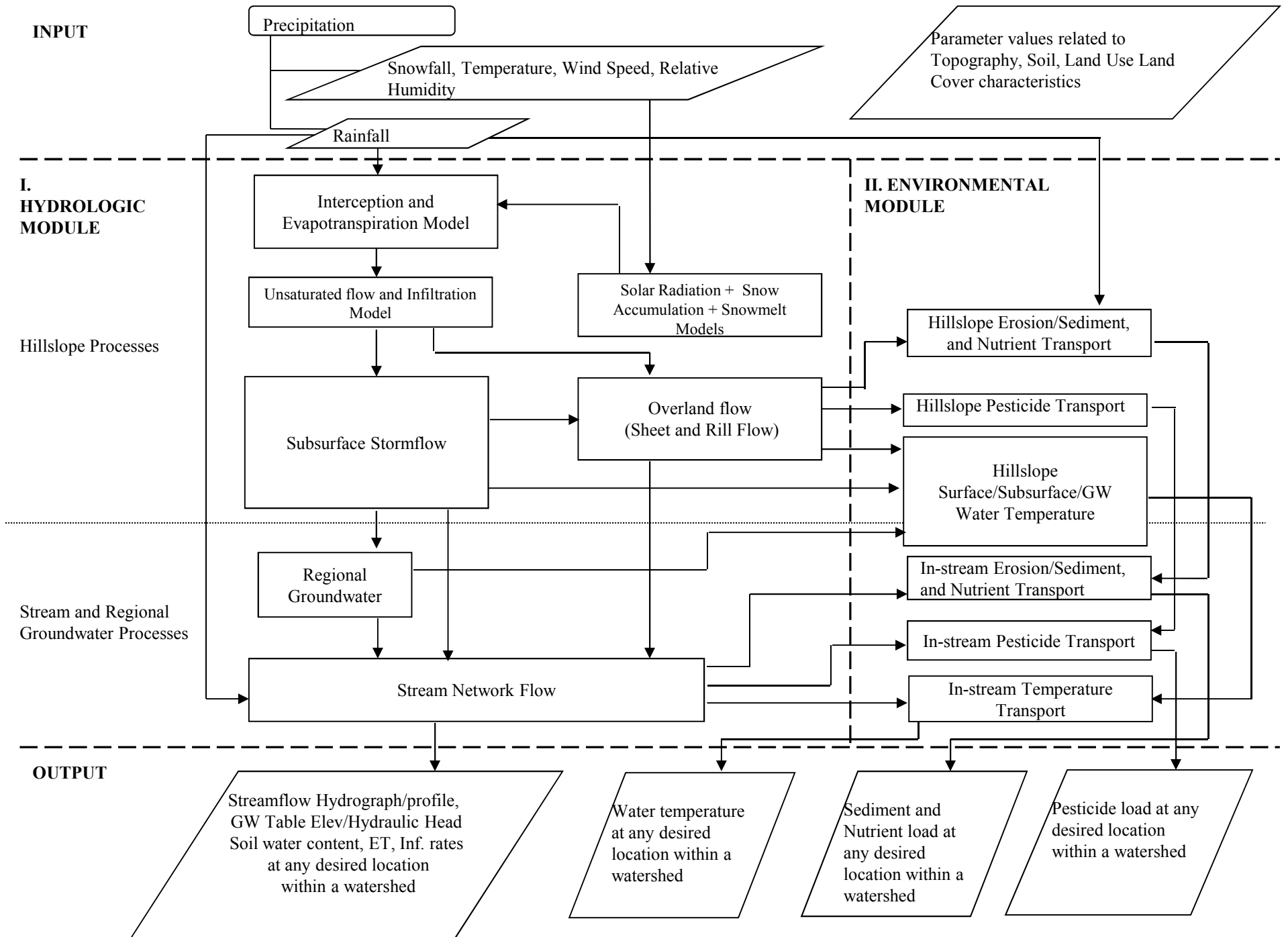
of

hydrologic and environmental processes.

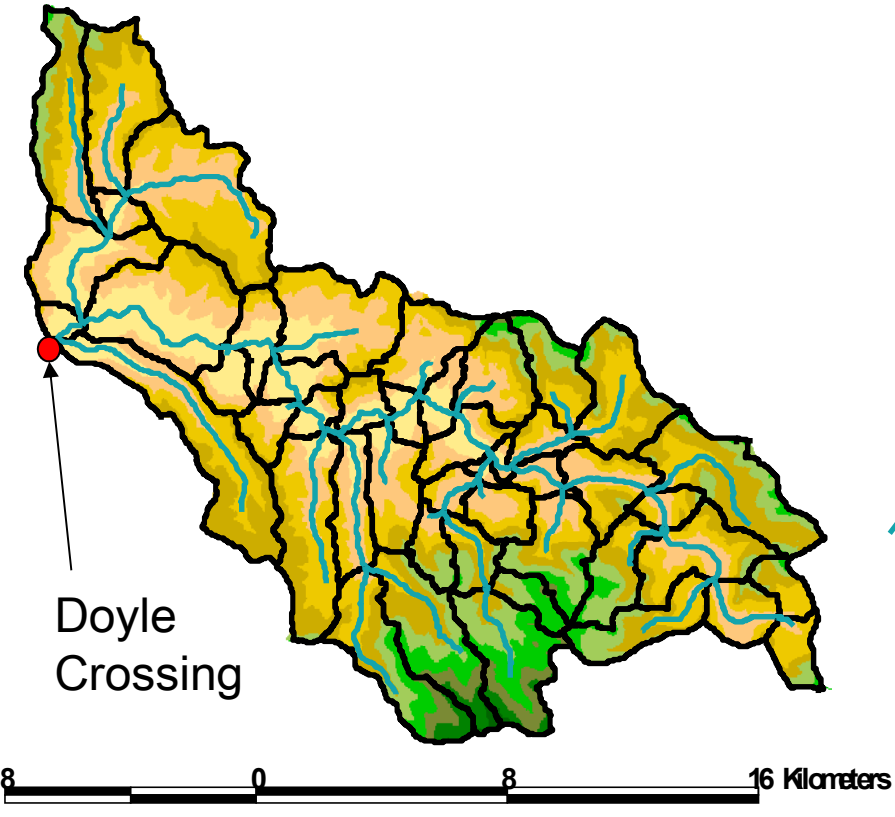
It was peer-reviewed and published

(Nov/Dec 2004 issue of Journal of Hydrologic Engineering).

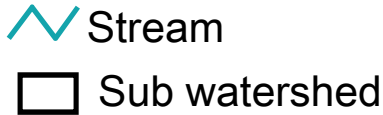
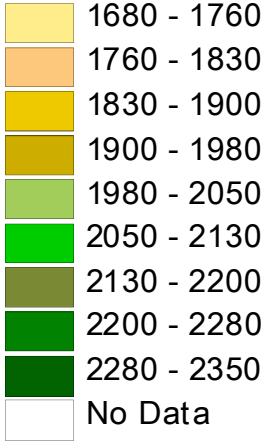




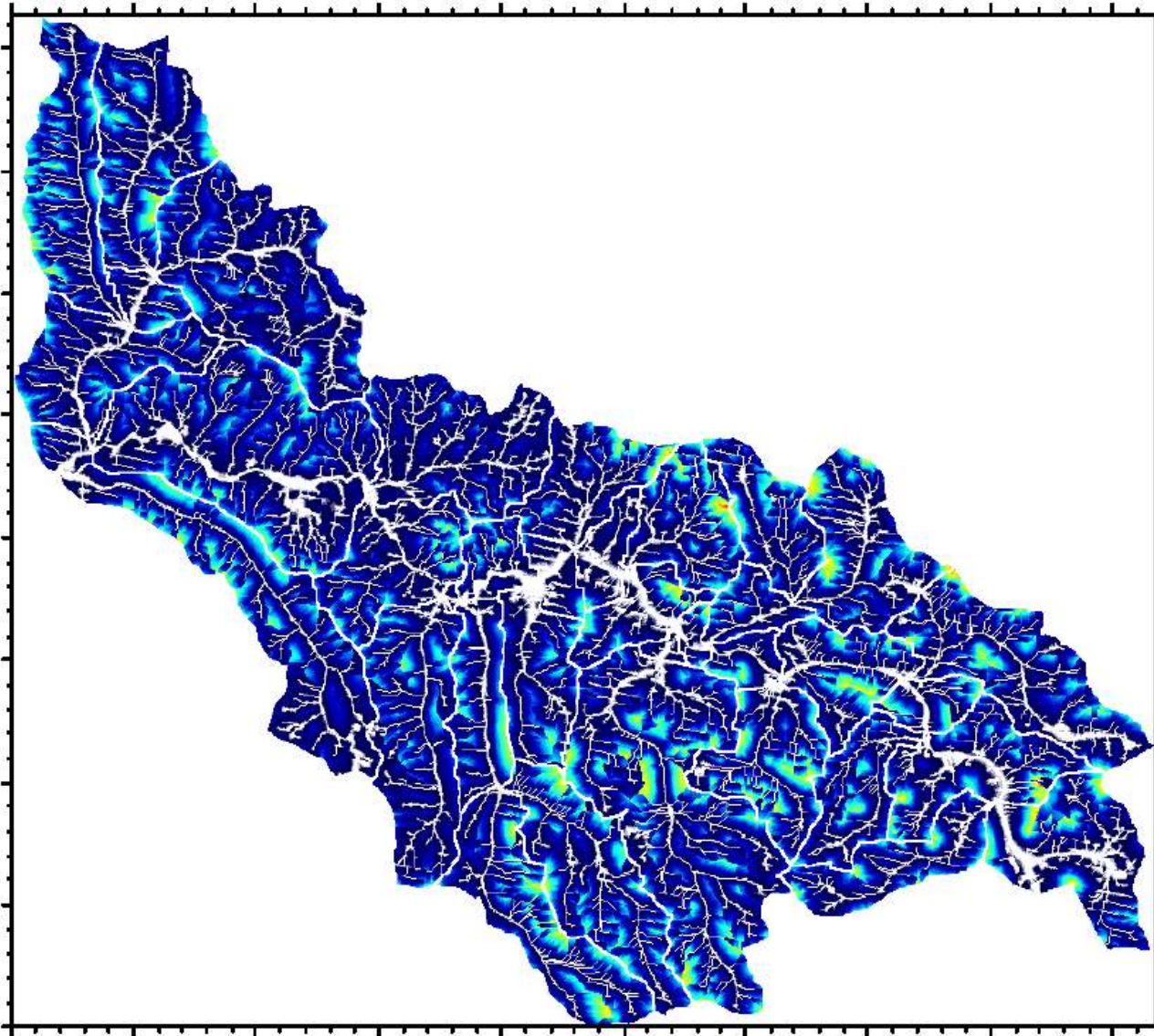
# Develop the GIS (Geographical Information System) for the watershed based upon existing databases and build model parameters



### Elevation (m)

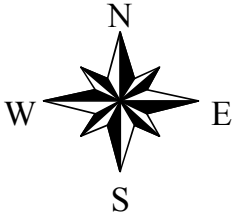
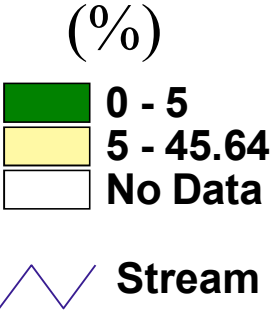
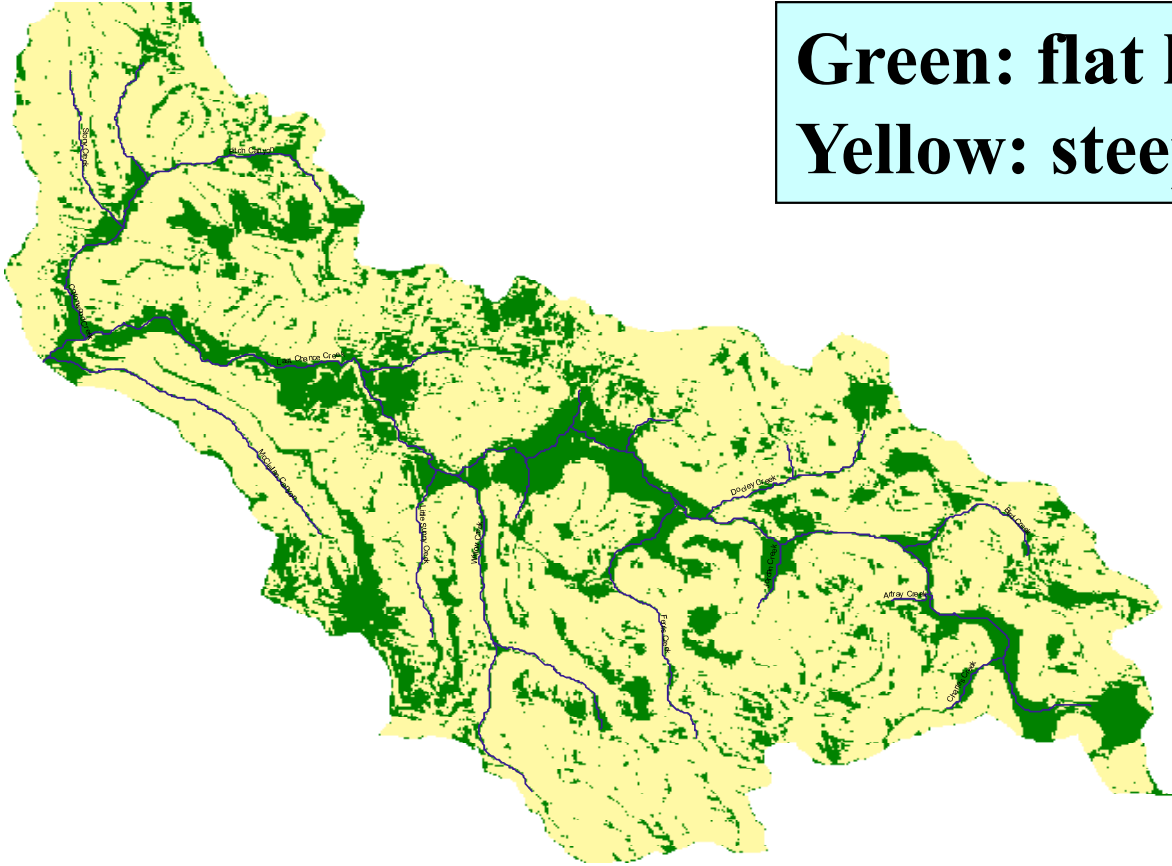


