Overview of Watershed-Wide Instream Flow Criteria Report Methodology

California Department of Fish and Wildlife
Instream Flow Program

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Overview of Watershed-Wide Instream Flow Criteria Report Methodology

Version 3

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INSTREAM FLOW PROGRAM

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All photos in this document were taken by Department staff. Cover photo is of Deep Creek (Mojave River watershed, San Bernardino County).

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Introduction

Throughout California, water demand, variable hydrology, climate change, and limited baseline information on stream conditions create complex challenges for freshwater ecosystem management. The mission of the California Department of Fish and Wildlife (Department) is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. Over-allocation of freshwater resources may result in significant negative impacts to the public trust and public enjoyment of these resources.

South Fork Eel River
SOUTH FORK EEL RIVER WATERSHED, MENDOCINO COUNTY

The Instream Flow Council[1] describes the connection of people, fish, and water as follows:

> "All water uses, whether for industry, municipalities, or instream flow are for the benefit or enjoyment of people. But ultimately, reservation of water for instream flow is about use and enjoyment of riverine resources by future generations. Since these future users are not available to express their needs or desires, fish—like the canary in the coalmine—often serve as a surrogate for healthy riverine conditions. Preserving instream flows (and fish) in effect preserves water management options for future generations" (Annear et al. 2004).

[1] Instream Flow Council website: https://www.instreamflowcouncil.org/.

The Department's Instream Flow Program is releasing ***instream flow criteria***[2] (flow criteria) at a watershed scale in a series of reports called Watershed-Wide Instream Flow Criteria (Watershed Criteria Reports). The Watershed Criteria Reports use the best available datasets and may be combined with field-based data at a subset of sites, when available. This approach enables the Department to rapidly provide high-quality information on instream flow needs for watersheds throughout the state. In some circumstances, the Department anticipates that it may supplement a Watershed Criteria Report with in-depth instream flow studies including more intensive fieldwork and/or modeling. In other circumstances, a Watershed Criteria Report may provide sufficient information for the development of flow criteria.

As a companion to the Watershed Criteria Reports, this document provides background, section-by-section explanations, and guidance on interpretation of results and development of flow criteria relevant to all Watershed Criteria Reports. This document and the Watershed Criteria Reports may be found on the Department's Instream Flow Program Watershed Criteria Report webpage (CDFW 2024). The intended audience for these documents includes water managers, the public, and staff from agencies and non-governmental organizations.

The Instream Flow Program has provided this document and the Watershed Criteria Reports in response to Department regional and program support requests and to support key actions identified in legislative mandates, such as those related to the development of instream flow recommendations. These reports use approaches and tools developed by the California Water Quality Monitoring Council's California Environmental Flows Workgroup, such as the functional flows approach and Natural Flows Database (CEFF TWG 2021; Zimmerman et al. 2023).

The Department provides this document as a tool for consideration in water management planning. It presents an analytical approach, flow results, and flow criteria that can be implemented, if appropriate, under the specific circumstances of a watershed, stream, or informational need. This document and the Watershed Criteria Reports, in and of themselves, should not be considered to provide binding guidelines, establish legal compliance, or ensure project success.

[2] A set of flow values that sustain ecological function and processes within a lotic water body and its margins.

Watershed Criteria Report Structure

Each Watershed Criteria Report presents instream flow results for select mainstem and tributary reaches within the watershed. Reach selection is driven by ***ecological management goals***[3], fish and wildlife needs, watershed characteristics, and input from Department staff. To build a consistent watershed-scale perspective, the Watershed Criteria Reports focus primarily on desktop analysis of best available data. In some cases, desktop analyses are used in conjunction with field assessments when appropriate field conditions and site access are available.

The Watershed Criteria Reports present a range of flow results that are used to develop flow criteria to address the ecological management goals of each watershed. These criteria address four of the five riverine components identified by Annear et al. (2004): connectivity, biology, geomorphology, and hydrology (Figure 1). A careful evaluation of water quality, the fifth riverine component, and other scientific information is recommended to protect riparian and aquatic species (Annear et al. 2004).

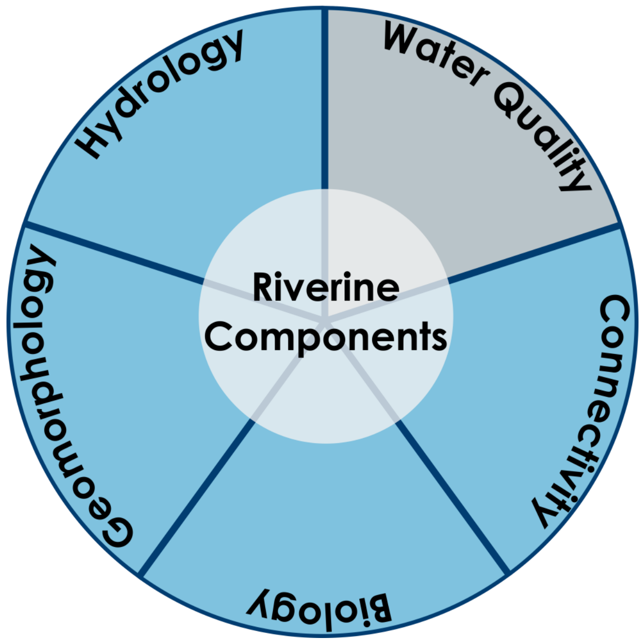

Figure 1. The five riverine components.

[3] Management targets focused on a particular ecological outcome.

Quality Assurance and Control

A key component of Watershed Criteria Report development is a thorough quality assurance and quality control (QA/QC) process conducted by the Instream Flow Program. The Instream Flow Program implements a robust QA/QC process that includes standardized procedures and documents, classroom and field training, designated project QA Officers, and third-party QA/QC process oversight. These components ensure that instream flow information collected by Instream Flow Program staff across California is consistent and comparable, and that the resulting data will be transparent, accountable, and scientifically defensible.

The QA/QC process was developed in partnership with the QA Services Group from the Marine Pollution Studies Laboratory at the Moss Landing Marine Laboratories in Moss Landing, California. The Instream Flow Program's standard operating procedures and guidance documents are based on published methods, analyses, and research, and were peer-reviewed by outside technical experts. The process includes templates for pre- and post-study documentation as well as fact sheets for training and outreach.

Moss Landing Marine Laboratories performs audits of select Instream Flow Program studies to confirm that procedures and models used meet strict QA standards and are appropriate for their intended use. Instream Flow Program staff receive ongoing QA/QC training, as well as intercalibration with peers. Data collection, verification, validation, and analysis are carried out by trained Instream Flow Program Environmental Scientists and Senior Environmental Scientists with input from a Senior Hydraulic Engineer. All data collected are reviewed for completeness and records are maintained at the Department's Headquarters office.

Mattole River
MATTOLE RIVER WATERSHED, HUMBOLDT COUNTY

Guide to Methodology and Results

A variety of methods were used to develop ecosystem flows, channel maintenance flows, and species-specific flows. The methods are briefly described in this document, with examples of how data are presented in the Watershed Criteria Reports.

