Hydrologic Methods

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Outline

- What is a watershed
- Hydrologic Cycle
- Hydrologic Modeling
- Components of Hydrologic Model
- Model Application

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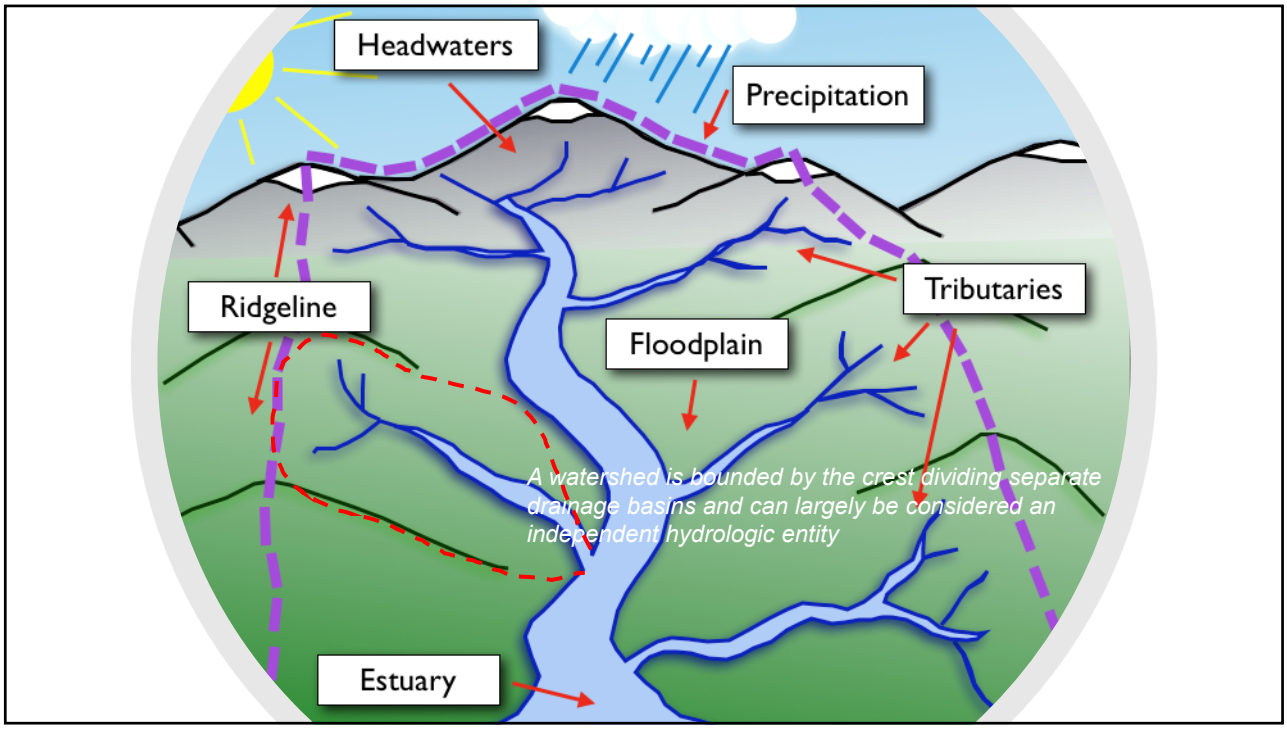
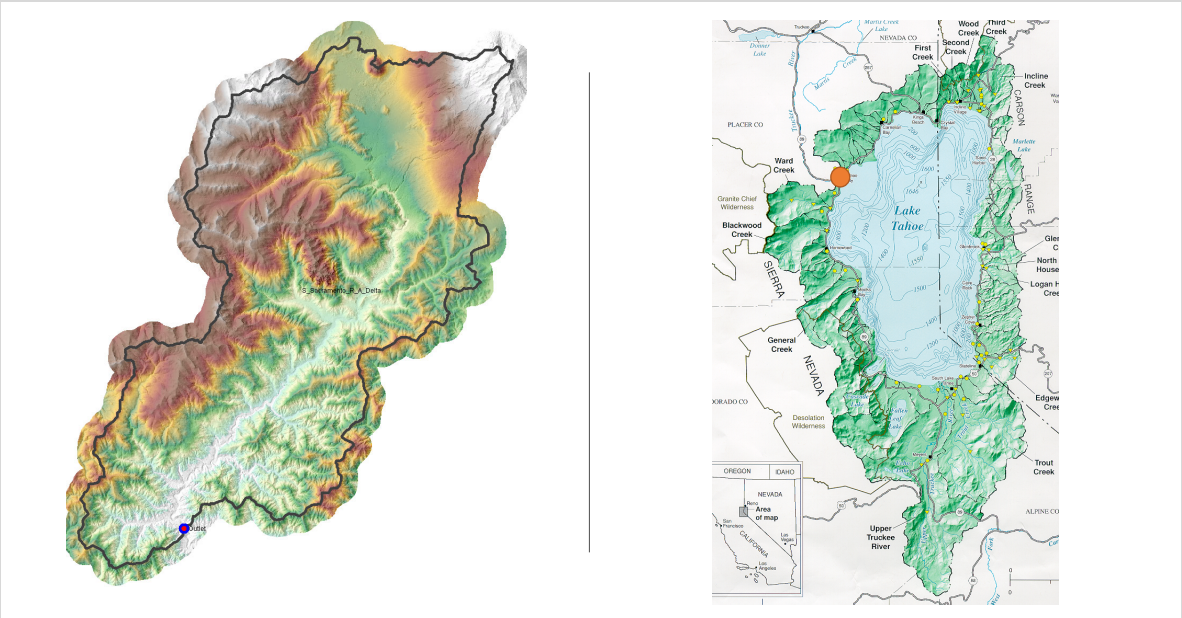