# Stream network at Last Chance Creek watershed

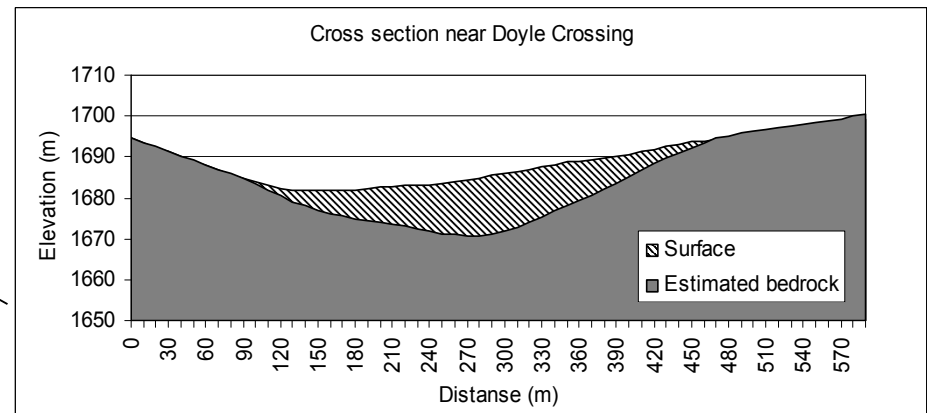
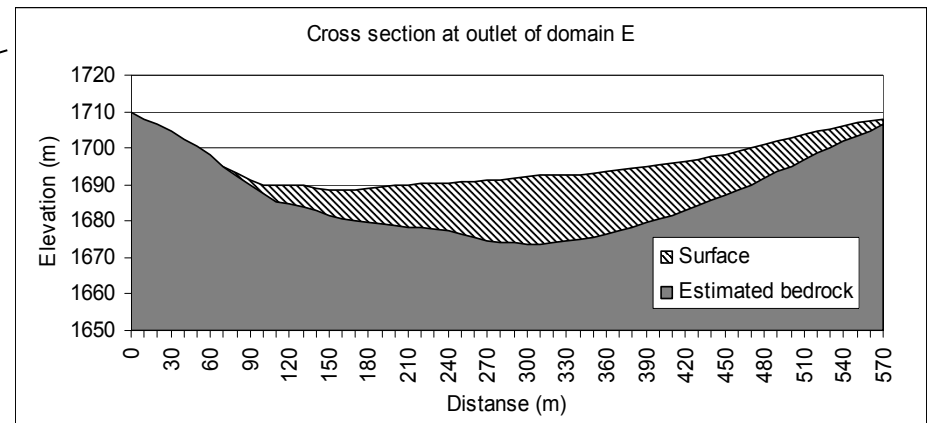
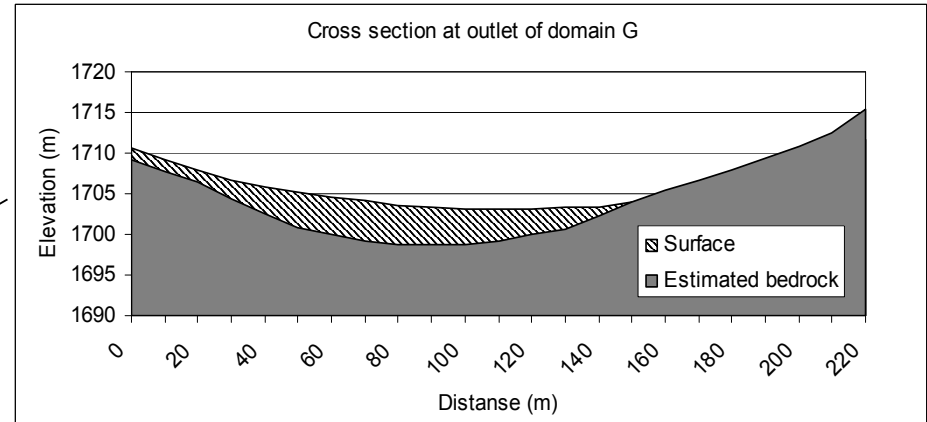
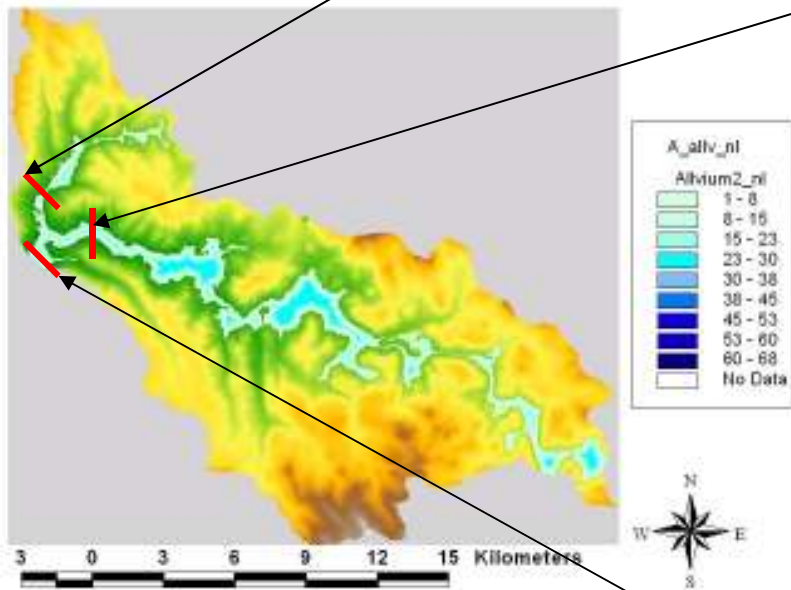


# Slope map and delineation of meadow land

**Green: flat land**  
**Yellow: steep land**



# Groundwater Flow Domain



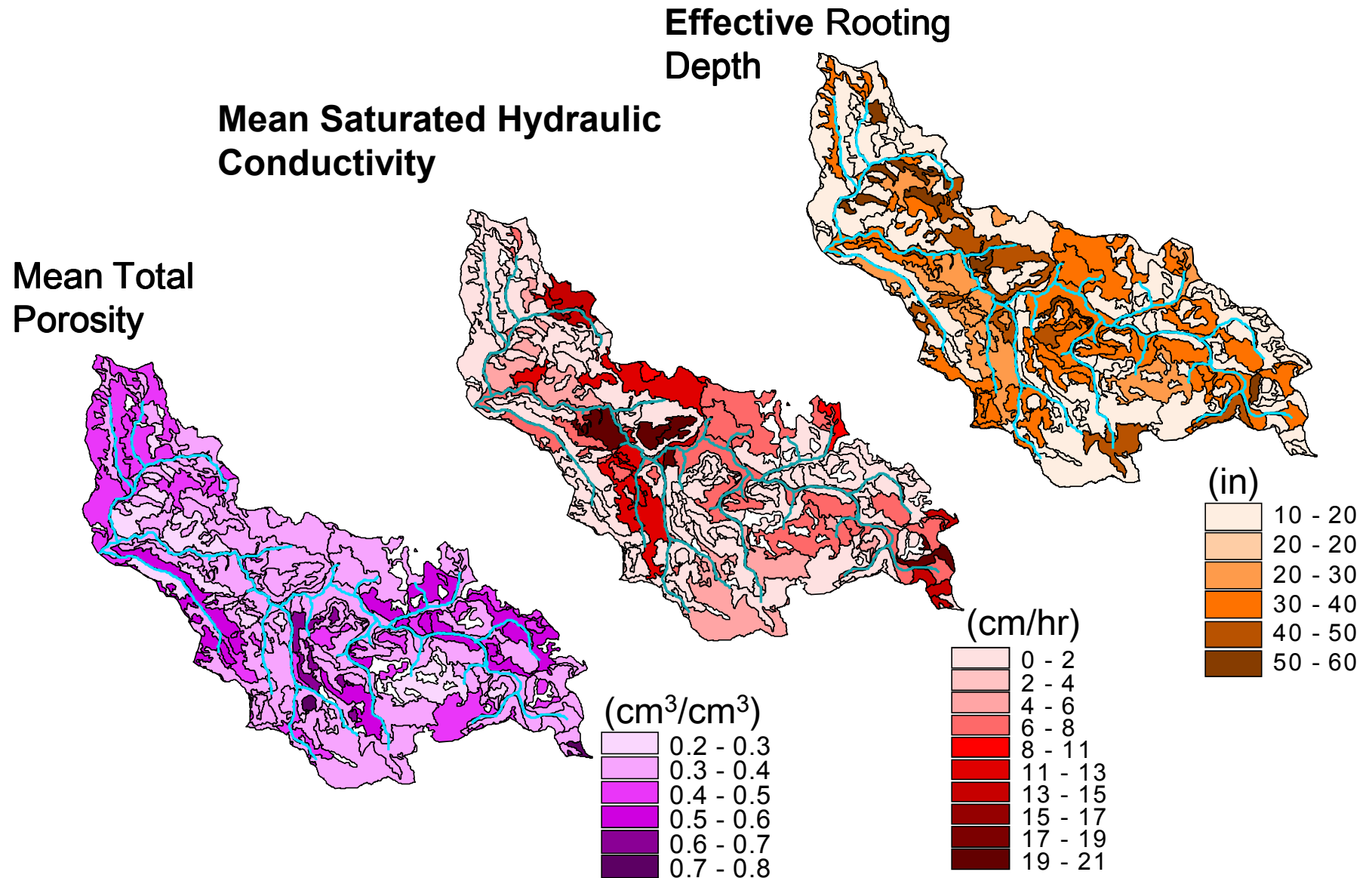
# Soil database (USFS soil survey)



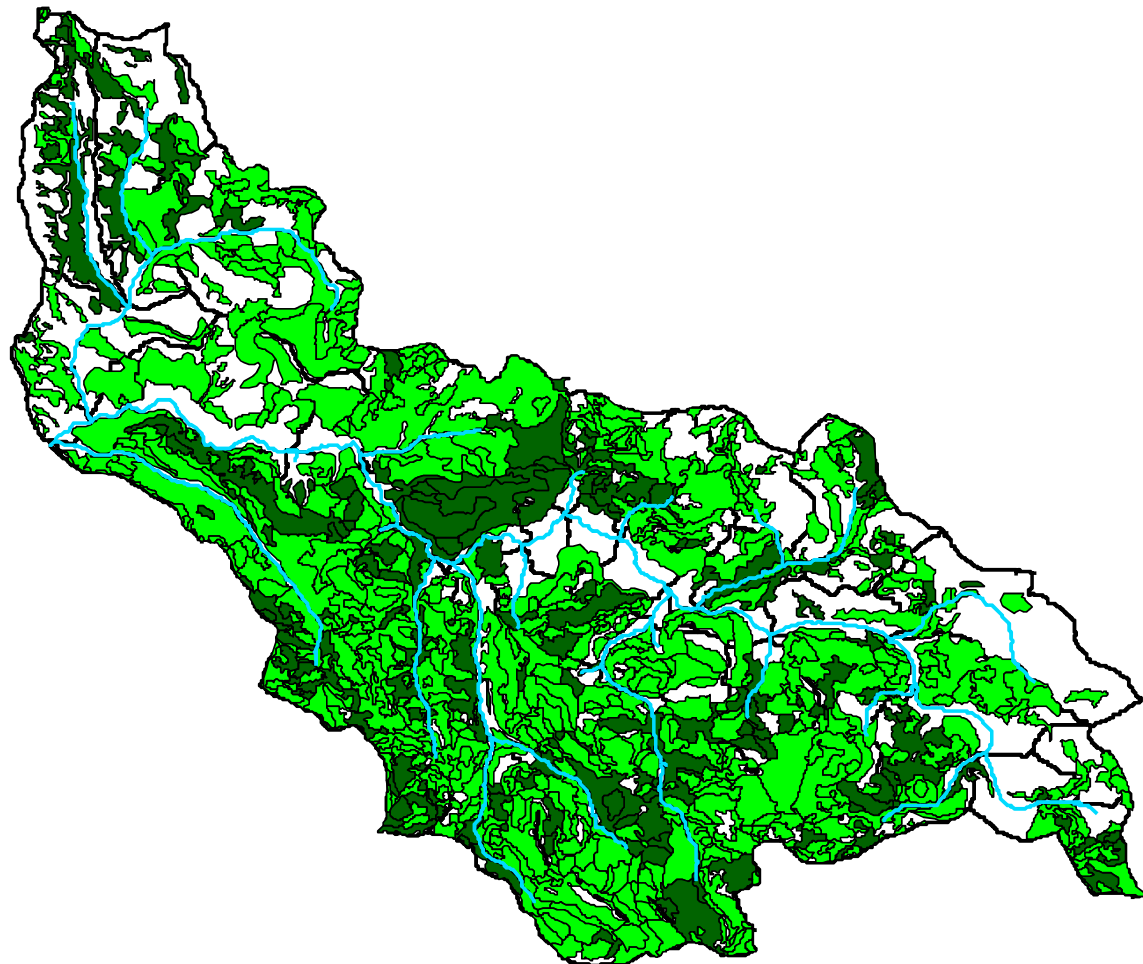
Soil map unit

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# Estimated soil parameters for WEHY model over Last Chance Creek watershed (selected)