The sections of this document and the Watershed Criteria Reports use color-coding to link the detailed descriptions in this document with the sections in the Watershed Criteria Reports. The sections include flow variation, natural flows, functional flows, ecosystem baseflows, salmonid habitat optimum flows, sensitive period indicators, and habitat connectivity flows. The watershed criteria analysis key (Figure 2) appears in each Watershed Criteria Report and provides a color-coded summary of the analyses used. Variation may exist between the procedures or details described in this document and what is appropriate at a particular site. Any variation to these analyses is described in the Watershed Criteria Report for that watershed.

Each Watershed Criteria Report includes a color-coded key that describes the analyses performed on selected reaches within the watershed (Figure 2).

Flow Variation — Annual and interannual variation in flows is critical to long-term ecological functioning. These data provide an example of natural variation in the selected watershed.

Natural Flows — Median natural flows present estimated natural streamflow data by water month type for each reach.

Functional Flows — Functional flows perform key ecological and geomorphic functions. This section presents information on the timing, magnitude, and duration of key functional flows within the annual hydrologic cycle.

Ecosystem Baseflows — Ecosystem baseflows are monthly baseflows that preserve a healthy stream ecosystem. These are calculated as a percentage of monthly and annual natural flows and vary throughout the year.

Salmonid Habitat Optimum Flows — Salmonid habitat optimum flows provide optimal access to preferred salmonid habitat. This section presents the optimal discharge for select salmonid life stages for each stream reach.

Sensitive Period Indicators — Sensitive period indicator flows can be used to identify the low-flow period during which fish and wildlife may be particularly vulnerable to flow reductions. These flows are determined using a field-based method.

Habitat Connectivity Flows — Habitat connectivity flows provide enough water to maintain instream habitat and protect fish movement between mesohabitat units. These flows are determined using a field-based method.

Figure 2. Watershed criteria analyses key.

Flow Variation

An understanding of natural variability and projected future changes to flow patterns may inform the development of a flow regime that accounts for changes in water availability. Using gage data, this section presents a hydrograph for the driest, median, and wettest year in the gaged period of record along with monthly median natural flows for the gaged reach (Figure 3). If gage data are not available for the study stream, gage data from a surrogate stream may be used.

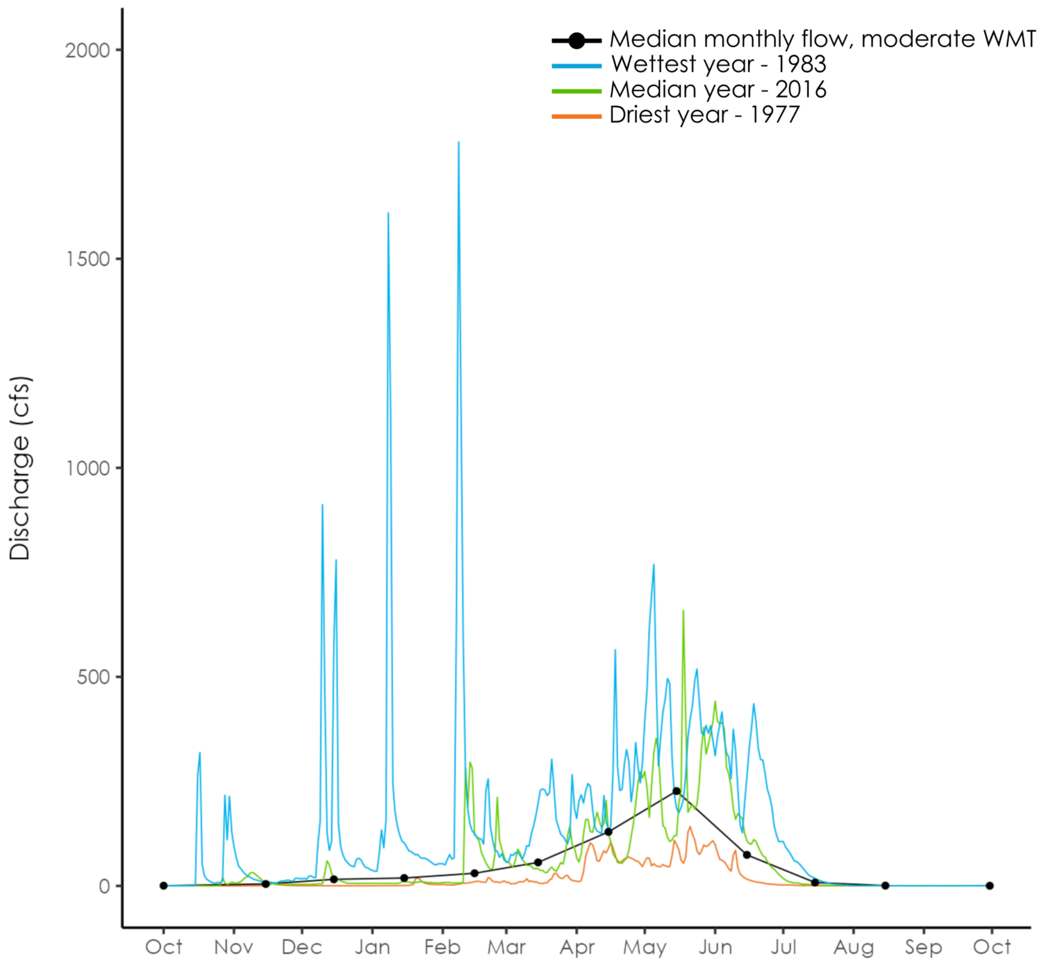

Figure 3. Example flow variation hydrograph. Mean daily flow for the driest, median, and wettest years on record are presented for an example stream gage.

The comparison of the driest, median, and wettest years on record in the flow variation plot (Figure 3) highlights the interannual variation of flows in the watershed. In addition, the plot illustrates that monthly flow values simplify highly variable daily flow patterns.

Preserving variability in flows both within a year and from year-to-year are important for long-term habitat maintenance and for the life cycles of many native species (Poff et al. 1997; Annear et al. 2004). Any annual flow regime should be designed to preserve intra- and interannual variation to protect or restore ecosystems and their functions.

Natural Flows

The natural flows section of each Watershed Criteria Report provides estimates of median monthly natural flows for each reach using data from the Natural Flows Database (Zimmerman et al. 2023). Monthly natural flows are used in the Watershed Criteria Reports to calculate water month type and are used as inputs to the ecosystem baseflows and salmonid habitat optimum flows analyses presented in subsequent sections of each report.

The Natural Flows Database uses a statistical modeling approach to estimate monthly flows that would be present in the absence of water use or land use impacts to natural hydrology (Zimmerman et al. 2023). The database estimates flows for each California stream reach in the NHDPlus medium-resolution dataset (USEPA and USGS 2012) for each month beginning in 1950. The Natural Flows Database was developed using a set of reference United States Geological Survey gages, along with data on watershed characteristics, weather, and climate for every stream reach. Arid watersheds are underrepresented in the reference gage network, and frequently have complex, groundwater-dominated hydrology (Lane et al. 2017). As a result, estimates for arid regions should be interpreted with caution (Zimmerman et al. 2023).

Natural Flows Database estimates are provided for every Watershed Criteria Report as part of the effort to produce a consistent statewide dataset. Where appropriate relatively unimpaired gage records are available, these site-specific data may be included as an appendix to the report. In these cases, the gage data are considered to replace the Natural Flows Database as an estimate of natural flow conditions.