Headwaters
Precipitation
Ridgeline
Tributaries
Floodplain
A watershed is bounded by the crest dividing separate drainage basins and can largely be considered an independent hydrologic entity
Estuary

3


Lake Tahoe
SIERRA
NEVADA
RANGE
CARSON
Ward Creek
Blackwood Creek
General Creek
Incline Creek
Trout Creek
Upper Truckee River
Wood Creek
First Creek
Second Creek
Third Creek
PLACER CO
NEVADA CO
Granite Chief Wilderness
Desolation Wilderness
OREGON
IDAHO
NEVADA
CALIFORNIA
Area of map

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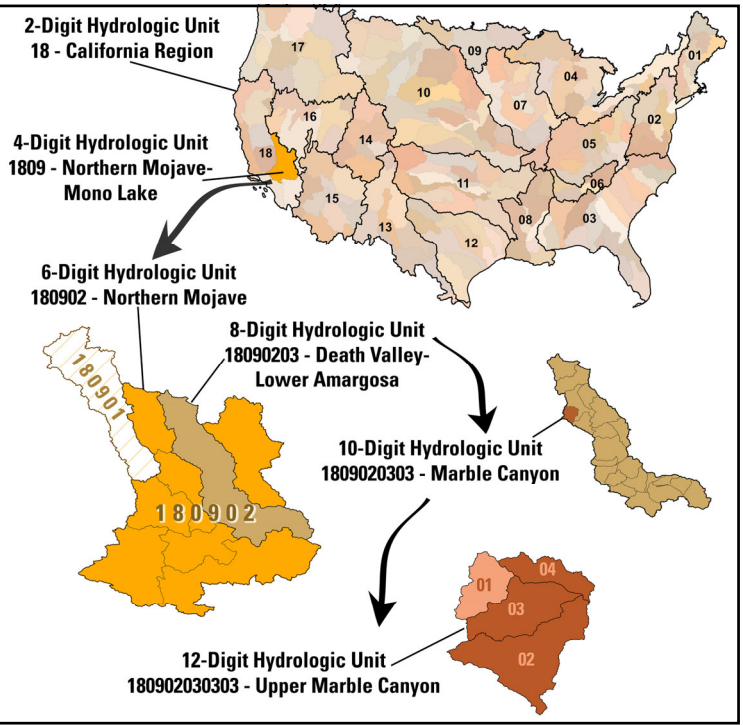
- Watershed Boundary Dataset (WBD)
  - Hydrologic Unit Code (HUC)
  - USGS



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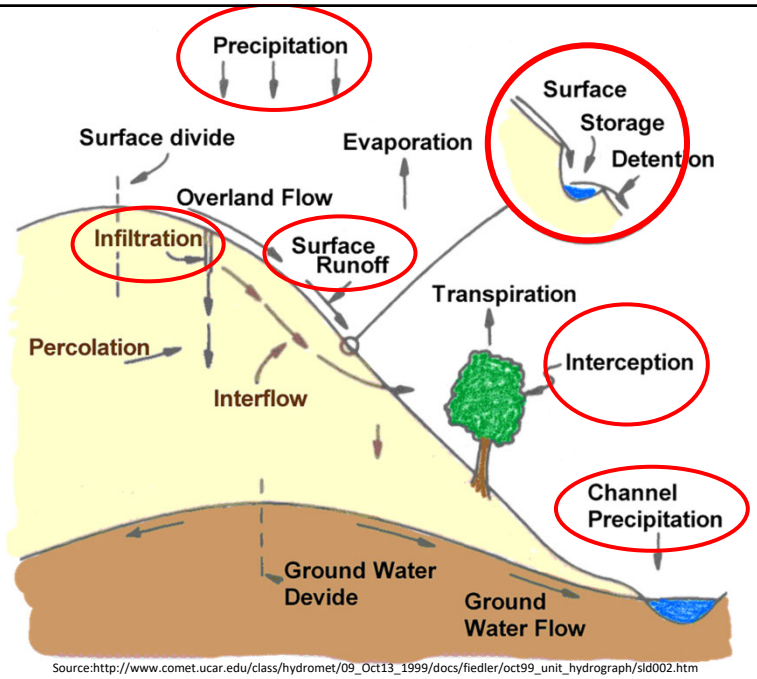