# Vegetation Map (USFS)

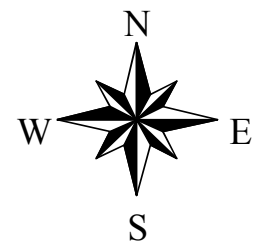


Number of  
Vegetation Layers

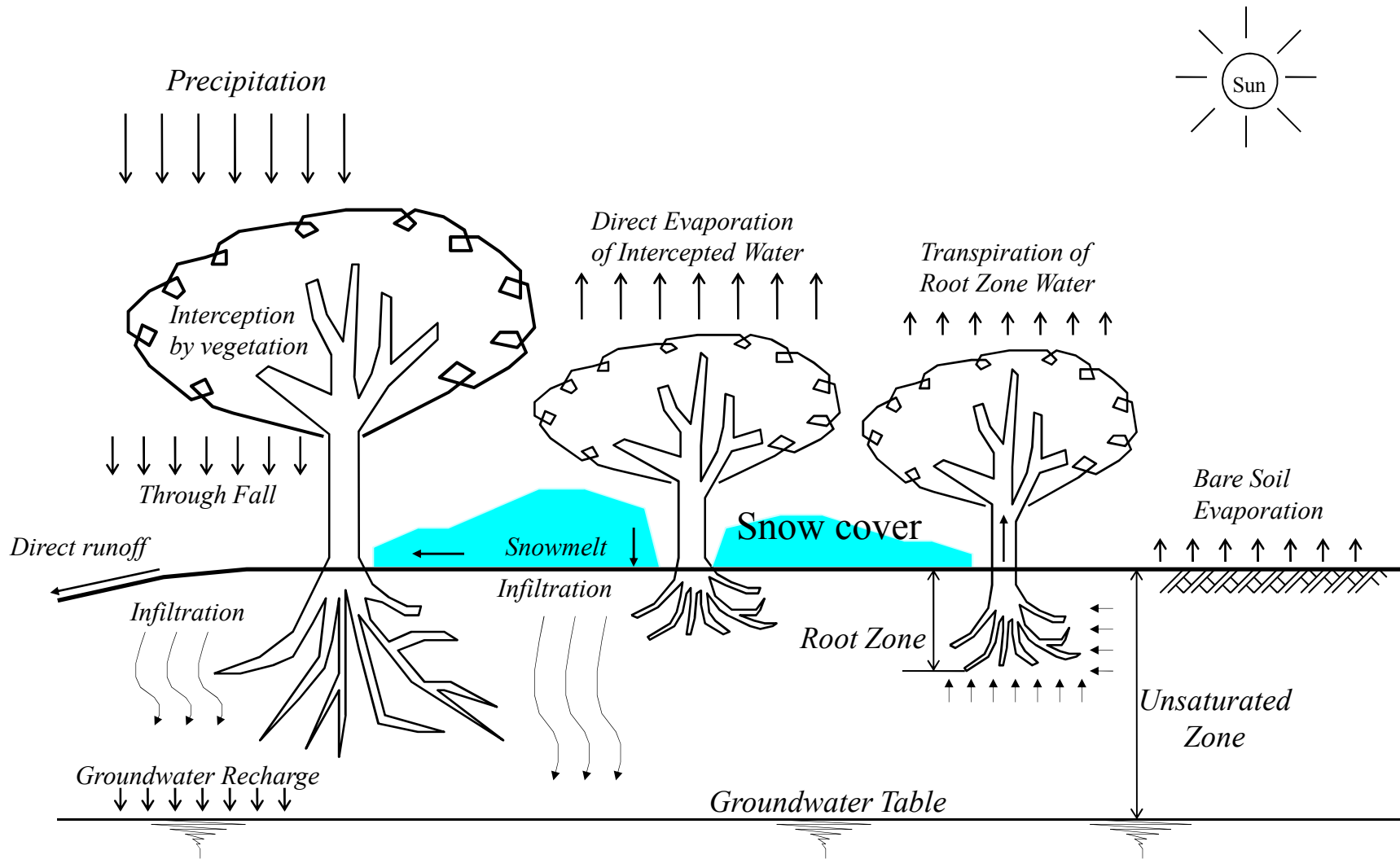
-  **1: Grass & shrub**
-  **2: Forest**

 Stream

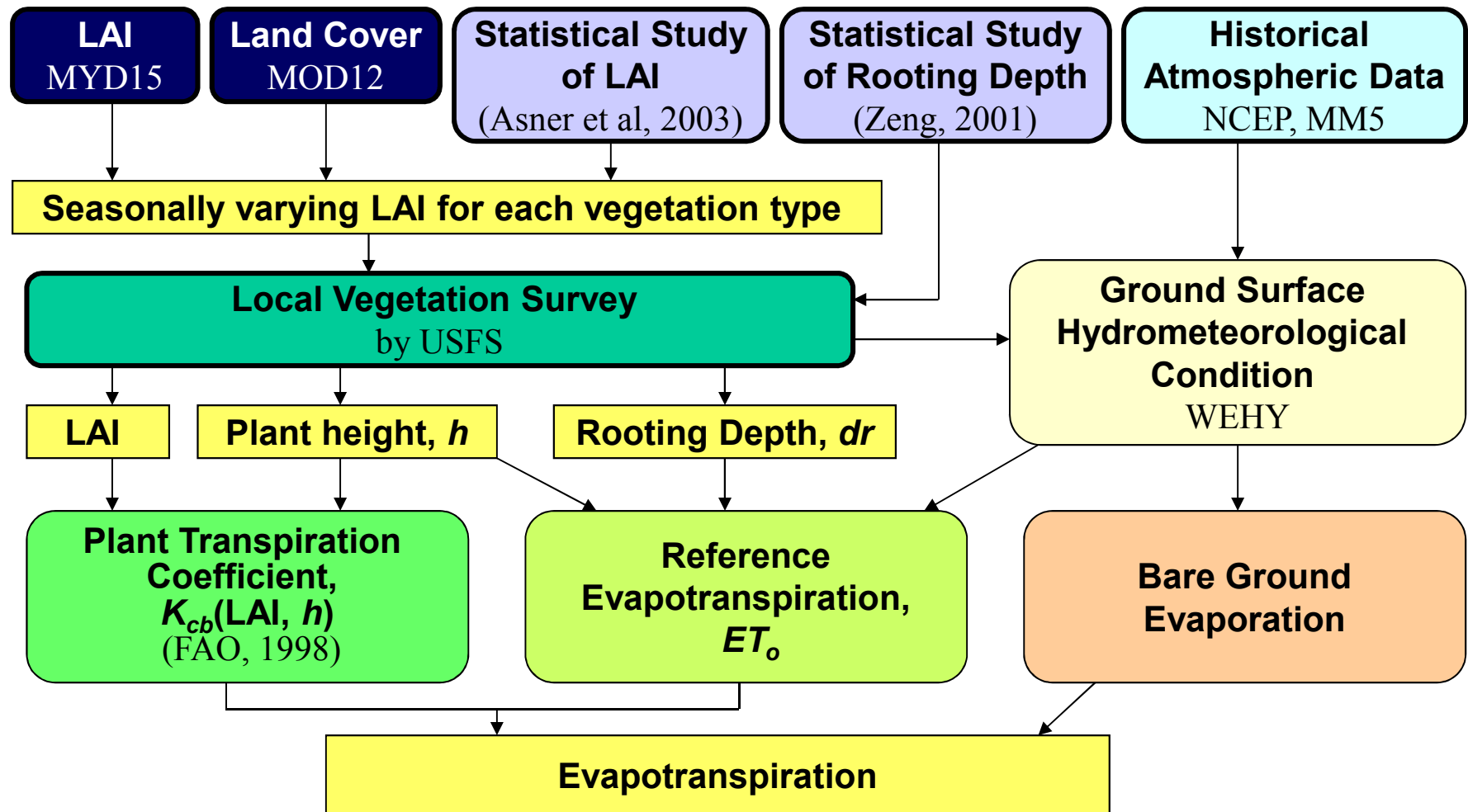
7 0 7 14 Kilometers



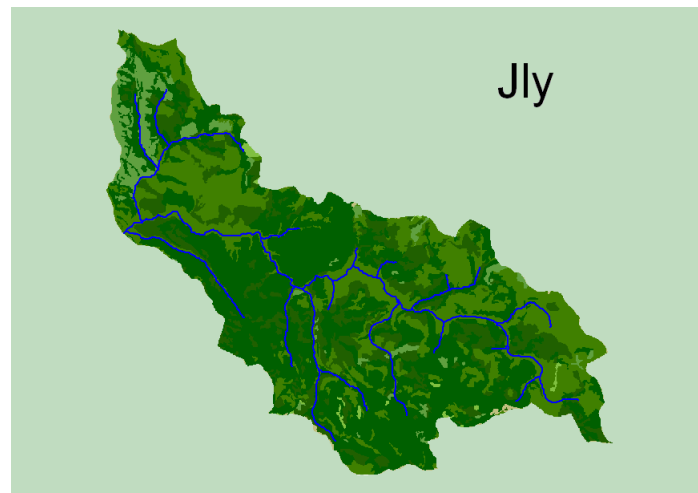
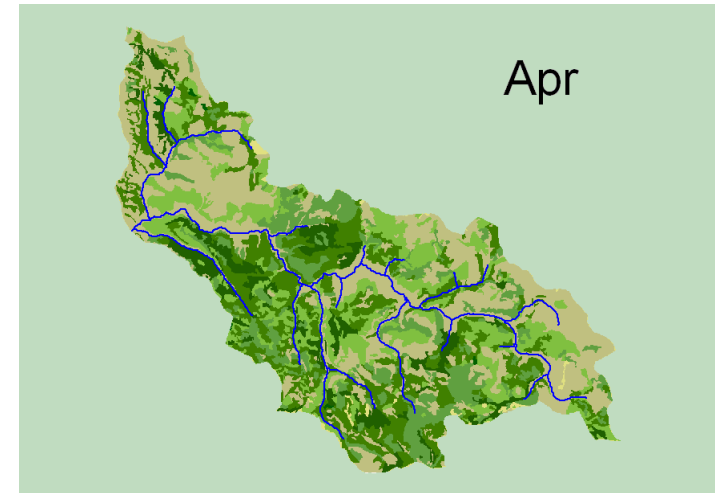




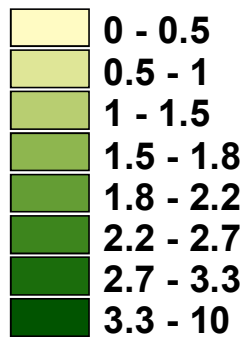
# Methodology for evapotranspiration with natural vegetation



