Appendix B. California Natural Streamflow Classification

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Summary
This appendix describes the methods used to determine the natural streamflow classification for the state of California and a description of each of the natural hydrologic classes. Nine classes were identified for the State of California (See Figure 1 and Table 1), that can be combined into three main categories: snowmelt, rain and mixed. Lane et al. (2017) originally identified eight natural hydrologic classes describing distinct hydrologic patterns and used climatic patterns, catchment properties, geology and soils characteristics to spatially predict the classification throughout the statewide streamflow network. Pyne et al. (2017) independently distinguished seven hydrologic classes for the state based on watershed, climate, and land use properties and used hydrologic metrics to verify that the grouping of classes was consistent. Lane et al. (2018) then reconciled these classifications, resulting in nine natural hydrologic classes and associated dimensionless reference hydrographs (DRHs) (Figure 2). A DRH is a scalable representation of reference hydrology based on streamflow data from unimpaired streamflow gauges in a hydrologic stream class. The y-axis is expressed in dimensionless units by dividing daily streamflows by average daily streamflow for that water year.

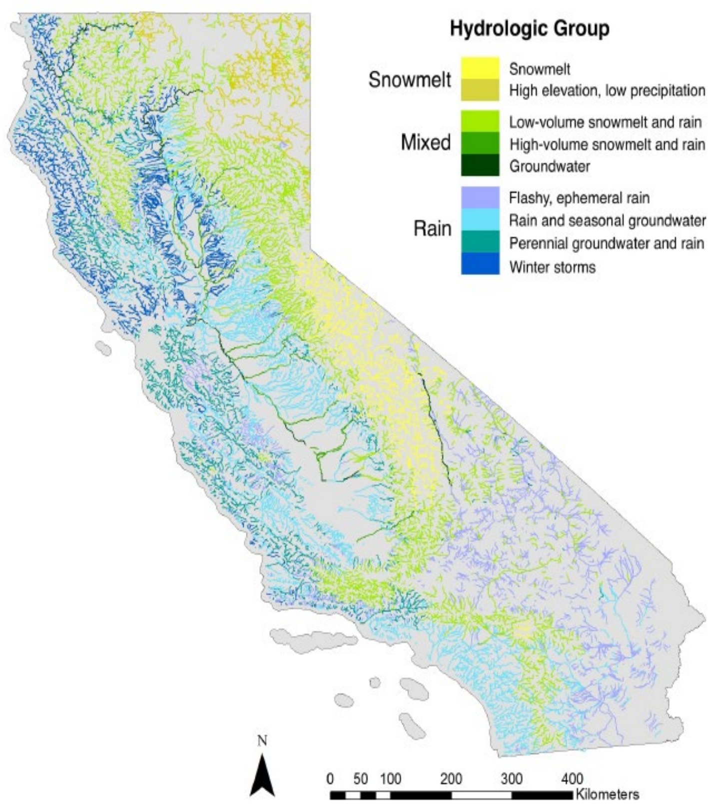

Figure 1 – Natural Streamflow Classification for the State of California

Table 1 – Characterization of each Natural Streamflow Class

Class	Name	Hydrologic Characteristics	Physical and Climatic Catchment Controls
SM	**Snowmelt**	• Large spring snowmelt pulse (~May 24) • Very high seasonality index • Extreme low flows (<10th percentile) Sep-Feb	• High elevation catchments (>2,293 m), major snow influence
LSR	**Low-volume snowmelt and rain**	• Transition between SM and HSR • Bimodal snow - rain hydrograph driven by spring snowmelt pulse and winter rain	• Mid-elevation catchments with limited area (<2,144 km²) [low winter temperatures (Jan temp <-5C°), high stream density (>0.65 km/km²)]
HSR	**High-volume snowmelt and rain**	• Spring snowmelt pulse (~May 4) • High seasonality but larger winter storm contributions • Retain high baseflow throughout summer Bimodal snow - rain hydrograph	• Mid-elevation catchments (1,126 - 2,293 m), large contributing area (>2,144 km²) *not* underlain by volcanic geology [high stream density (>0.65 km/km²), mild winter temperatures (Jan temp >-5C°)] **OR** • Low elevation (<1,125 m) with very large contributing area (>15,420 km²) and high clay content soils (>17% clay)