Source:http://www.comet.ucar.edu/class/hydromet/09_Oct13_1999/docs/fiedler/oct99_unit_hydrograph/sld002.htm

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Watershed	Precipitation Volume (in)	Loss Volume (in)	Direct Runoff (in)	Baseflow Volume (in)	Discharge Volume (in)
Sacramento River at Delta (Sacramento Basin)	18.92	10.45	9.23	5.37	14.60
Uncompahgre River (Gunnison basin	**31.90**	**28.68**	**0.13**	**19.70**	**19.83**
Clear Creek (Trinity basin)	**44.80**	**41.42**	**3.38**	**3.66**	**7.04**

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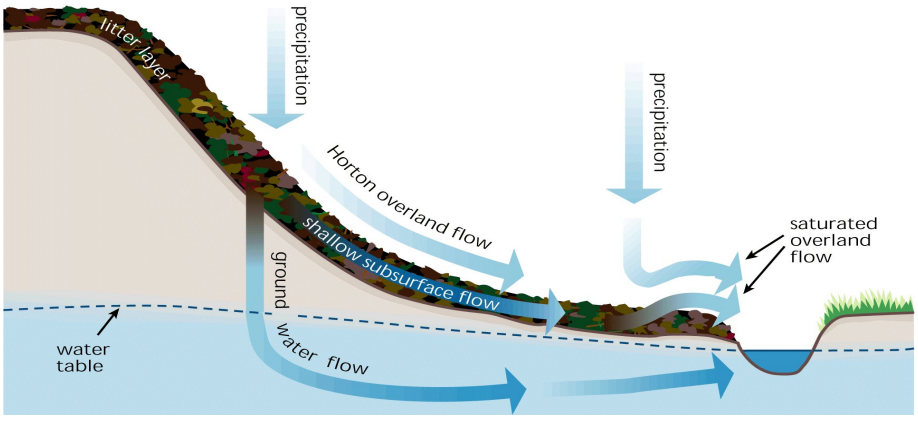
Hydrologic Processes

- Overland flow
- Groundwater flow
- Subsurface flow (Interflow)



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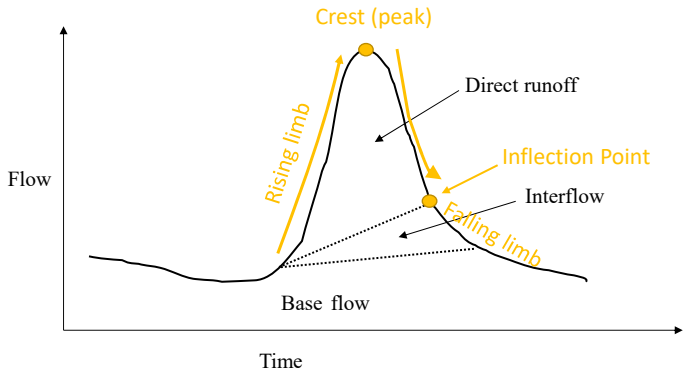
Hydrograph - Illustrated



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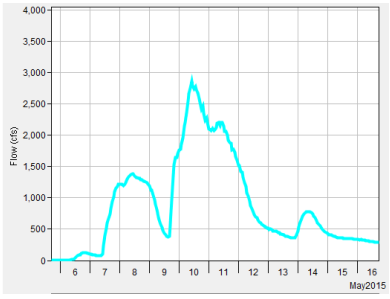