# Estimated monthly LAI based on local vegetation survey and MODIS data

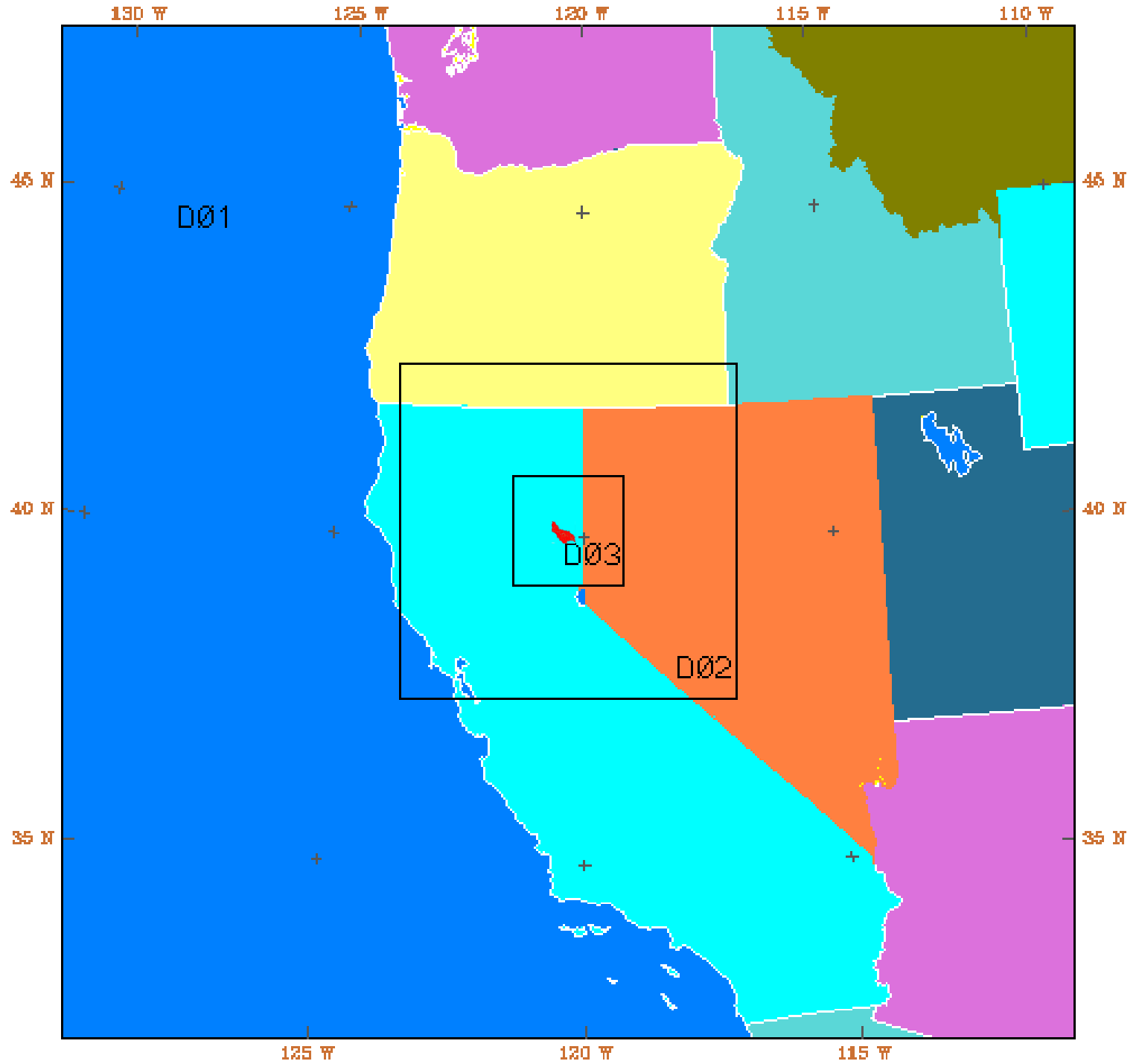


## Leaf Area Index



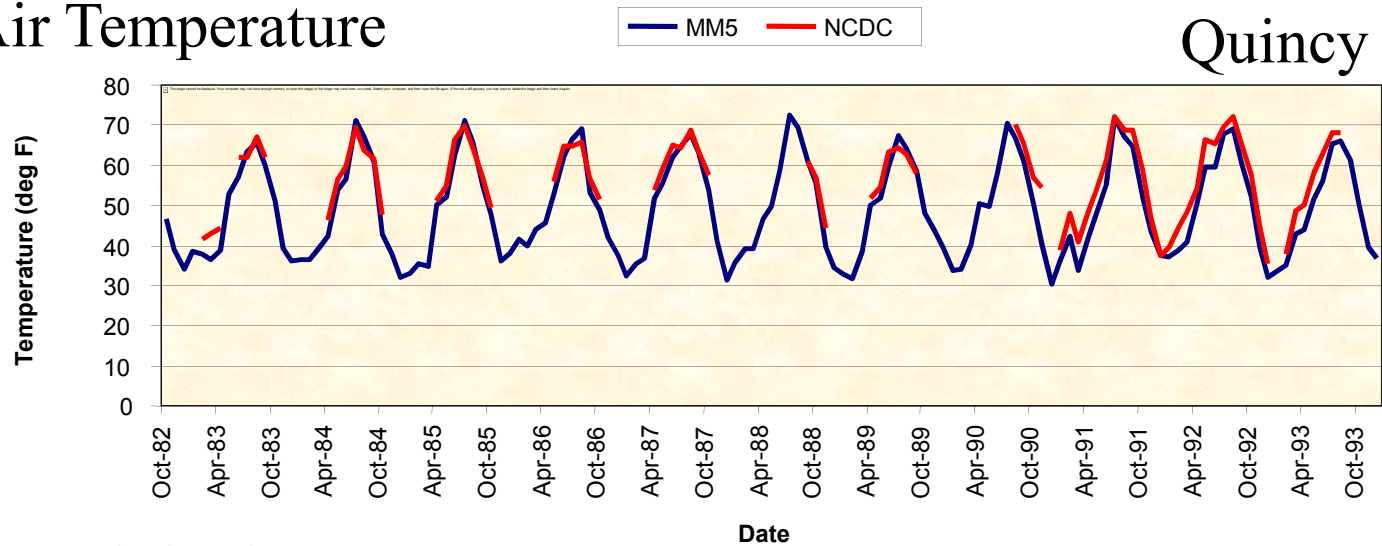
RECONSTRUCTION OF HISTORICAL ATMOSPHERIC DATA  
OVER THE WATERSHED AT 9 KM RESOLUTION  
BY  
DOWNSCALING FROM COARSE RESOLUTION (~280KM)  
GLOBAL DATASETS

MM5  
Domain  
Nesting  
for  
Last  
Chance  
Creek  
Watershed  
Model

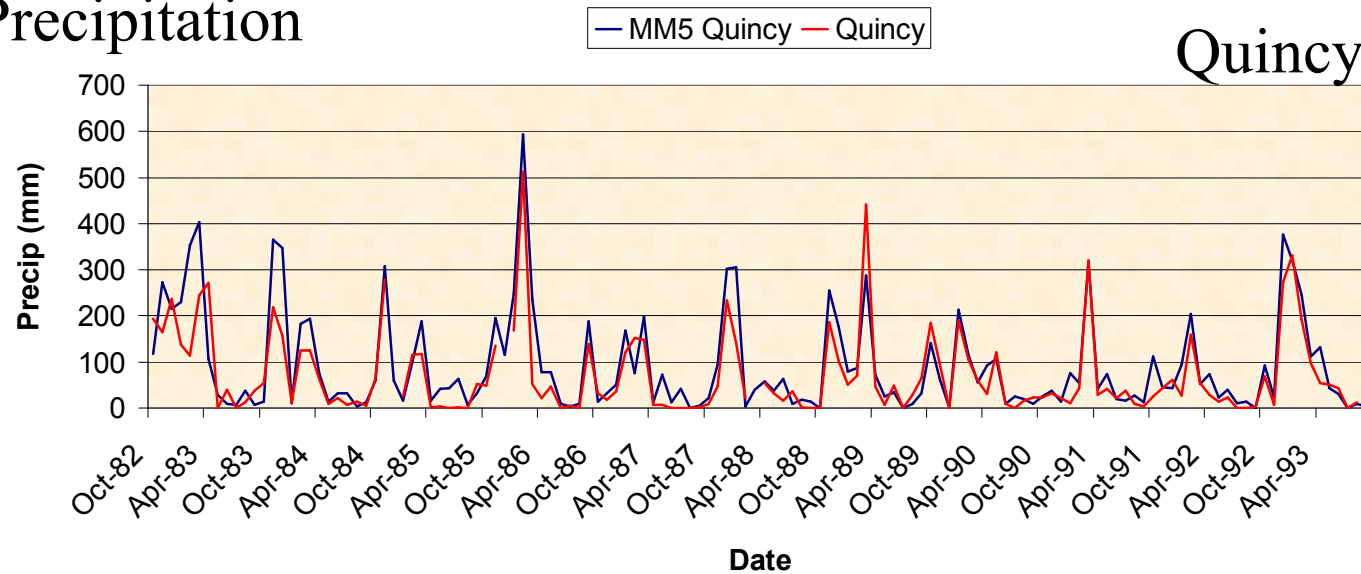


# Reconstructing distributed atmospheric data for validation and for critical hydrologic periods

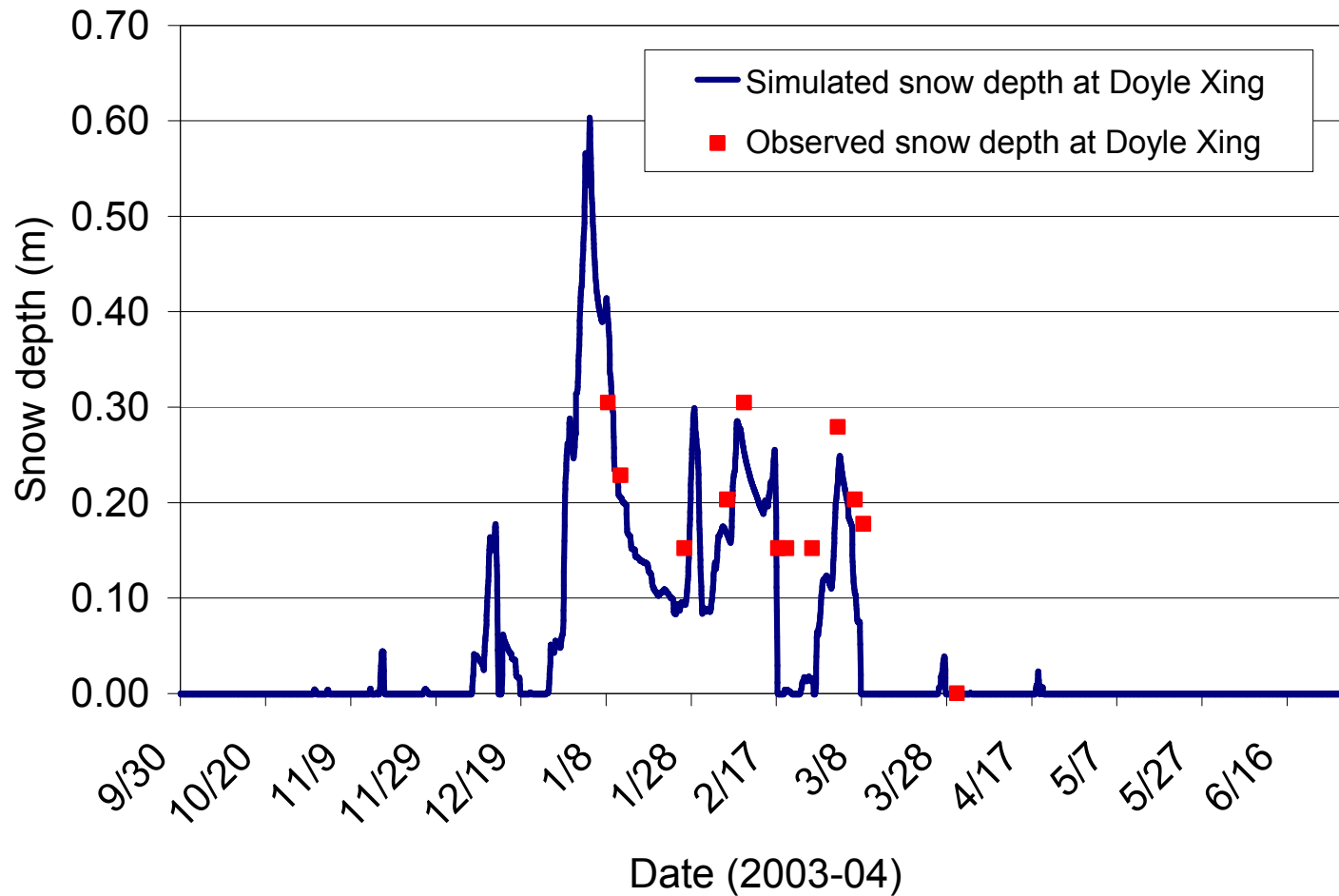
## Air Temperature



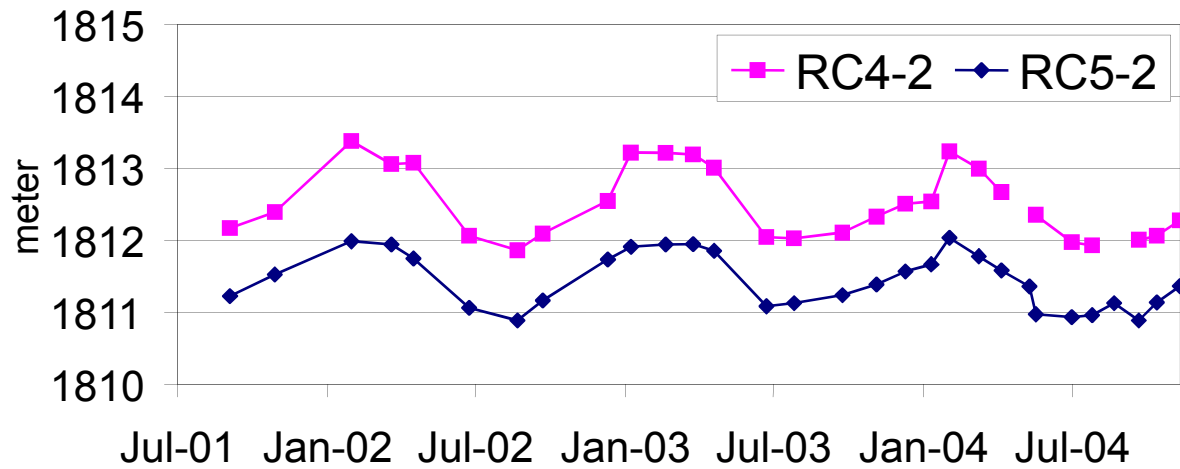
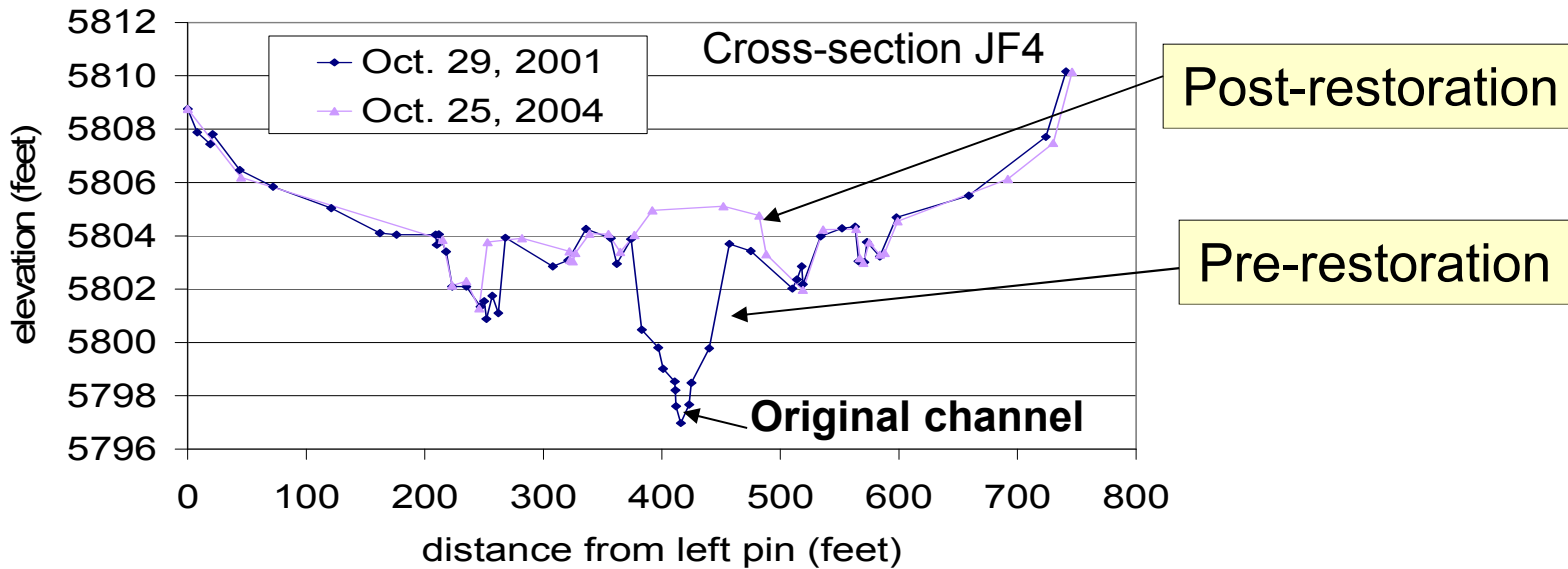
## Precipitation