West Fork San Gabriel River
SAN GABRIEL RIVER WATERSHED, LOS ANGELES COUNTY

To depict water availability by reach, median monthly natural flow estimates are presented for wet, moderate, and dry water month types. To determine these median monthly values, each month of each year is assigned a water month type for that reach using mean monthly flow, analogous to the process used to determine water year types. In the example below, January mean monthly flows of every year were compared so that each January could be assigned to one of three categories based upon exceedance percentages: wet (i.e., lowest 30% exceedance), moderate (i.e., middle 40%), and dry (i.e., highest 30%). The median value of the median monthly flows within each of these categories (i.e., wet, moderate, and dry) is presented for January (Figure 4). This process is repeated for each month and reach. Median monthly flow values are presented rather than mean values because medians are less sensitive to extreme values, and thus provide a more accurate depiction of typical water availability.

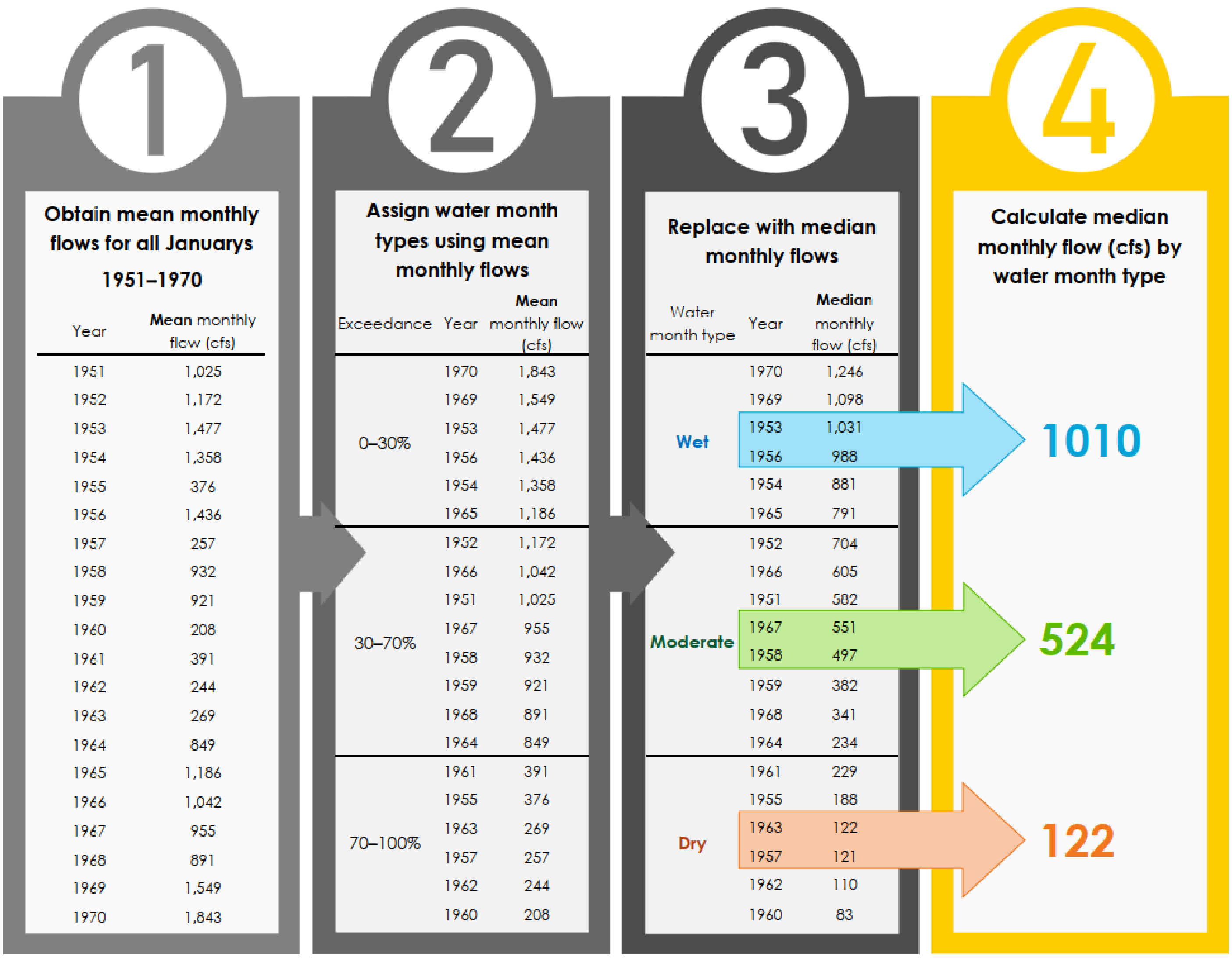

Figure 4. Water month typing example for the month of January.

In the Watershed Criteria Reports, median natural flows by water month type are presented for each reach in the form of a table (Table 1) and are included on plots in subsequent sections of the Watershed Criteria Reports.

Table 1. Example of median natural flows by water month type.

1) Dry Creek 1.4 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	258	185	169	117	41	22	7	4	2	5	73	205
Moderate	124	106	97	55	23	9	6	3	3	3	23	95
Dry	42	44	60	29	14	8	5	3	2	1	6	24

Functional Flows

The functional flows section presents information about the key elements of the natural flow regime for each watershed. The California Environmental Flows Framework (CEFF) identifies five key functional flow components: the fall pulse flow, peak magnitude flows, the wet-season baseflow, the spring recession flow, and the dry-season baseflow (Figure 5; CEFF TWG 2021). These key portions of the flow regime sustain ecological function over time (Yarnell et al. 2015; CDFW 2018a; Yarnell et al. 2020) and are summarized in the following paragraphs.

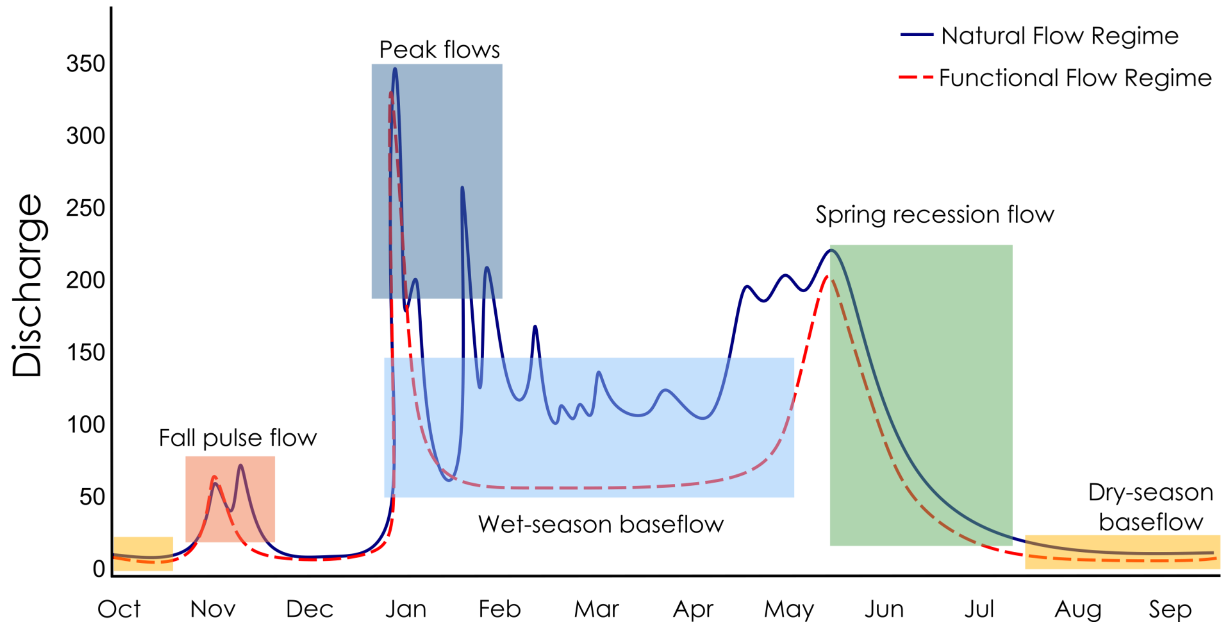

Figure 5. The functional flow components (adapted from Yarnell et al. 2015).