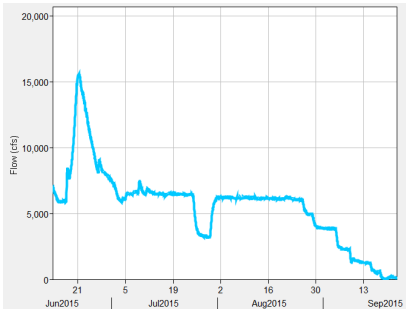

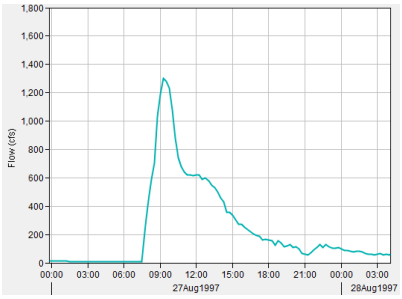

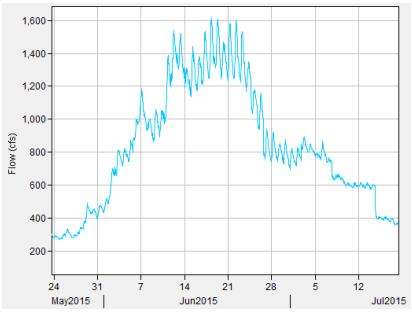

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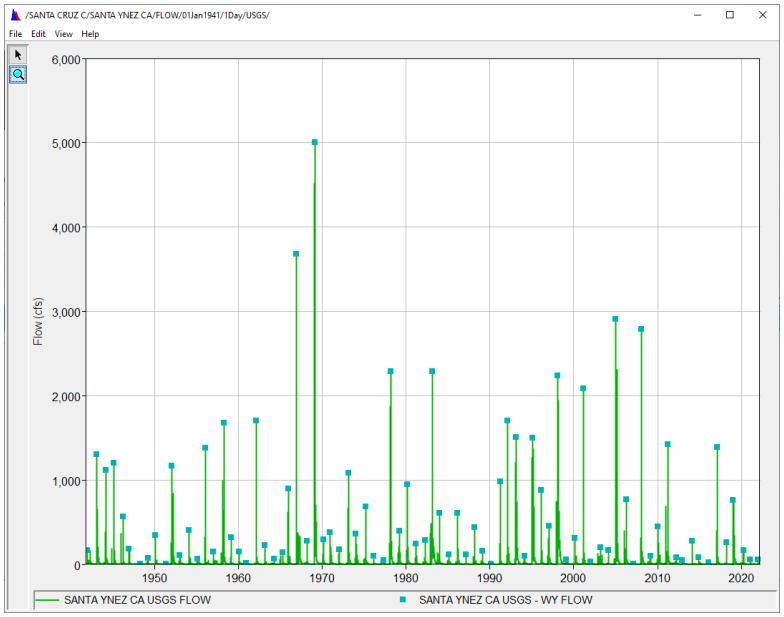
Annual Maximum Flows



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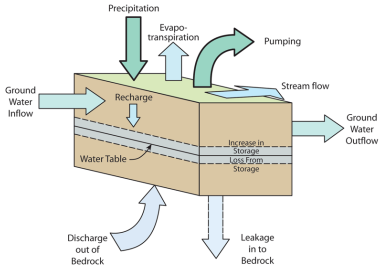
Purpose of Hydrologic Modeling

- Replicate the hydrologic response within a watershed
  - No discharge gage exists in watershed
- Simulate Scenarios/Prediction/Changing stresses
  - Flood risk analysis
  - Effects of land use changes
  - Climate change effects from higher temperatures
- Water Budget
  - Evapotranspiration estimates
  - Crop Patterns
- Boundary conditions for other models



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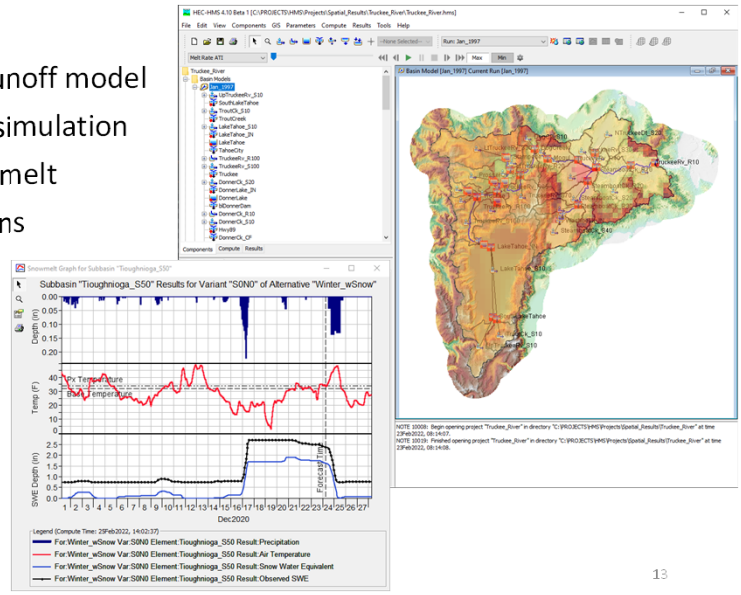
HEC-HMS Software

- HEC-HMS is a precipitation-runoff model
- Event based and continuous simulation
- Evapotranspiration and snowmelt
- Simple reservoir and diversions
- Uncertainty analysis options
- Integrated GIS



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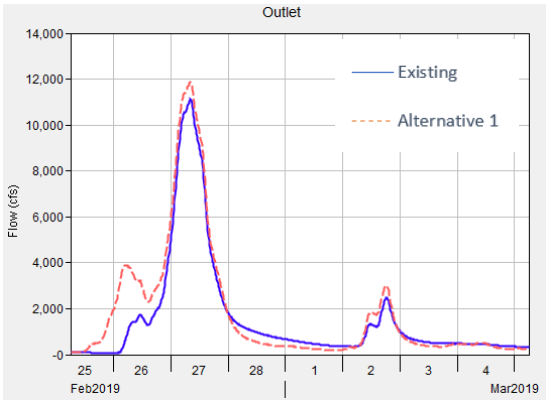
Alternative Analysis

- How does the flow volume/rate change?
  - Existing Condition
  - Proposed Condition
    - Land use change
    - Detention basin
  - Stressors
    - Climate Change - Temperature/Precipitation
    - Flood after fire