# Snow module to simulate accumulation and melt processes of snow

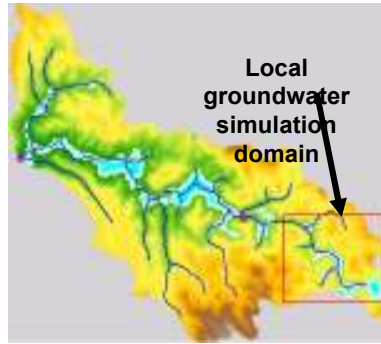


# Monitored Data Collected for Model Validation

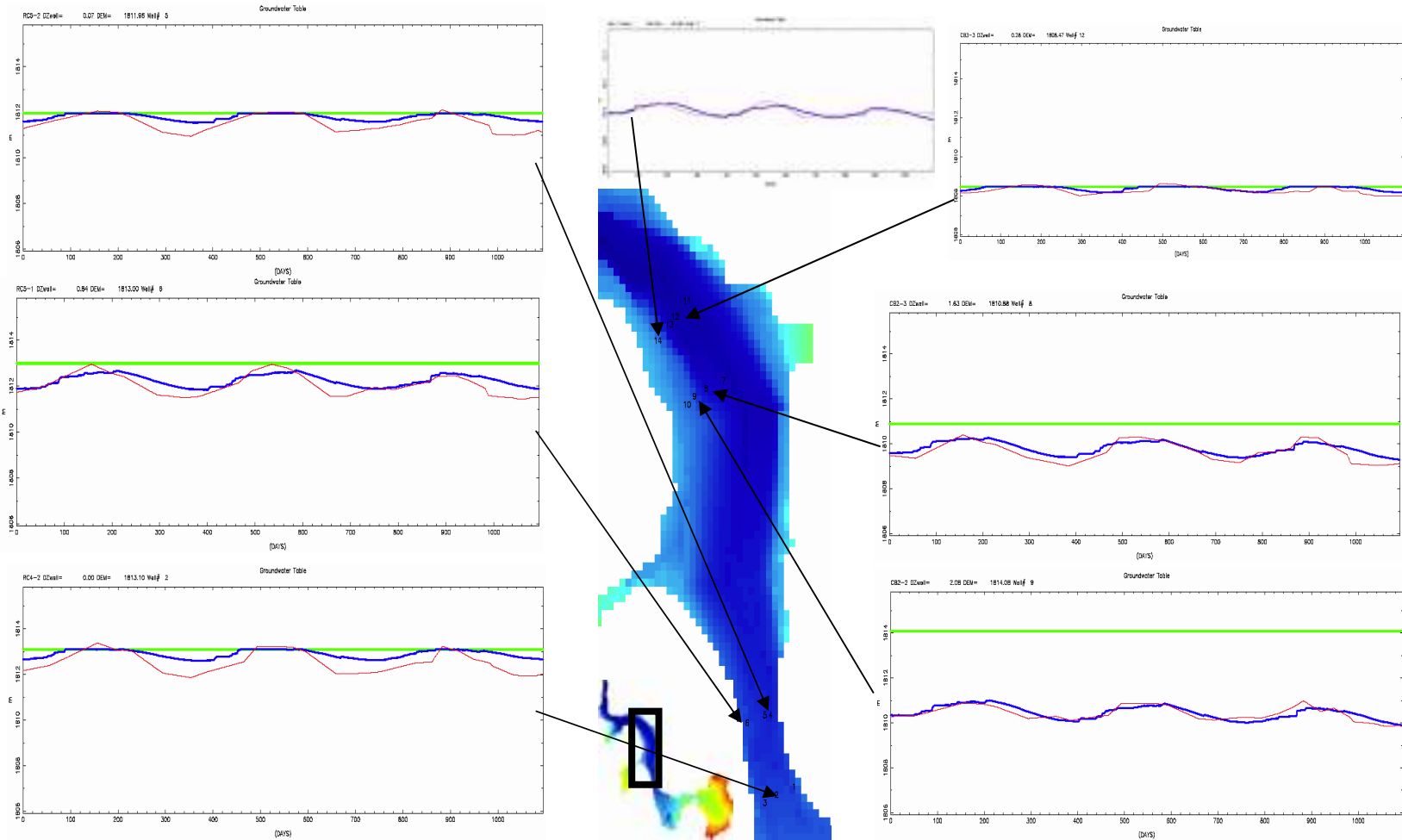




# Local Groundwater Simulation at Rowland-Charles Reach (Oct 1, 2001 – Sep 30, 2004)



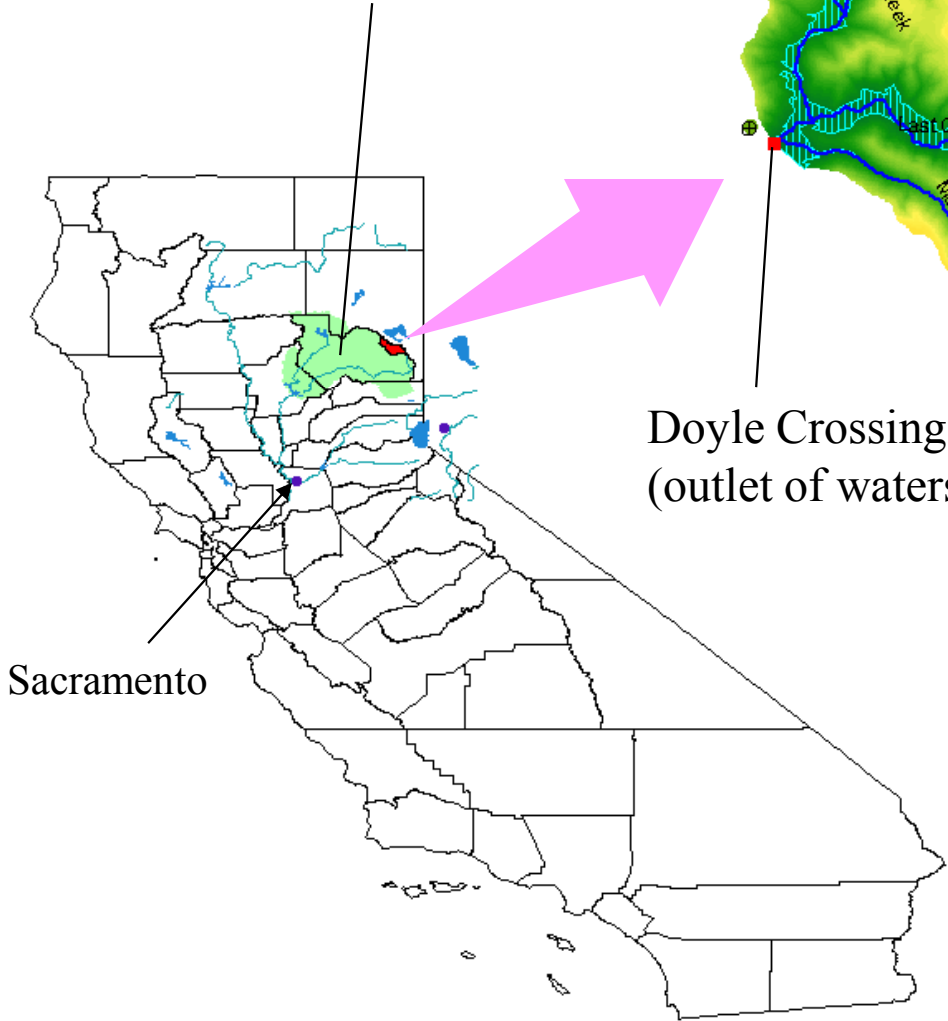
- Observed Groundwater Table
- Simulated Groundwater Table
- Ground Surface



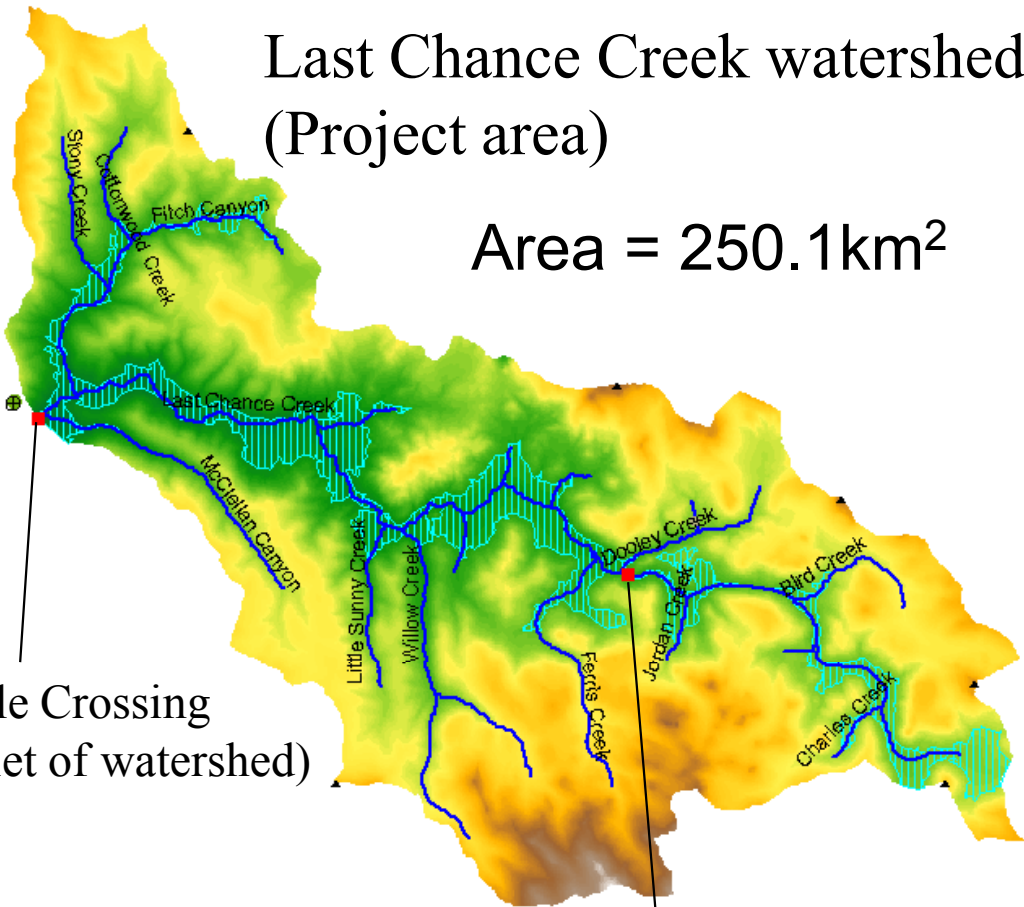
# Last Chance Creek watershed (Project area)

Area = 250.1km<sup>2</sup>

## Feather River Basin



Sacramento

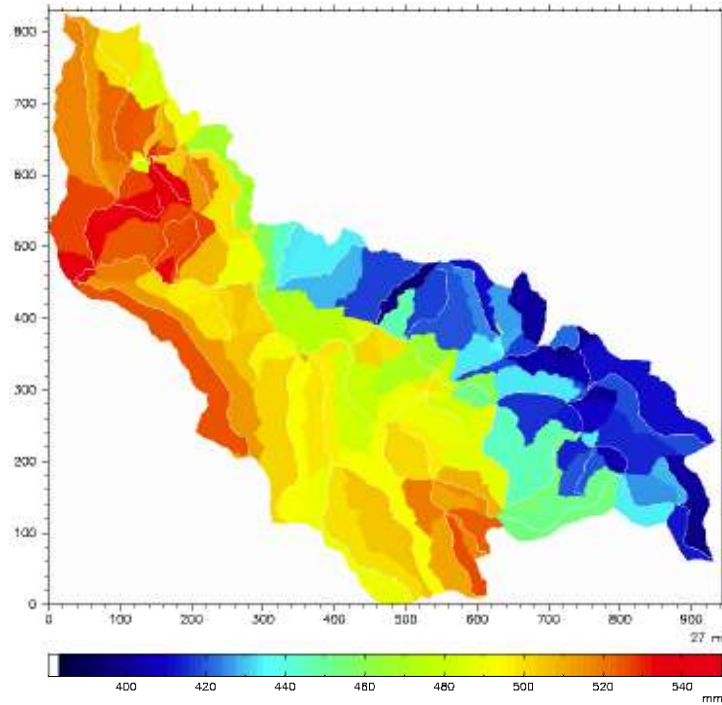


Doyle Crossing  
(outlet of watershed)