The fall pulse flow follows the first major storm event after the dry season and represents the transition between the dry and wet seasons. This flow moves nutrients downstream and provides cues that aquatic species use to time behaviors such as migration and spawning. Depending on the region, this flow may not occur every year.

Peak magnitude flows are large-scale disturbances responsible for significant sediment transport and the maintenance and restructuring of river channels and floodplain landforms. These peak flows maintain habitat diversity over the long term.

The wet-season baseflow is defined by a prolonged period of elevated baseflow between winter storms. This higher flow supports movement and provides habitat for species that over-winter in streams.

The spring recession flow represents the transition between high and low flows. These gradually receding flows redistribute sediment mobilized by the higher flows earlier in the year and cue reproduction and migration of native species.

The dry-season baseflow is the low flow that occurs annually. This low flow favors native species that have adapted to withstand this biologically-stressful period.

Each functional flow component is quantified by a set of functional flow metrics, which describe the timing, magnitude, duration, frequency, and rate of change. For a series of relatively unimpaired reference gages, natural functional flow metrics have been calculated using observed streamflow data and a stream classification developed by Lane et al. (2018). Metrics may also be calculated for non-reference gages. In the Watershed Criteria Reports, metrics calculated using gage data are referred to as observed functional flow metrics.

Natural ranges of functional flow metrics have also been estimated for each reach in the state[4] using models trained on streamflow data from reference gages and watershed variables that describe topographic, geologic, hydrologic, weather, and climatic characteristics of each reach. In the Watershed Criteria Reports, these are referred to as modeled functional flow metrics. Both observed and modeled functional flow metrics are available online (CEFWG 2024). Where available, gaged functional flow metrics will be presented in the Watershed Criteria Reports. For ungaged or poorly gaged reaches, modeled functional flow metrics may be presented.

In the Watershed Criteria Reports, functional flow metrics are presented in a table stratified by water year type (Table 2). Median values are presented for each metric. The range of values in 80% of years (i.e., 10–90th percentile values) are also provided in parentheses. Where gage data are available, plots of observed functional flows are also included, which provide a visual comparison of metrics in wet, moderate, and dry water year types (Figure 6).

[4] Metrics have been estimated for all NHDPlus medium-resolution stream reaches in California, with the exception of those located within legal Sacramento-San Joaquin Delta.

Arroyo Seco

SALINAS RIVER WATERSHED, MONTEREY COUNTY

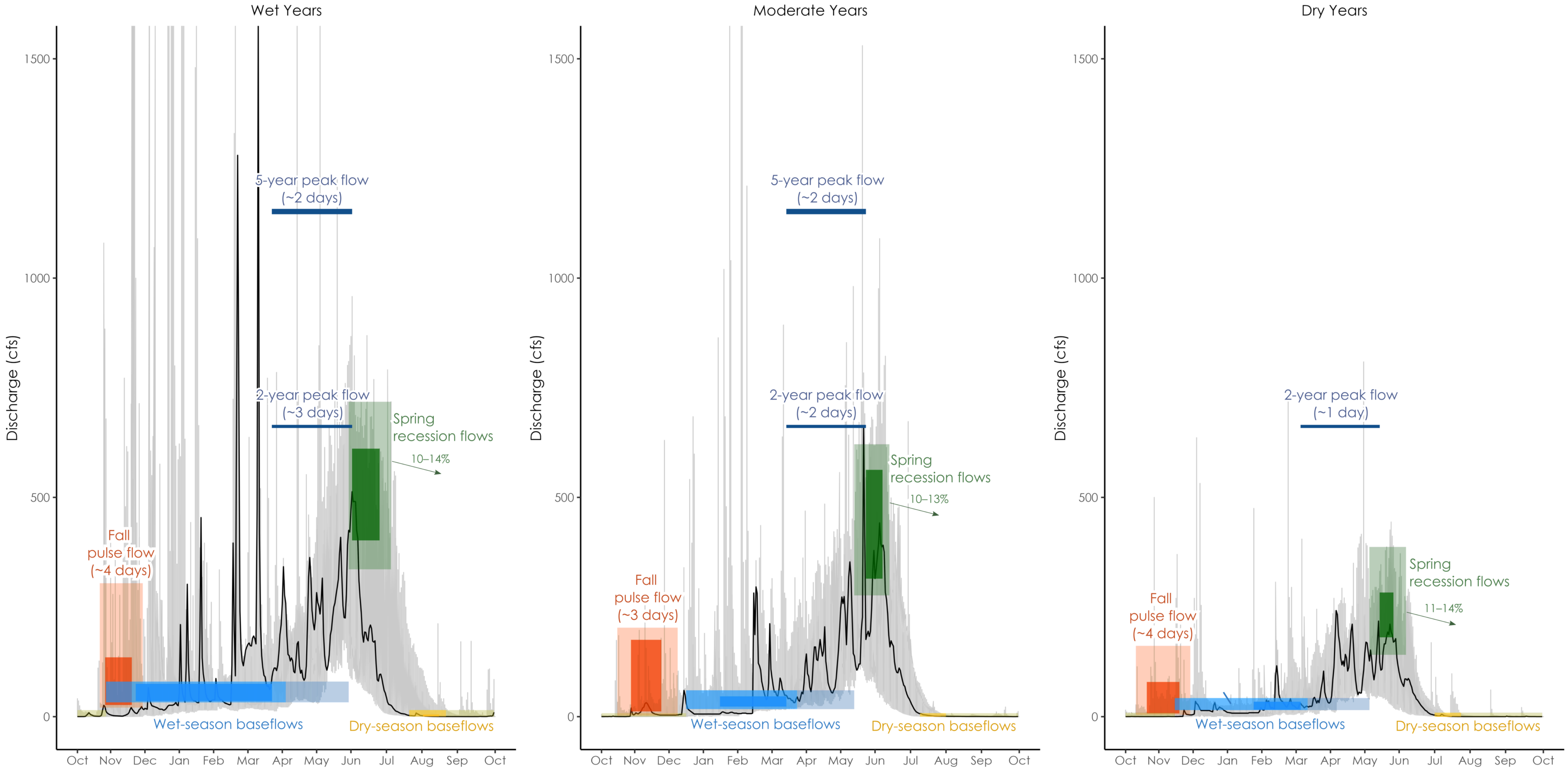

Figure 6. Timing and magnitude of functional flows by water year type (from left to right: wet, moderate, and dry years) for a stream in the northern sierras. The darker colored boxes indicate the start timing and magnitude in 50% of years (i.e., 25th–75th percentile values) for each functional flow component. The lighter colored boxes represent start timing and magnitude in 80% of years (i.e., 10th–90th percentile). The light-blue and light-yellow boxes link wet-season start and dry-season start to the next functional flow season. The arrow indicates the spring recession rate in 80% of years (i.e., 10th–90th percentile).