WS	**Winter storms**	• Predictable large fall and winter storms • Earliest peak flows (in January)	• Low elevation catchments with substantial winter precipitation **OR** • Low elevation, mid-slope (31 - 24%) catchments with low winter precipitation but high riparian soils clay content (>23%) **AND** • Underlain by unconsolidated aquifers covered by thick alluvium
GW	**Groundwater**	• Highest mean annual flows and highest minimum flows • Low seasonality and high predictability	• Mid-elevation catchments with large area (>2,144 km²) underlain by volcanic (basaltic and andesitic) geology [low stream density (<0.65)] **OR** • Low elevation, limited winter precipitation, very large contributing area (>15,420 km²) with low riparian soils clay content (<17%) **AND** • Underlain by igneous and metamorphic rock aquifers
PGR	**Perennial groundwater and rain**	• Low seasonality and mean annual streamflow • Transition between WS and GW, with winter rain contributions but generally stable flows	• Low elevation catchments with low clay content riparian soils (<23%) [low stream density (<1.1 km/km²)] **AND** • Underlain by sedimentary rock materials in Central Coast region
RGW	**Rain and seasonal groundwater**	• Bimodal hydrograph driven by winter rain pulse and percolating winter rain appearing as baseflow pulse later in year; can be ephemeral	• Low elevation with limited winter precipitation and low slopes (<24%) **AND** • Coastal catchments with small aquifers driving short residence times
FER	**Ephemeral, flashy rain**	• Lowest mean annual flows, often ephemeral • Highest CV, lowest predictability • Longest extreme low flow duration • Highest flows in winter	• Low elevation catchments with high clay content soils (>23%) and high slopes (>31%) [high stream density (>1.15 km/km²)]
HLP	**High elevation, low precipitation**	• Low mean annual flows • Highest flows in winter	• High elevation but low slope • Low precipitation and limited snow influence

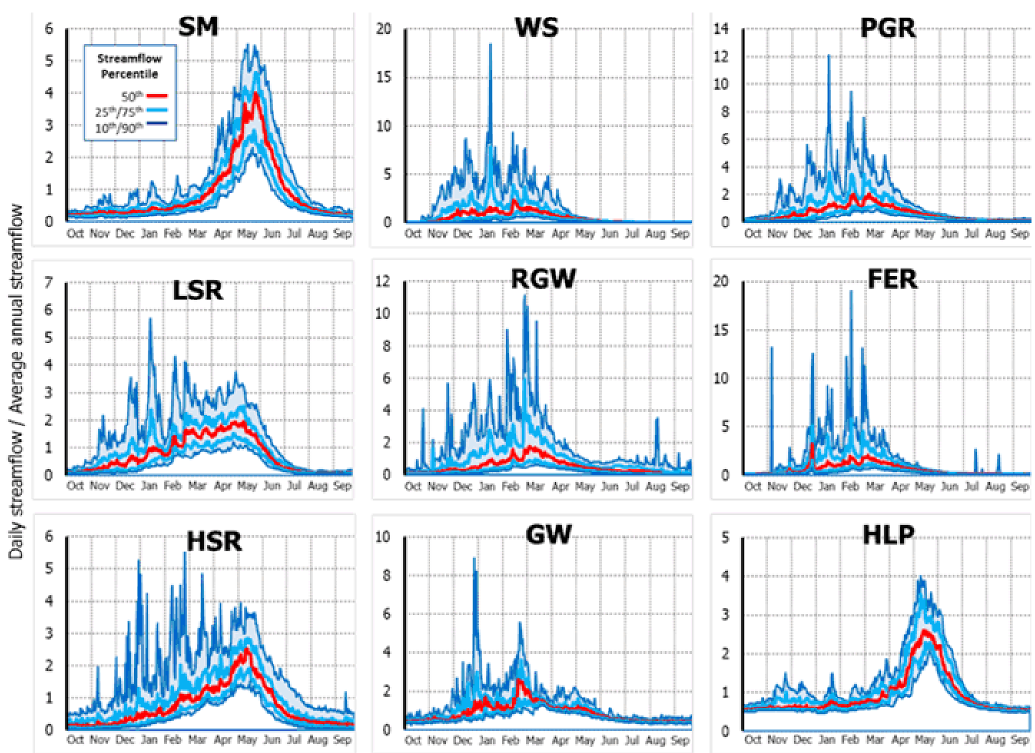

Figure 2 – Dimensionless reference Hydrographs (DRH) for each of the Natural Hydrologic Classes in California.

References

Lane, B.A., Dahlke, H.E., Pasternack, G.B., and Sandoval-Solis, S. (2017). Revealing the diversity of natural hydrologic regimes in California for environmental flows applications. J. American Water Resources Association. https://doi.org/10.1111/1752-1688.12504

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