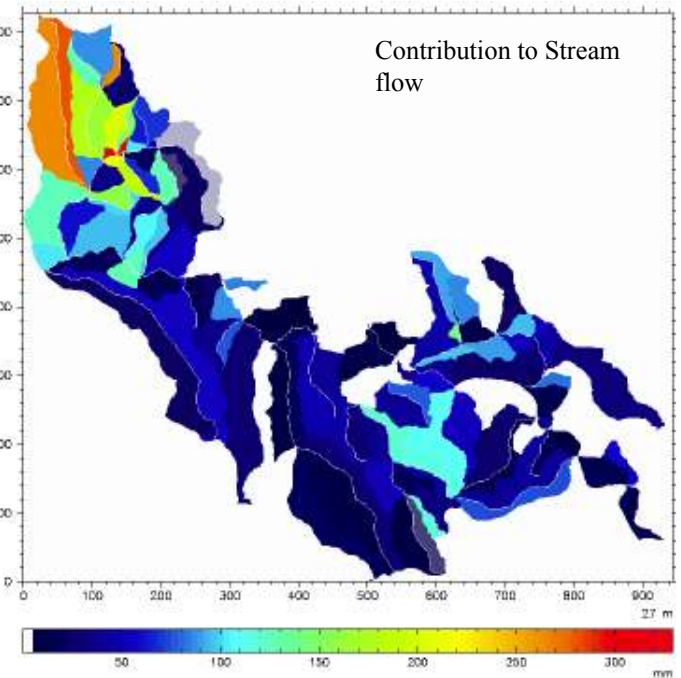
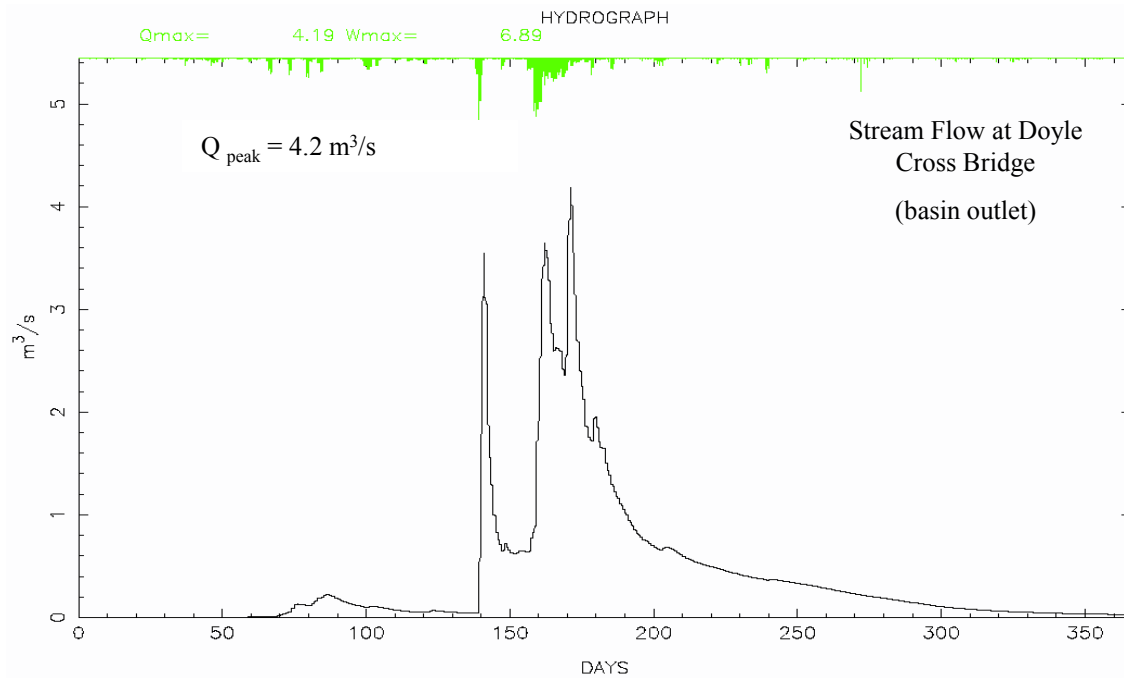
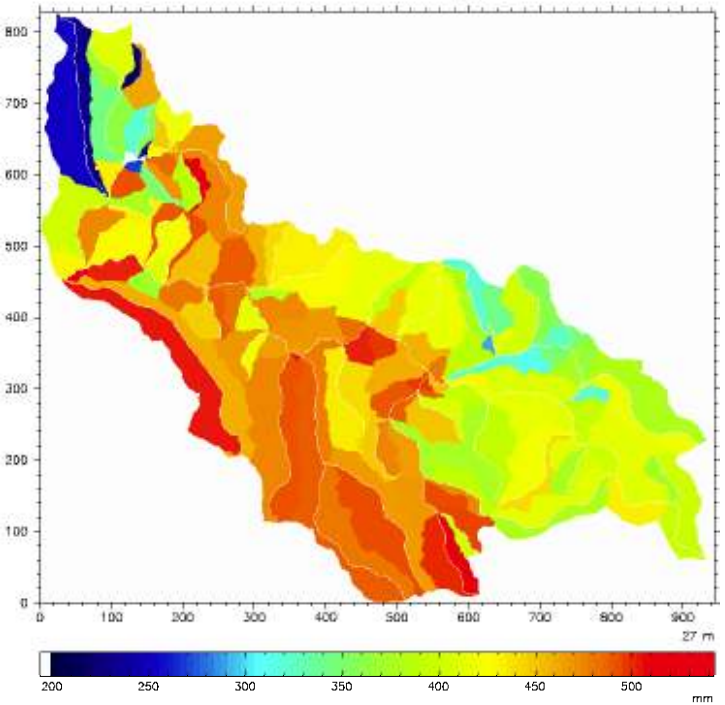
Million \$ Bridge

Simulated  
Hydrological  
Conditions  
Water Year  
10/2003-9/2004

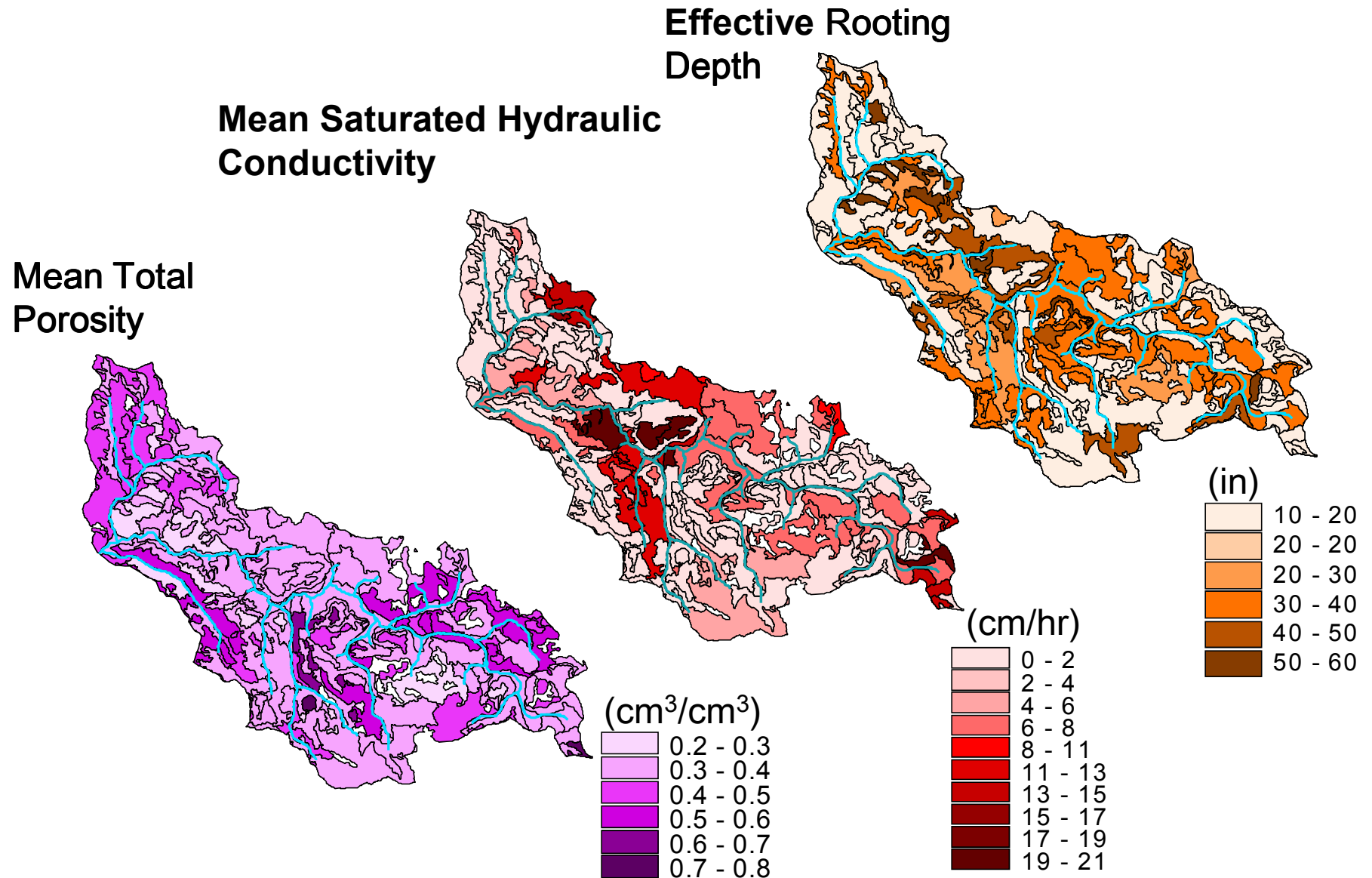
Annual Rain+Snowmelt



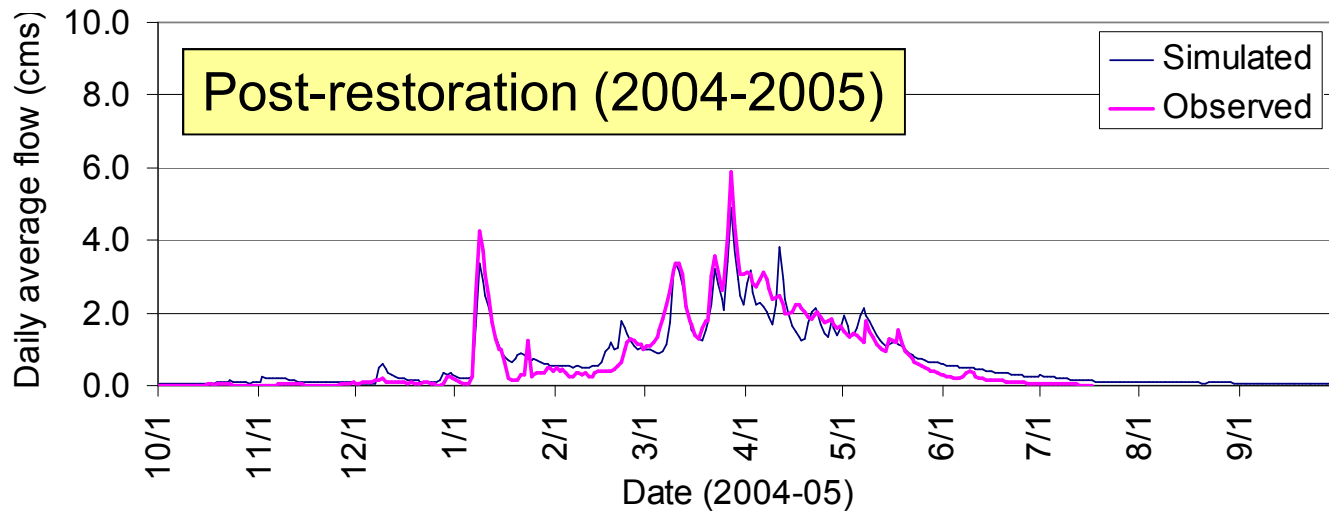
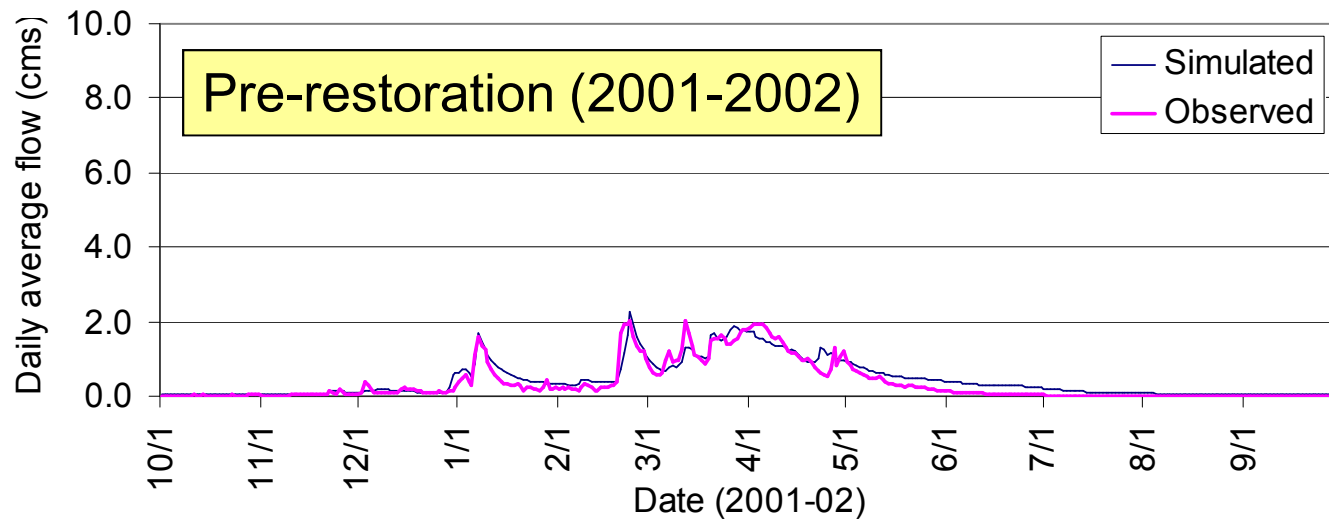
Annual ET from Soil and Vegetation