Table 2. Example functional flow metric ranges for three water year types (i.e., wet, moderate, and dry). Each cell provides the median (i.e., 50th percentile) metric value and the 10th–90th percentile range in parentheses.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	65 (21–304)	40 (2–203)	14 (4–161)
Fall pulse flow duration (total days per year, when present)	4 (2–7)	3 (2–6)	4 (2–8)
Fall pulse flow start timing	Nov 08 (Oct 20–Nov 27)	Nov 09 (Oct 14–Dec 6)	Nov 12 (Oct 10–Nov 26)
Wet-season baseflow magnitude (cfs)	47 (33–80)	38 (17–60)	24 (15–42)
Median wet-season flow magnitude (cfs)	140 (61–328)	120 (56–210)	80 (43–116)
Wet-season duration (days)	123 (61–208)	102 (60–158)	97 (65–179)
Wet-season start timing	Feb 16 (Oct 25–Apr 1)	Feb 11 (Dec 13–Mar 21)	Feb 20 (Nov 13–Mar 8)
2-year peak flow magnitude (cfs)	658	658	658
2-year peak flow duration (total days per year, when present)	3 (1–7)	2 (1–5)	1
2-year peak flow frequency (events per year, when present)	2 (1–4)	1 (1–3)	1
5-year peak flow magnitude (cfs)	1,146	1,146	NA
5-year peak flow duration (total days per year, when present)	2 (1–5)	2 (1–2)	NA
5-year peak flow frequency (events per year, when present)	1 (1–3)	1 (1–2)	NA
Spring recession flow magnitude (cfs)	500 (334–728)	350 (272–621)	220 (141–388)
Spring recession flow duration (days)	55 (44–77)	50 (42–62)	51 (39–76)
Spring recession flow start timing	Jun 9 (May 26–Jul 2)	May 27 (May 9–Jun 9)	May 15 (May 2–Jun 3)
Spring recession flow rate of change (%)	12 (10–14)	11 (10–13)	12 (11–14)
Dry-season baseflow magnitude (cfs)	1 (1–15)	1 (1–8)	1 (<1–3)
Dry-season duration (days)	188 (137–248)	196 (104–253)	212 (138–246)
Dry-season start timing	Aug 3 (Jul 18–Aug 19)	Jul 15 (Jul 7–Jul 28)	Jul 9 (Jun 28–Jul 21)

Ecosystem Baseflows

Ecosystem baseflows are the monthly instream flows needed to preserve a healthy stream ecosystem. Using Tessmann's adaptation of the Tennant method (Tennant 1976; Tessmann 1980), flows are calculated as a percentage of monthly and annual mean natural flows and vary throughout the year. This method is also used in the California State Water Resources Control Board's Cannabis Cultivation Policy to determine interim instream flow requirements (SWRCB 2019).

During drier months, when mean monthly discharge (MMD) is less than 40% of mean annual discharge (MAD), the MMD is the selected flow for that month. In wetter months, 40% of the MMD is the selected flow for that month. In months where 40% MAD is less than the MMD and 40% of the MAD is greater than 40% MMD, 40% MAD is the selected flow for that month. See Figure 7 for a visual representation of this process.

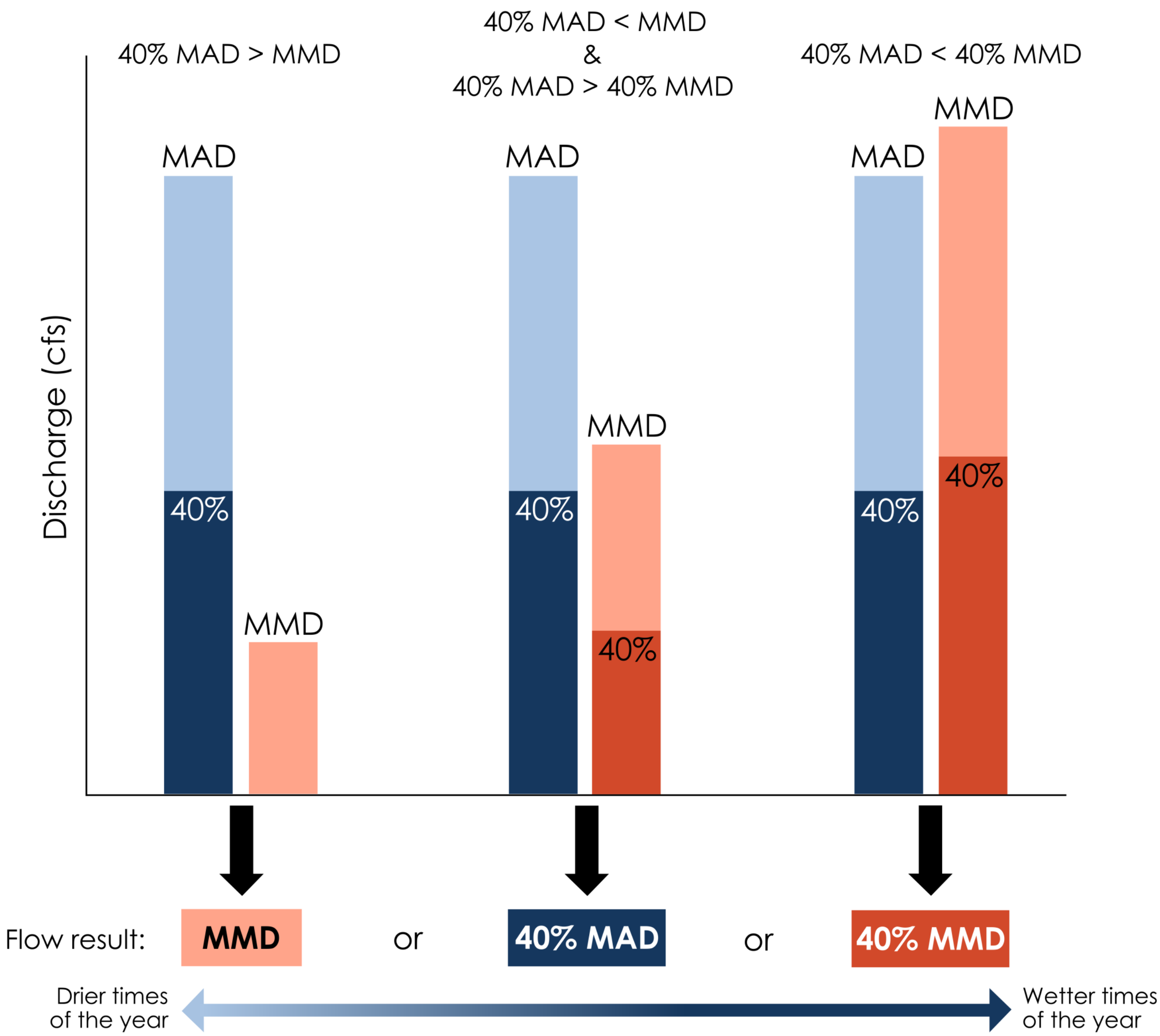

Figure 7. Comparisons used to define ecosystem baseflows.