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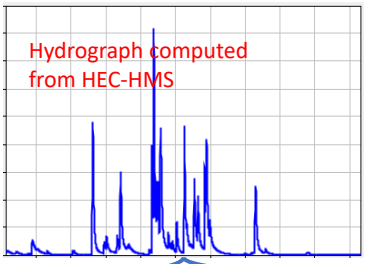
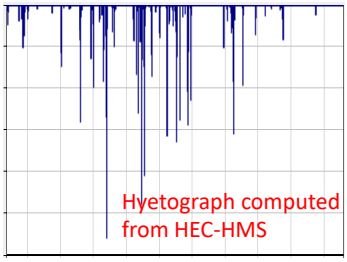
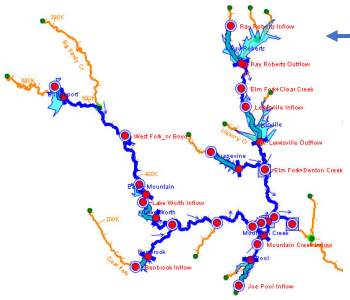
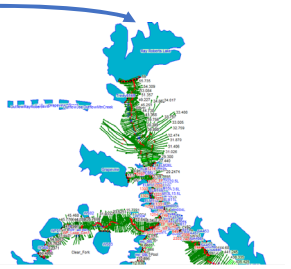
Boundary Conditions

- Hydraulic models
- Reservoir Models
- Ecosystem Restoration









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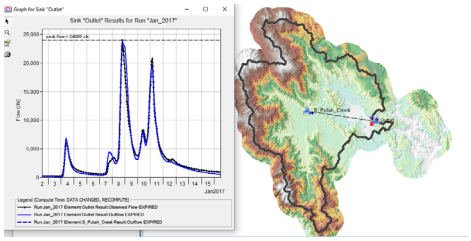
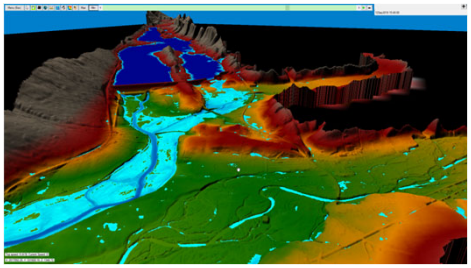
Hydrology vs Hydraulic

- Hydrology – how much volume?
  - Quantity of runoff
  - Translation of hydrograph upstream to downstream
  - Modeling software: HEC-HMS
- Hydraulic – where does the flow go? How fast? How high can the stage get?
  - Motion of water
  - Inundation boundary
  - River stage
  - Modeling software: HEC-RAS





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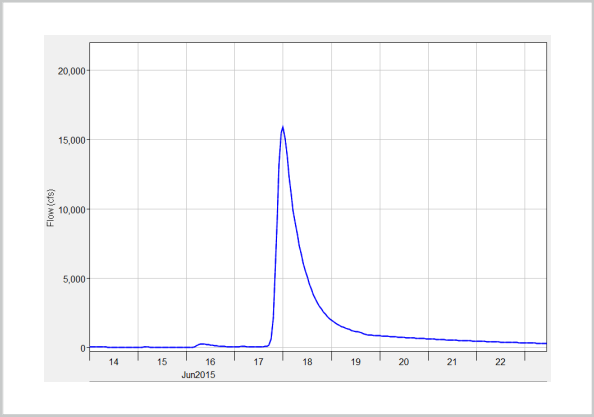
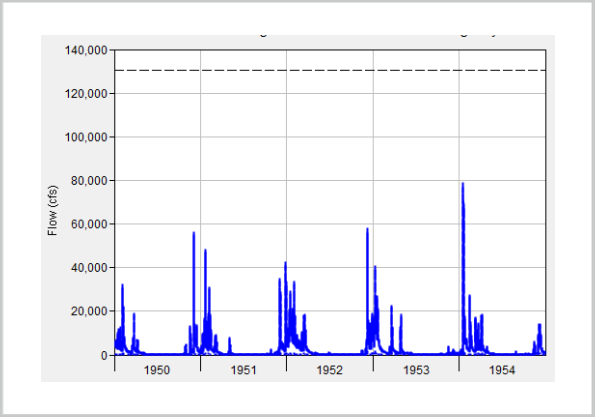
Event vs. Continuous





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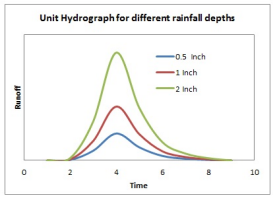
Synthetic Hydrograph generation

- Rational method
- Unit Hydrograph
- Kinematic wave
- Diffusion wave (2d surface runoff)

$$Q = C*i*A$$



$$S_f = S_0 - \frac{\partial y}{\partial x} - \frac{V}{g}\frac{\partial V}{\partial x} - \frac{1}{g}\frac{\partial V}{\partial t}$$

$$\frac{\Omega_i^{n+1} - \Omega_i^n}{\Delta t} - \sum_{k \in \mathrm{K}(i)} s_{i,k} \frac{\alpha_k}{\Delta x_N} \left(z_{s,R}^{n+\theta} - z_{s,L}^{n+\theta} \right) = Q_i$$