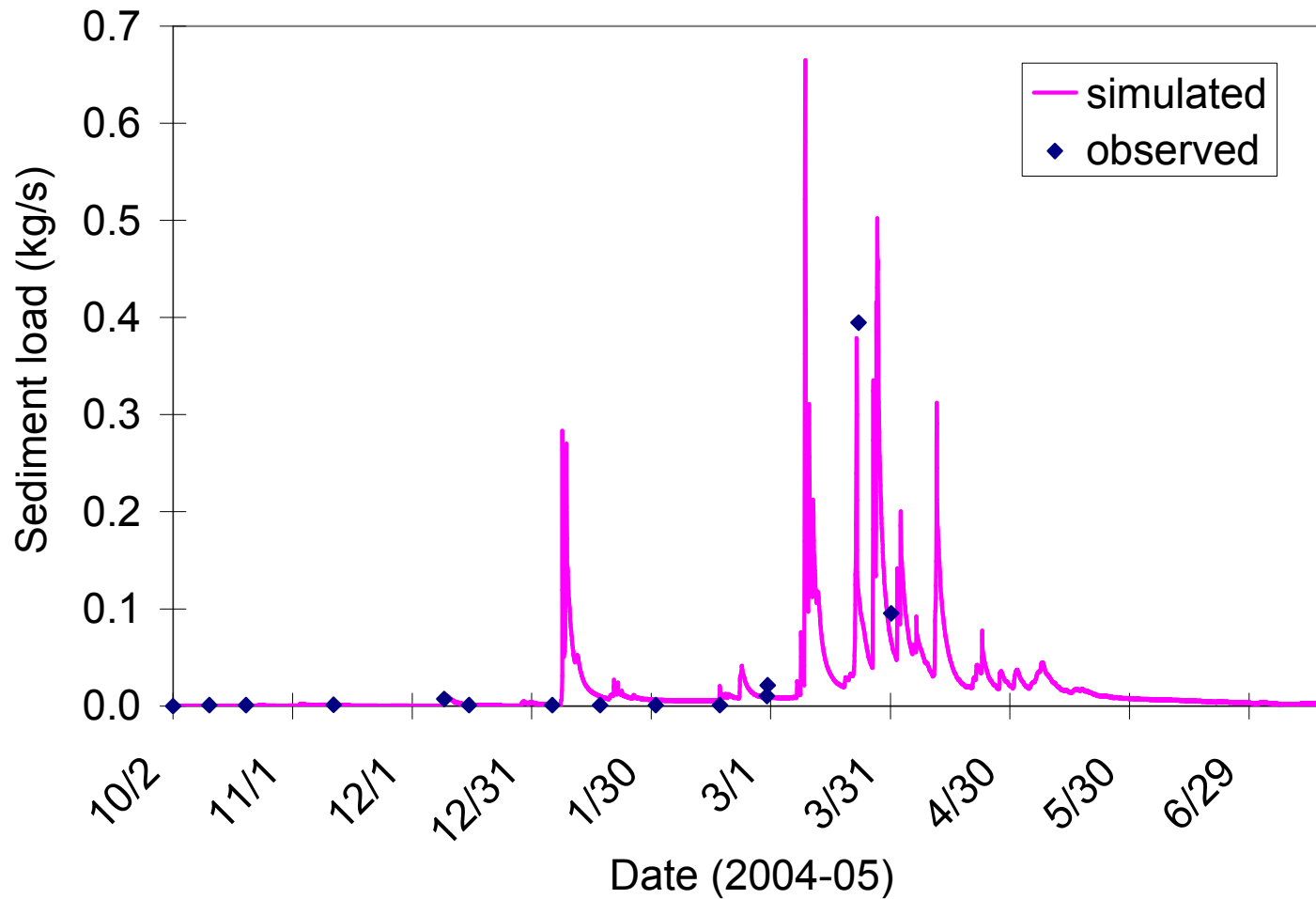
# Estimated soil parameters for WEHY model over Last Chance Creek watershed (selected)



# Comparison of model simulated and observed runoff at Doyle Crossing for Pre-restoration condition (Oct. 2001 - Sep.2002) and Post-restoration condition (Oct. 2004 - Sep.2005)



# Comparison of model simulated and observed sediment load at Doyle Crossing for post-restoration condition (Oct. 2004 - Sep. 2005)



ASSESSMENT OF RESTORATION ACTIVITIES  
IN  
LAST CHANCE CREEK WATERSHED

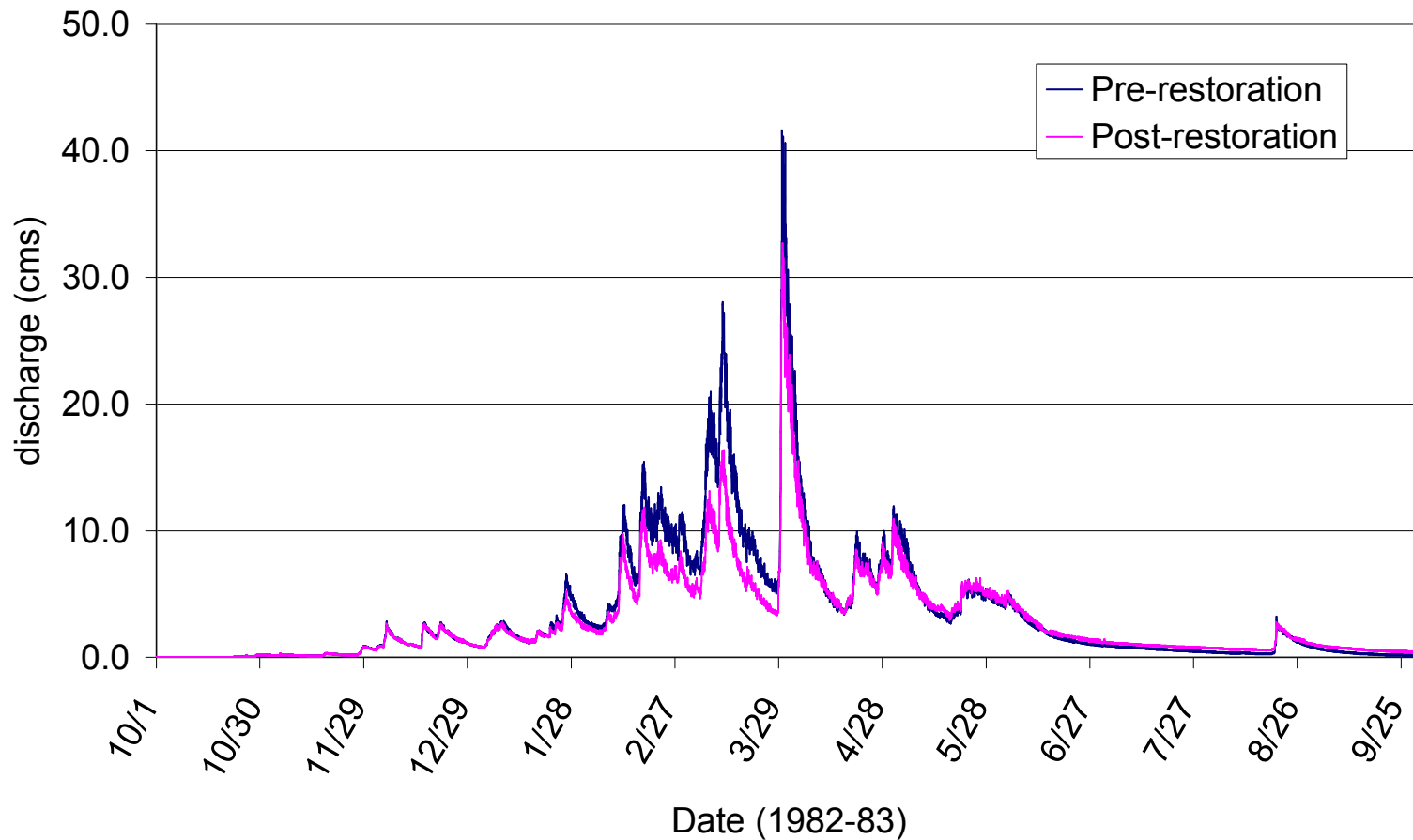
FOR TWO SCENARIOS:

- 1) PRE-RESTORATION CONDITION;
- 2) POST-RESTORATION CONDITION,

under the same atmospheric inputs  
corresponding to wet water year  
(Oct. 1982- Sep. 1983)

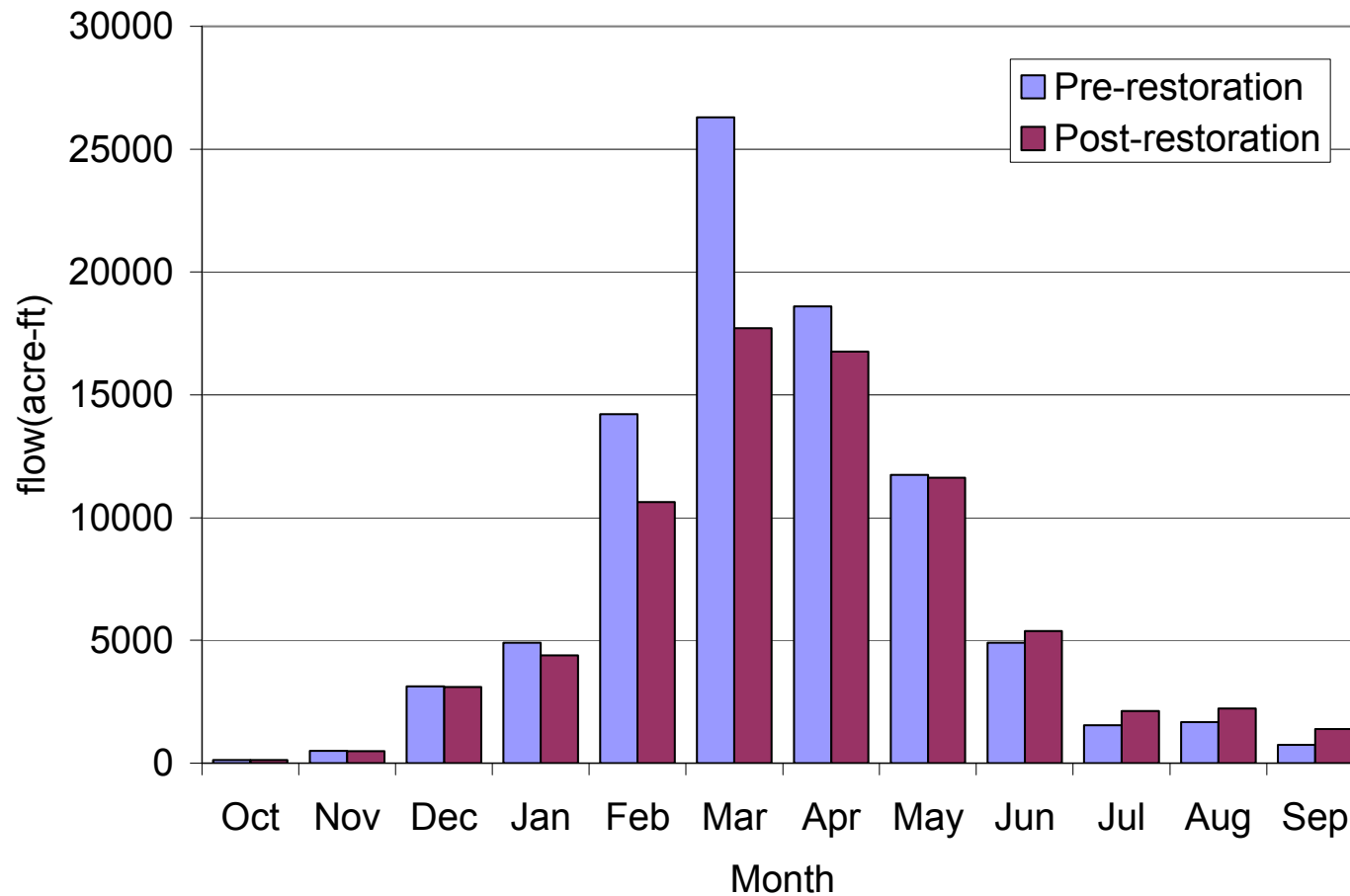
ARE  
SIMULATED AND COMPARED.