In the Watershed Criteria Reports, monthly ecosystem baseflow values are provided for each reach (Table 3).

Table 3. Example of ecosystem baseflows by month.

Stream	Drainage Area (mi²)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1) Dry Creek	1.4	172	147	120	72	64	37	12	6	5	25	64	141

Additionally, ecosystem baseflows are plotted against median natural flows for dry, moderate, and wet water month types for a representative reach to demonstrate when these monthly flows are typically met or exceeded in the watershed (Figure 8).

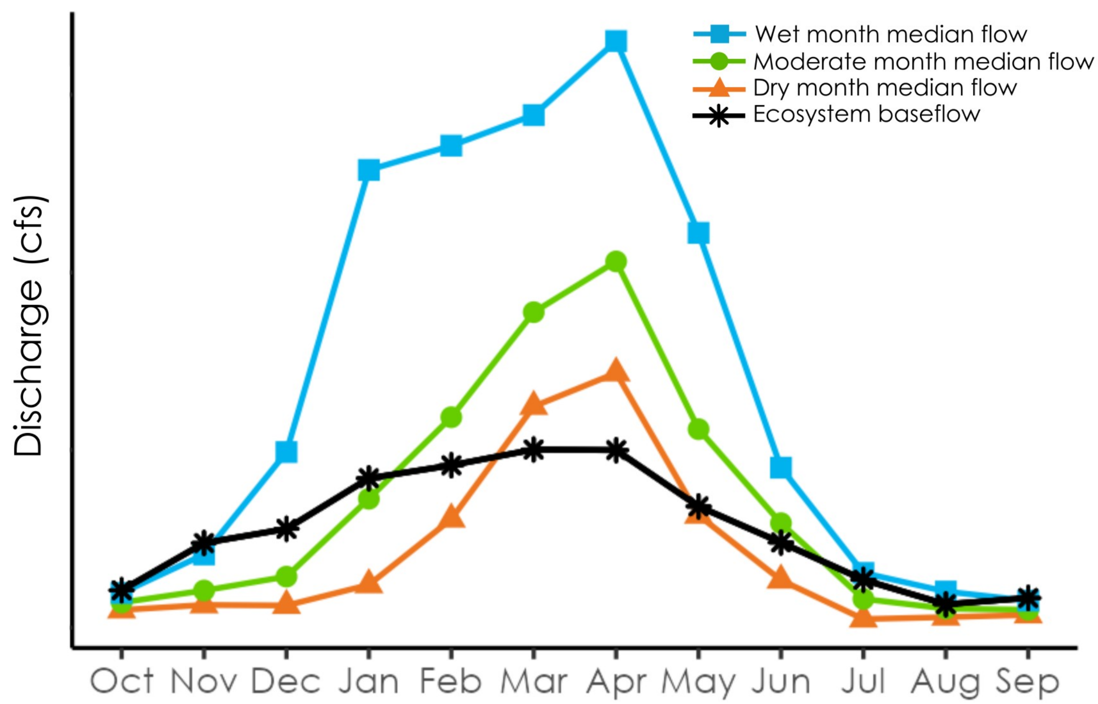

Figure 8. Example of ecosystem baseflows with median natural flows.

Ecosystem baseflows are calculated using mean natural flows and there may be instances when the ecosystem baseflow exceeds the median natural flow. In addition, ecosystem baseflows are not defined by water month type, so they may be higher than median natural flows in dry water month types and lower in wet water month types.

Salmonid Habitat Optimum Flows

Salmonid habitat optimum flows provide optimal access to preferred salmonid habitat. These flows are determined using equations published by Hatfield and Bruce (2000) and were developed as a synthesis of PHABSIM studies conducted across the western United States. The equations estimate the discharge that will maximize the usable habitat for select salmonid species and life stages using information about mean annual discharge, latitude, and longitude of the reach of interest.

In the Watershed Criteria Reports, salmonid optimum flows are provided for each reach in the form of a table (Table 4). Plots of salmonid habitat optimum flows against median natural flows are also provided for a subset of reaches (Figure 9).

Table 4. Example salmonid habitat optimum flows.

Stream	Drainage Area (mi^2)	Juvenile Steelhead Optimum Flow (cfs)
1) Dry Creek	1.4	4

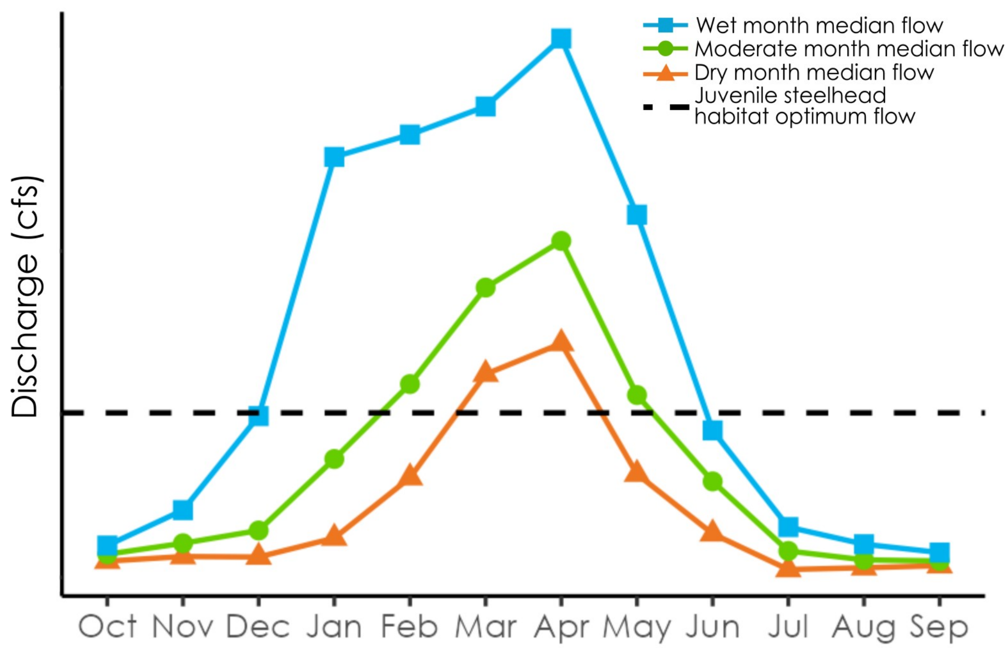

Figure 9. Example of salmonid habitat optimum flow with median natural flows.

Salmonid habitat optimum flows are a single flow value for the entire year. Because this flow value is static and does not capture intra- and interannual variability in flows, salmonid optimum flows should be considered in combination with other results (e.g., functional flows) when developing ecological flow criteria.