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Components of a Hydrology Models

- Input Data
  - Meteorology
  - Terrain
  - Flow
  - Soil/Land use

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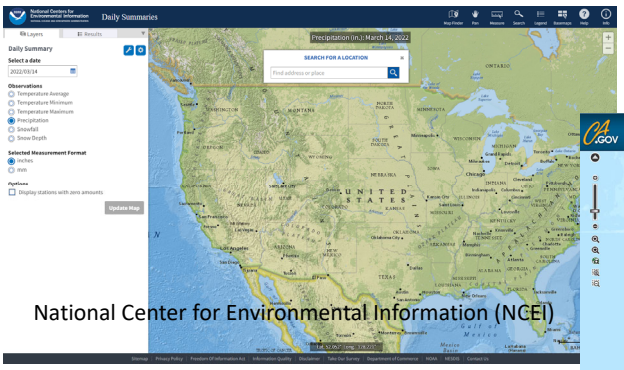
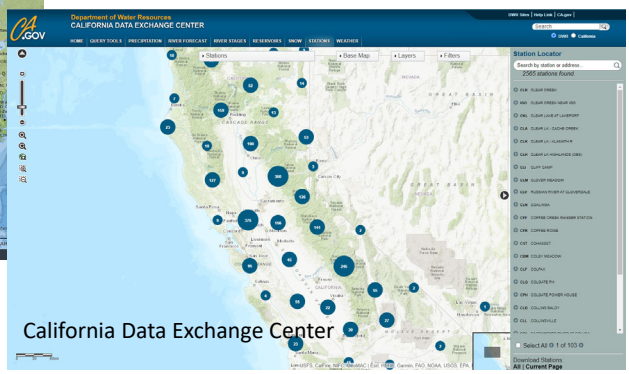
Meteorologic Data



National Center for Environmental Information (NCEI)



California Data Exchange Center

https://www.ncei.noaa.gov/maps/daily-summaries/
http://cdec.water.ca.gov/cdecstation2/

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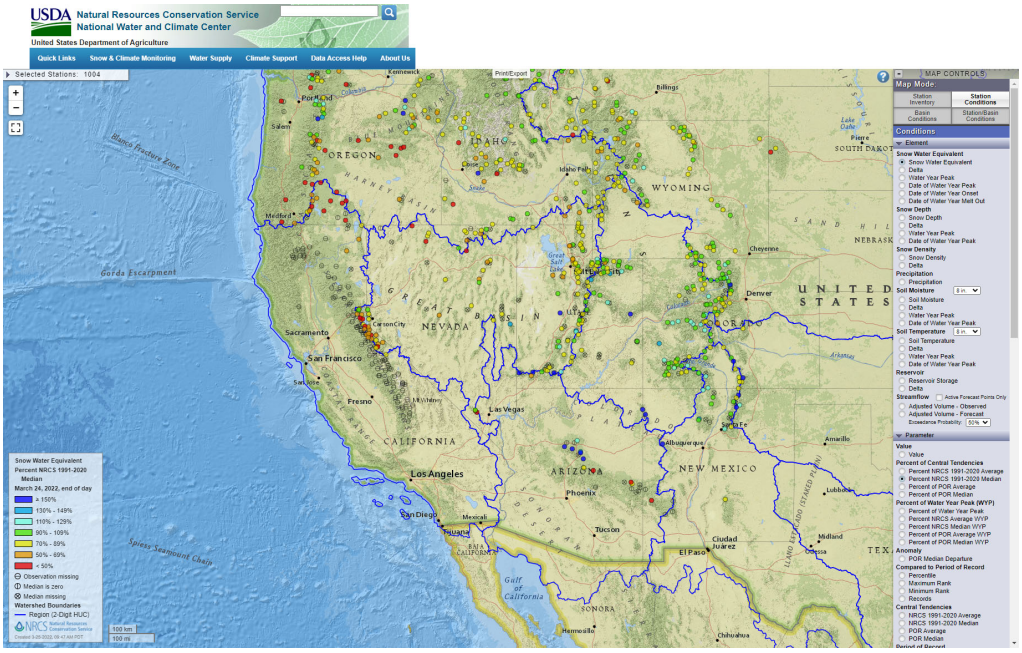

https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring/snowpack/

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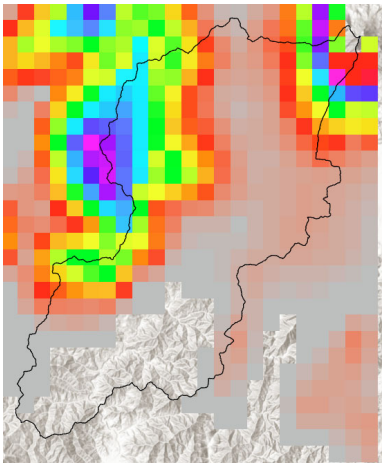
Gridded Data Sources