# Comparison of flow discharge at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)





# Comparison of monthly flow at Doyle Crossing between pre-restoration and post-restoration conditions (Oct. 1982 - Sep. 1983)

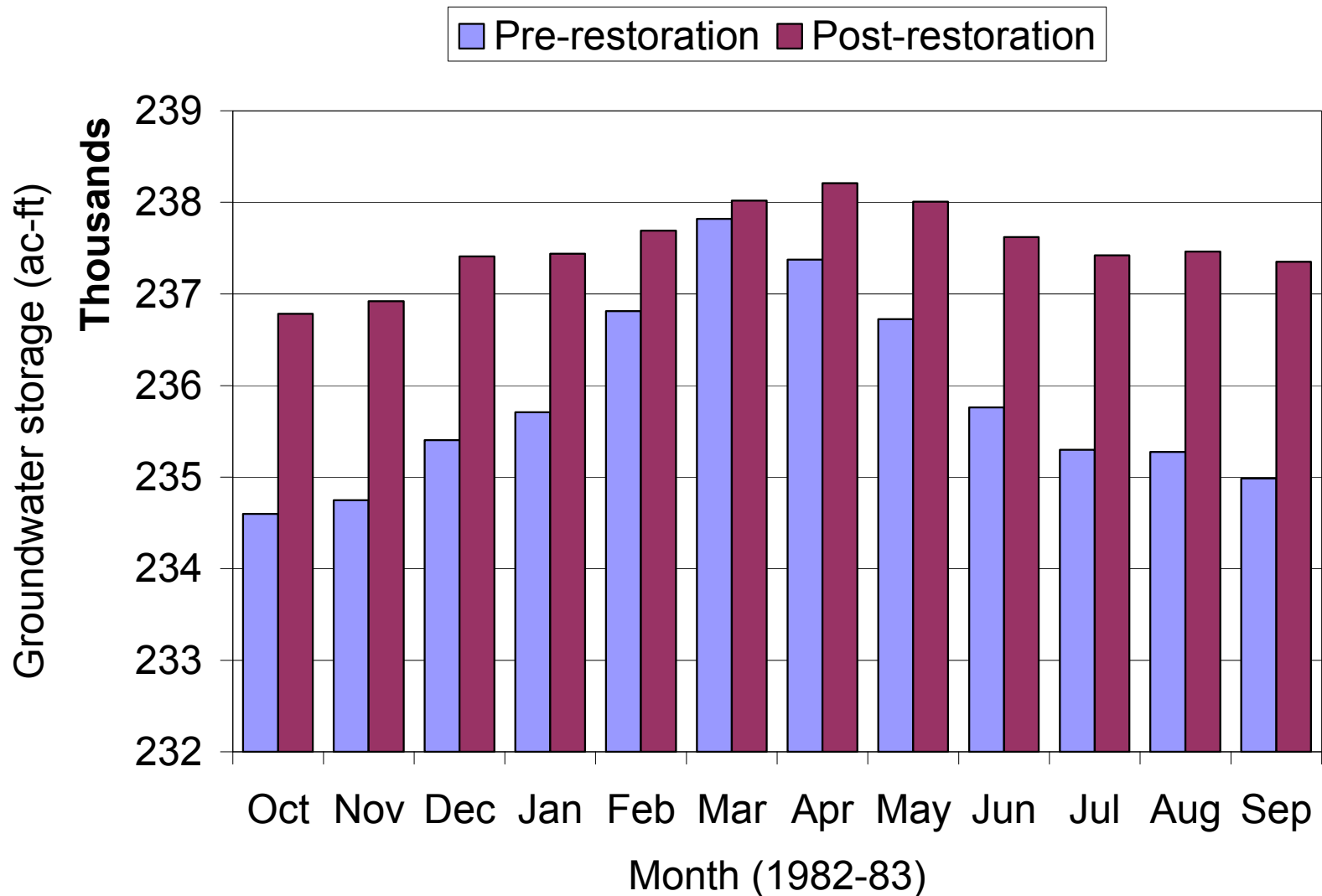


**Assessment of restoration activities:  
Monthly Flow at the Doyle Crossing (Oct.1982-Sep.1983)**

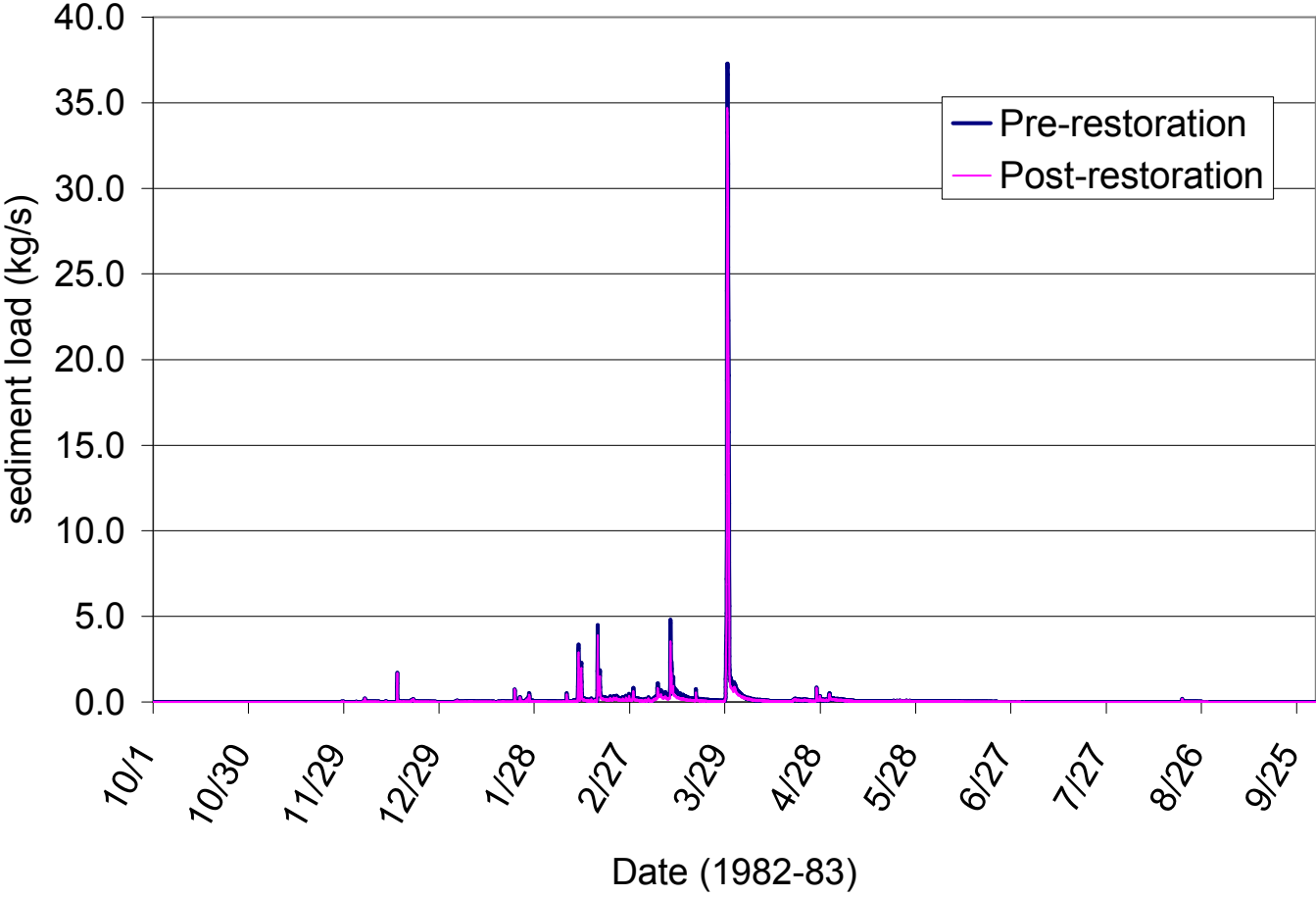
	Pre-restoration (acre-ft)	Post-restoration (acre-ft)	absolute diff (acre-ft)	relative diff (%)
Oct	132	132	0	0.00
Nov	505	499	-5	-1.06
Dec	3133	3109	-24	-0.77
Jan	4916	4388	-528	-10.74
Feb	14204	10631	-3574	-25.16
Mar	26302	17709	-8594	-32.67
Apr	18600	16762	-1838	-9.88
May	11744	11628	-116	-0.99
Jun	4898	5386	488	9.97
Jul	1545	2129	584	37.82
Aug	1680	2222	542	32.28
Sep	749	1393	643	85.84
Annual	88408	75988	-12420	-14.05

**32.7% reduction** of flow in March (wet month) may be expected, and **85.8% increase** of flow in September (dry month) may be expected because of the restoration.

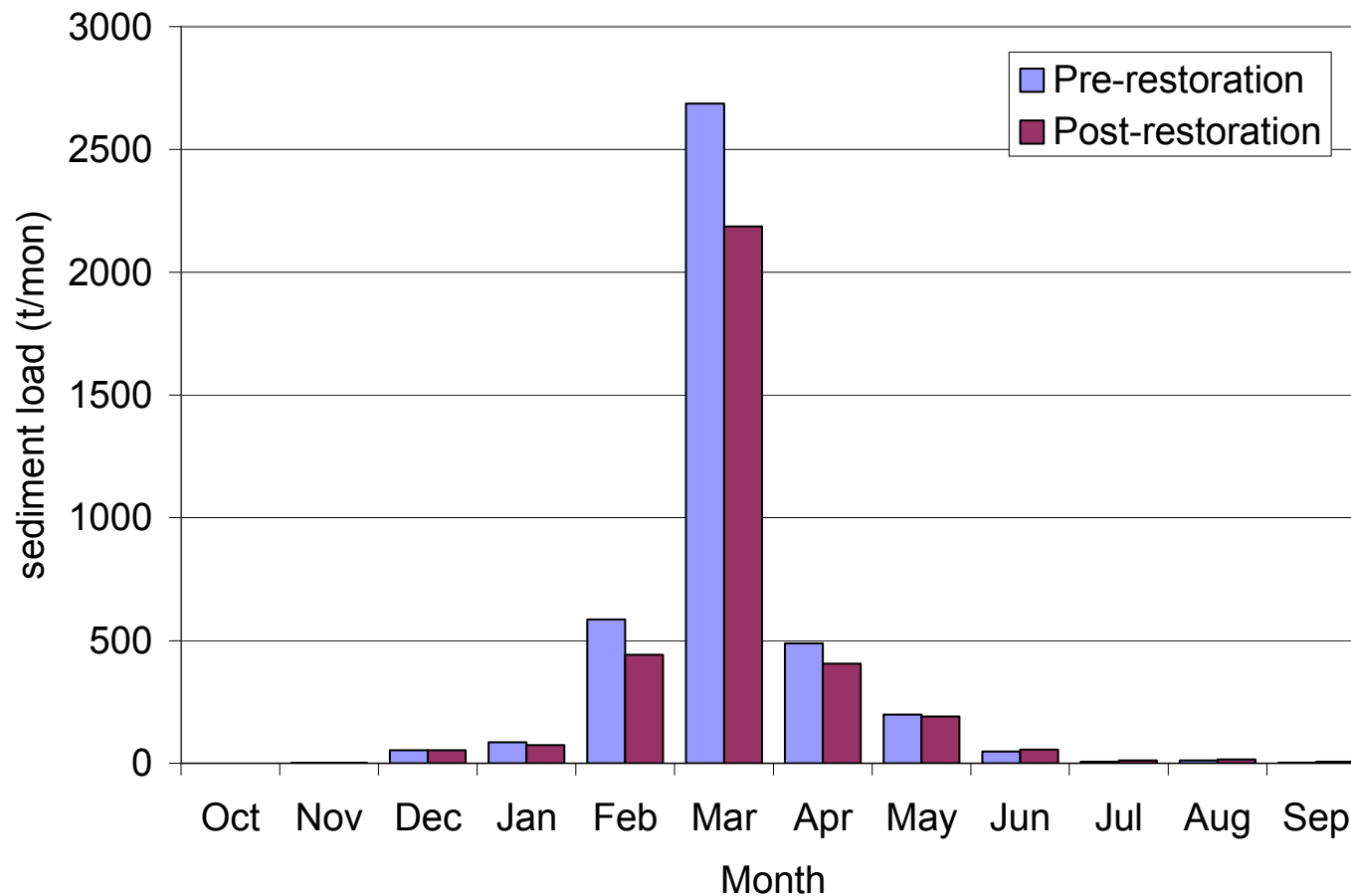
# Comparison of monthly mean groundwater storage between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)



# Comparison of sediment load at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983 )



# Comparison of monthly sediment load at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)



**Assessment of restoration activities:  
Monthly Sediment load at the Doyle Crossing (Oct.82-Sep.83)**

	Pre-restoration (t)	Post-restoration (t)	absolute diff (t)	relative diff (%)
Oct	0.2	0.2	0.0	-0.59
Nov	2.1	2.1	0.0	-2.02
Dec	53.7	53.0	-0.7	-1.37
Jan	85.6	73.2	-12.4	-14.45
Feb	585.3	442.0	-143.3	-24.49
Mar	2687.2	2186.4	-500.8	-18.64
Apr	489.1	406.2	-82.9	-16.94
May	199.5	191.1	-8.4	-4.19
Jun	48.9	55.6	6.7	13.62
Jul	7.2	11.4	4.3	59.24
Aug	11.8	15.3	3.5	29.74
Sep	2.7	6.2	3.5	133.46
<b>Annual</b>	<b>4173.3</b>	<b>3442.8</b>	<b>-730.5</b>	<b>-17.50</b>

**17.5% reduction** of annual sediment discharge may be expected because of the restoration.

# Conclusions

1. WEHY (Watershed Environmental Hydrology) Model has been applied to the Last Chance Creek Watershed for the Assessment of the Impact of Restoration Activities on the Water Supply/Flood Control/NPS Pollutant Discharge;
2. WEHY Model demonstrated that restoration activities in Last Chance Creek will store more water during wet periods (reducing flood discharge) while increasing base flows during dry periods; groundwater storage in the watershed will increase by the restoration activities;

3. WEHY Model also demonstrated that the undertaken restoration activities will reduce the sediment discharge from Last Chance Creek watershed.
4. WEHY Model can be applied to any watershed in California for the assessment of restoration activities.

**Acknowledgement:**

This study was funded by CALFED Watershed Program.