Sensitive Period Indicators

The sensitive period indicator flow identifies the period where aquatic species may be particularly vulnerable to reductions in flow. The wetted perimeter method may be used to identify the sensitive period indicator. In the Department's Standard Operating Procedure for the Wetted Perimeter Method (CDFW 2020a), wetted perimeter refers to the perimeter of a cross-sectional area of a streambed from wetted edge to wetted edge (Figure 10). To implement the wetted perimeter method, channel cross sections are surveyed at select riffle crests with an accompanying discharge measurement, and then the wetted perimeter length is modeled at a range of discharges. The sensitive period indicator flow must produce a wetted perimeter that covers at least 50% of the bankfull channel perimeter in streams up to 50 feet wide and 60–70% in wider streams, in addition to meeting other criteria (CDFW 2020a). When these criteria are not met, the stream ecosystem is likely to be in a sensitive period (CDFW 2017).

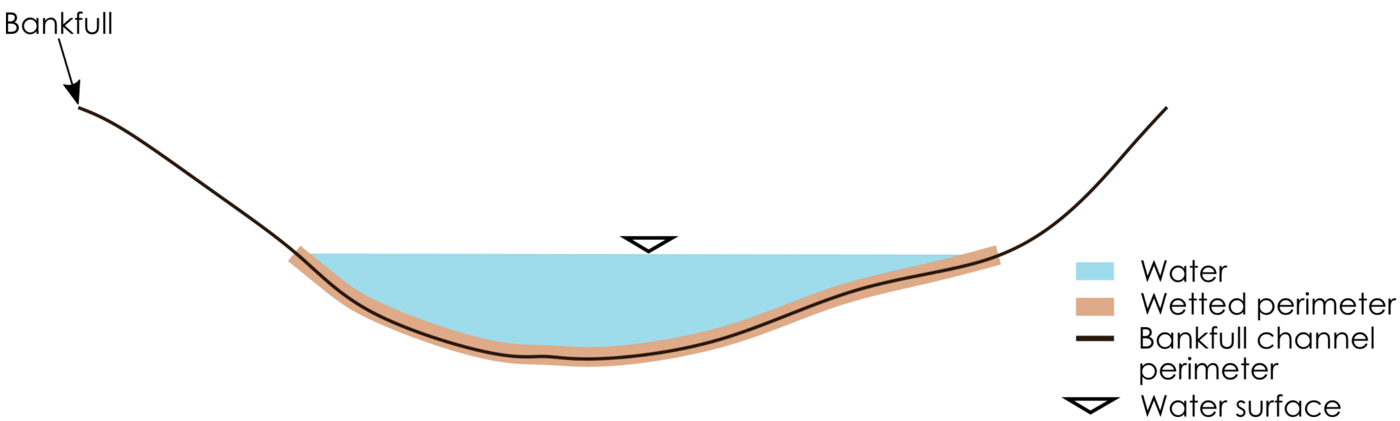

Figure 10. Wetted perimeter and bankfull channel perimeter.

These flows are provided in Watershed Criteria Reports for watersheds with wetted perimeter method field data (Table 5). They are accompanied by additional information, including water surface elevation transects and wetted perimeter-discharge curves, in an appendix.

Table 5. Example of sensitive period indicator flows.

Stream	Drainage Area (mi^2)	Number of Sites	Sensitive Period Indicator (cfs)
1) Dry Creek	1.4	3	4

When streamflow drops below the sensitive period indicator, fish and benthic macroinvertebrates may be particularly sensitive to additional water reductions and other stressors, such as poor water quality (Annear et al. 2004; CDFW 2017).

Habitat Connectivity Flows

Habitat connectivity flows provide information on the flows required to maintain instream habitat and protect fish movement between mesohabitat units. For a subset of streams in each watershed, field data may be collected to assess habitat connectivity flows using the Standard Operating Procedure for the Habitat Retention Method in California (CDFW 2018b). To perform this method, channel cross sections are surveyed at the ***hydraulic control***[5] of riffles (Figure 11) with an accompanying discharge measurement (CDFW 2020b). Hydraulic parameters (i.e., depth, velocity, and wetted perimeter) are then modeled across a range of flows. Connectivity criteria for target salmonid species and life stages are provided in CDFW 2018b.

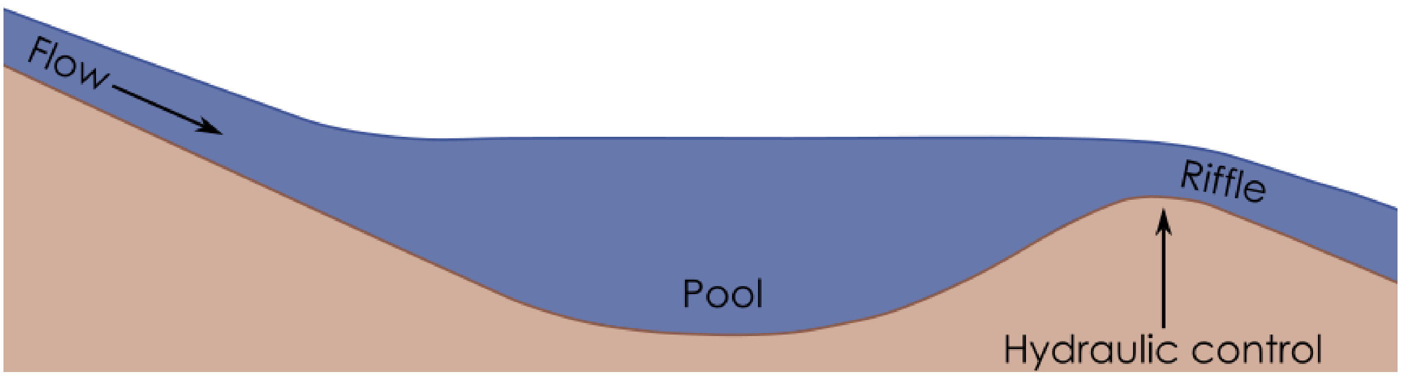

Figure 11. Schematic of a hydraulic control at a riffle.

[5] A horizontal or vertical constriction in the channel, such as the crest of a riffle, which creates a backwater effect (Annear et al. 2004).

Habitat connectivity flows are the flows sufficient to protect movement of salmonids throughout the stream (Annear et al. 2004). When streamflow drops below the habitat connectivity flow for juveniles, juvenile fish pool-to-pool movement becomes limited (CDFW 2018b). Because habitat connectivity flows are focused on particular taxa and are provided as a single flow value, they should be used in combination with other results when developing flow criteria in order to capture flow needs of the ecosystem throughout the year.

The species- and life-stage-specific passage flow values represent values averaged across multiple sites within a reach (number of sites per reach will be provided as shown in Table 6).

Table 6. Example of habitat connectivity flows.

Stream	Drainage Area (mi^2)	Number of Sites	Juvenile Steelhead Connectivity Flow (cfs)
1) Dry Creek	1.4	3	7

Fresno River
FRESNO RIVER WATERSHED, MADERA COUNTY

Flow Criteria

Results from the analyses sections in the Watershed Criteria Reports may be used to develop flow criteria for locations of interest throughout the watershed. Criteria are intended to produce flow patterns that vary within and between years to mimic the natural hydrograph and maintain or restore processes that sustain natural riverine characteristics. Flow criteria provide target flow values for streamflow management that are protective of the aquatic and riparian ecosystem.