Historical

Name	Variables	Source	Domain	Period of Record	Timestep	Resolution	Format	Archive
Multi-Radar Multi-Sensor Quantitative Precipitation Estimate (MRMS QPE)	Precipitation	NOAA National Severe Storms Laboratory	CONUS	2012-present	1 hr	1 km	GRIB	IA State Mesonet (2015-present) NCEI Orders
Real-time Mesoscale Analysis (RTMA)	Precipitation, Temperature, et al.	NOAA National Centers for Environmental Prediction	North America	2006-present	1 hr	2.5 km	GRIB	IA State Mesonet (2012-present)
Parameter-elevation Regressions on Independent Slopes Model (PRISM)	Precipitation, Temperature, et al.	Oregon State University, USDA, NOAA	North America	1895-present	1 day	4 km, 800 m (for fee)	ASCII, BIL	PRISM Climate Group
Next-generation Radar Quantitative Precipitation Estimate (NEXRAD QPE)	Precipitation	NOAA National Centers for Environmental Information	CONUS	2002-2011	5 min	1 km	NetCDF	NCEI Orders
NOAA National Centers for Environmental Prediction (NCEP) Stage IV Data	Precipitation	NOAA NCEP	CONUS	2002-present	1 hr	4 km	GRIB	NCAR / EOL
Analysis of Period of Record for Calibration (AORC)	Precipitation, Temperature	NOAA Office of Water Prediction	North America	1979-present	1 hr	4 km	NetCDF	FTP
Integrated multi-satellite retrievals for global precipitation measurement (IMERG/GPM)	Precipitation	NASA	Global	2000-present	30 min	0.1 degree	NetCDF	GES DISC Also see GES DISC downloader
Climate Prediction Center Morphing Technique (CMORPH)	Precipitation	NOAA NCEP	Global	1998-present	30 min, 1 hr, 1 day	8 km, 0.25 degree	NetCDF	FTP
Daymet	Precipitation, Temperature	NASA, ORNL	North America	1980-present	1 day	1 km	NetCDF	ORNL DAAC



https://www.hec.usace.army.mil/confluence/display/HMSGUIDES/Gridded+Data+Sources

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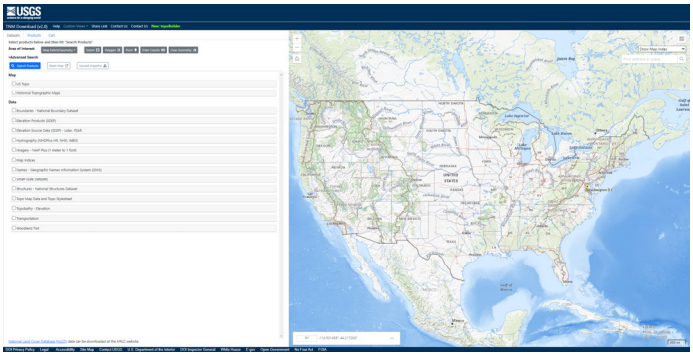
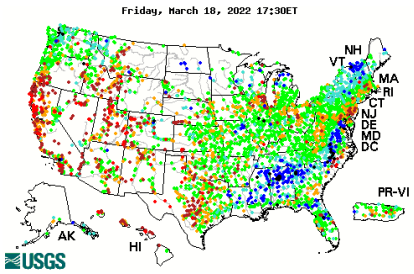
Flow Data and Terrain





Ask a water manger!

https://waterdata.usgs.gov/nwis/rt
https://apps.nationalmap.gov/downloader/

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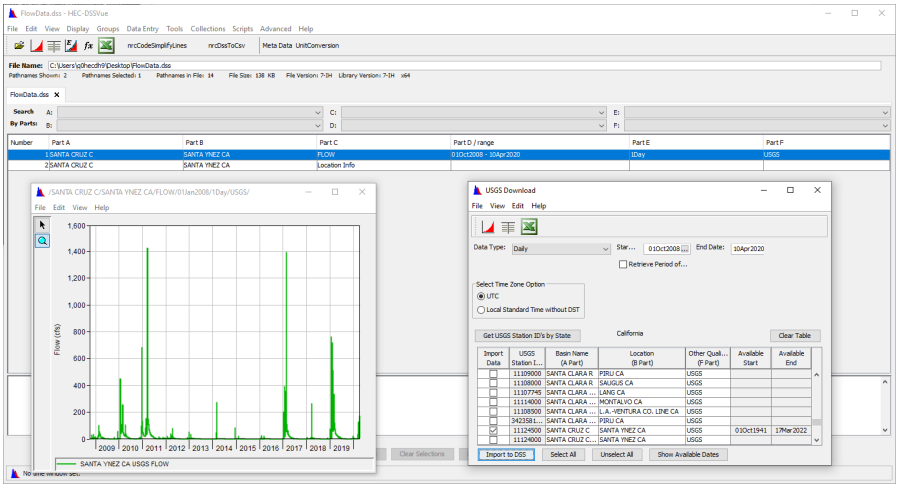
HEC-DSSVue



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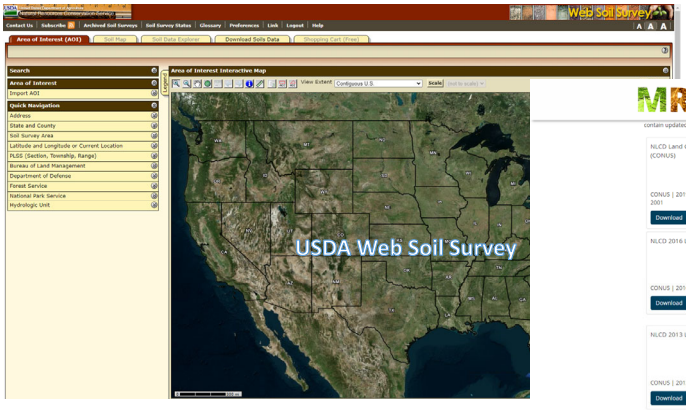
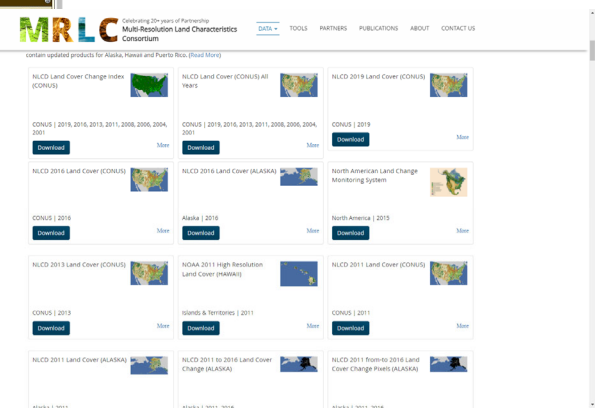
Soil/Land Use





https://www.mrlc.gov/data
https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

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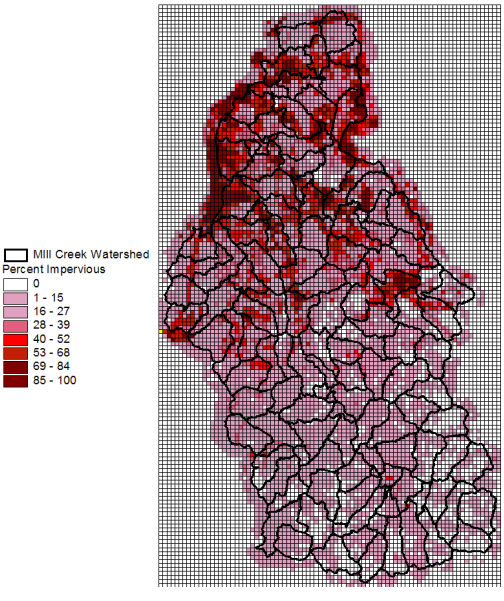
Model Application

- Mill Creek Hydrologic Model
  - Multi-purpose model
  - Event and continuous based simulation
  - Existing condition model
  - Alternative Scenario
    - Allow Nashville District to create different land use scenarios
    - Boundary condition for hydraulic model
      - Impact to habitat restoration with levee raise



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Model Application

- Estimating Annual Exceedance Probability
  - https://www.hec.usace.army.mil/confluence/sspdocs/ssptutorialsguides/other-statistics-tutorials/bulletin-17c-flow-frequency-augmented-by-precipitation-frequency-with-hec-hms
  - https://www.hec.usace.army.mil/confluence/hmsdocs/hmsguides/new-tutorials-to-check-out/applying-the-new-frequency-analysis-compute-type

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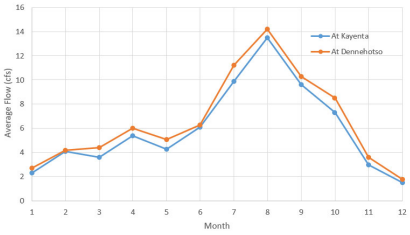
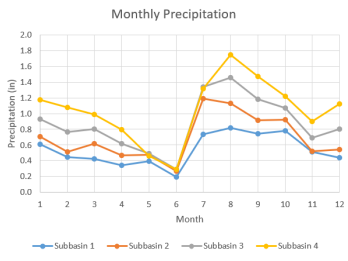
Model Application

- Navajo Nations
  - Event and continuous model
  - Sediment yield and sediment trap analysis
    - Estimate sediment volume
  - Monthly flow volume estimate for irrigation dam
    - No existing gage
    - Collected historical precipitation and temperature to model existing condition





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List of Data

- Meteorology
  - https://www.ncei.noaa.gov/maps/daily-summaries/
  - http://cdec.water.ca.gov/cdecstation2/
  - https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring/snowpack/
  - https://www.hec.usace.army.mil/confluence/display/HMSGUIDES/Gridded+Data+Sources
- Flow - https://waterdata.usgs.gov/nwis/rt
- Terrain - https://apps.nationalmap.gov/downloader/
- Land Use - https://www.mrlc.gov/data
- Soil Data - https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

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