Results from the functional flows section provide the foundation for the development of flow criteria in the Watershed Criteria Reports. Functional flows are based on reference hydrologic conditions and are broadly protective of the aquatic and riparian ecosystem while not focusing on a single species. Functional flows are available for every stream reach in the state, so these metrics can be consistently applied to reaches throughout a watershed and across watersheds statewide. Functional flows are also used in the California Environmental Flows Framework, a product developed by state agencies, non-profits, and academic institutions via the California Water Quality Monitoring Council.

When site-specific results (e.g., sensitive period indicator flows and habitat connectivity flows) are available for a watershed, they may be used in conjunction with functional flows to develop flow criteria. Other results presented in the Watershed Criteria Reports provide valuable context on the watershed's hydrologic patterns (e.g., flow variation and median natural flows) as well as information about specific flow needs of a particular species or life history (e.g., salmonid habitat optimum flows).

Functional flows provide a broadly protective set of results with which to develop flow criteria, and may be used in combination with other data not provided in the Watershed Criteria Reports when appropriate. For example, because the Watershed Criteria Reports are hydrology-based and do not explicitly address water quality, site-specific water quality information such as temperature or dissolved oxygen data could be incorporated to set thresholds when developing flow criteria. Additionally, depending on management needs, site- or species-specific habitat suitability data and hydraulic habitat models may be needed to further develop flow criteria.

In the Watershed Criteria Reports, flow criteria are provided for a select reach or reaches as an example of how to develop criteria for the watershed of interest. Flow criteria are displayed in a table for three water year types (i.e., wet, moderate, and dry) organized by functional flow seasons with additional detail describing transitional periods, such as the spring recession (Table 7). The information in these tables consolidates the results from the functional flows section of the Watershed Criteria Report. In addition, hydrographs showing an example flow regime by water year type are provided in the Watershed Criteria Report to present an example of how flow criteria could be applied (Figure 12).

Table 7. Example flow criteria for three water year types (i.e., wet, moderate, and dry).

Water Year Type	Wet Season Nov-May	Spring Recession Week 1	Spring Recession Week 2	Spring Recession Week 3	Spring Recession Week 4	Spring Recession Week 5	Spring Recession Week 6	Spring Recession Week 7	Spring Recession Week 8	Dry Season Jul-Nov
Wet	47†	352	144	59	24	10	4	2	1	1‡
Moderate	38†	253	112	50	22	10	4	2	1	1‡
Dry	24†	155	63	26	11	4	2	1	-	1‡

† Approximately every two years, protect two peak flow events of 700 cfs as they occur. Approximately every five years, protect at least one peak flow event of 1,200 cfs as it occurs.

‡ In November, allow a fall pulse event of at least 40 cfs.

- The length of the recession varies by water year type. The recession lasts for 6 weeks in wet and moderate years, and 5 weeks in dry years. The rate of change for wet and dry years is 12% per day, and 11% per day in moderate years.

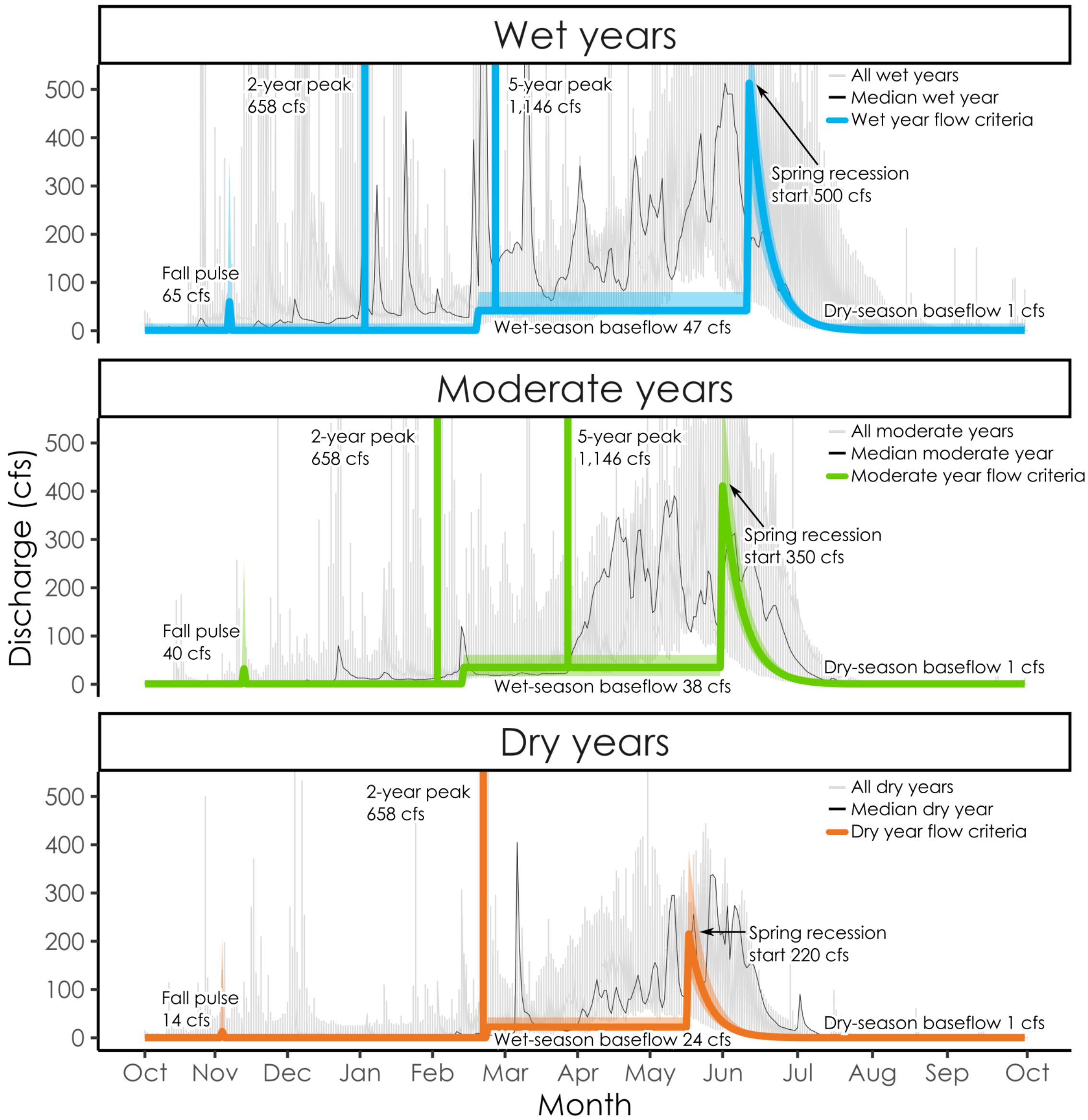

Figure 12. Example flow criteria using values from Table 7.

Flow Criteria Implementation

An understanding of site context and ecological management goals is necessary to effectively apply the flow criteria from the Watershed Criteria Reports. Ecological management goals should address a specific ecological concern but may vary in their degree of specificity. These goals should be developed independently of other non-ecological management goals or concerns in the watershed or stream of interest.

When applying flow criteria in a management context, best professional judgement should be employed, and Department staff should be consulted. Additionally, following implementation of flow criteria, monitoring of hydrologic and ecological conditions should occur to determine the efficacy of flow criteria. These monitoring results should inform adaptive management actions.

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