Instream Flows, Inter-connected Surface Waters, and Groundwater-Dependent Ecosystems

A variable, or natural, flow regime plays an important role in governing ecological processes that shape riverine habitats and support healthy aquatic ecosystems. Functional flows are elements of the natural flow regime that perform distinct ecological and geomorphic functions and support the specific life history and habitat needs of native species (Yarnell et al. 2015; Yarnell et al. 2020). These flows are important for groundwater basin recharge, supporting surface water flows, and can be used to represent specific flow components needed for the environment.

In many groundwater basins, inter-connected surface waters (ISWs) intersect with sensitive species and habitats that rely on groundwater to sustain all or a portion of their water needs. If hydrologic connectivity exists between a terrestrial or aquatic ecosystem and groundwater, then that ecosystem may be considered a potential groundwater-dependent ecosystem (GDE). The connection between surface water flows and groundwater is complex, requires monitoring, hydrologic modeling, and an understanding of how this interconnection influences the environment, habitat, and fish and wildlife.


East and West Walker Creek
MONO COUNTY

Thoughtful groundwater planning, inclusive of natural flow regimes, can maintain or improve groundwater conditions for GDEs that provide essential forage and refuge for species. Conversely, poor groundwater management that disregards fish and wildlife needs can take water away from habitat, stressing terrestrial and aquatic species. The overuse of groundwater can adversely influence fish and wildlife; often, in basins where groundwater and surface water interconnect. Depletion of ISW can disturb important ecological and geomorphic functions in a stream system that once maintained healthy conditions for aquatic and riparian species.

Groundwater and Functional Flow Components

In California, functional flow components (Figure 1) include the fall pulse flow, the wet-season baseflow, peak flows, the spring recession flow, and the dry-season baseflow (CDFW 2021). Per use of flow regimes each functional flow component is quantified by a set of functional flow metrics, which describe the timing, magnitude, duration, frequency, and rate of change of flows. In a stream system with perennial, intermittent, or ephemeral connection to groundwater, the timing and quantity of depletion of ISW has the potential to alter functional flow metrics and disrupt key ecological functions that support GDEs and fish and wildlife use of groundwater (Barlow and Leake 2012). Key ecological functions include nutrient and sediment transport, channel restructuring and habitat maintenance, fish passage, riparian species recruitment, and groundwater recharge.

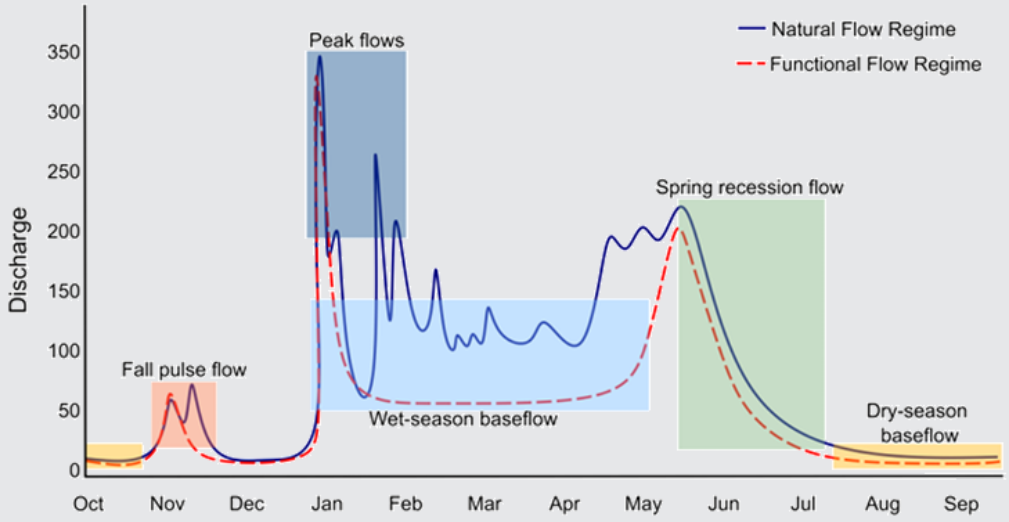

Figure 1. Hydrograph of functional flows.

Groundwater and Streamflow

Groundwater levels and stream flows generally reflect the seasonal and climatic conditions of a region, therefore, GDEs may rely more on groundwater than surface water during certain times of the year, and vice versa. Functional flow components can preserve key ecosystem functions, contribute to maintaining healthy ecosystems, and support aquifer storage and recharge where there is an interconnection to groundwater. Similarly, use of functional flow components can aid in the avoidance of depletion of ISW and alleviate negative influences to GDEs and fish and wildlife. Tables 1-5, adapted from the California Environmental Flows Framework (CEFF) Version 1.0, summarizes the five functional flow components and their supported ecosystem functions per benefits to ISWs, GDEs, and fish and wildlife where an interconnection to groundwater exists (CEFWG 2021).

Table 1. **FALL PULSE FLOW** metrics and ecosystem-function-associated benefits to ISWs and GDEs based on the CEFF Technical Report.

SUPPORTED ECOSYSTEM FUNCTION	TYPE OF ECOSYSTEM FUNCTION	ASSOCIATED FLOW CHARACTERISTIC
Flush fine sediment and organic material from substrate	Physical	Magnitude
Increase longitudinal connectivity	Physical	Magnitude, duration
Increase riparian soil moisture	Physical	Magnitude, duration
Flush organic material downstream and increase nutrient cycling	Biogeochemical	Magnitude, duration
Modify salinity conditions in estuaries	Biogeochemical	Magnitude, duration
Reactivate exchanges/ connectivity with hyporheic zone	Biogeochemical	Magnitude, duration
Decrease water temperature and increase dissolved oxygen	Biogeochemical	Magnitude, duration
Support fish migration to spawning areas	Biological	Magnitude, timing, rate of change

Table 2. WET-SEASON BASEFLOW metrics and ecosystem-function-associated benefits to ISWs and GDEs based on the CEFF Technical Report.

SUPPORTED ECOSYSTEM FUNCTION	TYPE OF ECOSYSTEM FUNCTION	ASSOCIATED FLOW CHARACTERISTIC
Increase longitudinal connectivity	Physical	Magnitude, duration
Increase shallow groundwater (riparian)	Physical	Magnitude, duration
Support hyporheic exchange	Biogeochemical	Magnitude, duration
Support migration, spawning, and residency of aquatic organisms	Biological	Magnitude
Support channel margin riparian habitat	Biological	Magnitude

Table 3. **WET-SEASON PEAK FLOW** metrics and ecosystem-function-associated benefits to ISWs and GDEs based on the CEFF Technical Report.

SUPPORTED ECOSYSTEM FUNCTION	TYPE OF ECOSYSTEM FUNCTION	ASSOCIATED FLOW CHARACTERISTIC
Scour and deposit sediments and large wood in channel, floodplains, and overbank areas; encompasses maintenance and rejuvenation of physical habitat	Physical	Magnitude, duration, frequency
Increase lateral connectivity	Physical	Magnitude, duration
Recharge groundwater (floodplains)	Physical	Magnitude, duration
Increase nutrient cycling on floodplains	Biogeochemical	Magnitude, duration
Increase exchange of nutrients and organic matter between floodplains and channel	Biogeochemical	Magnitude, duration
Support fish spawning and rearing in floodplains and overbank areas	Biological	Magnitude, duration, timing
Support plant biodiversity via disturbance, riparian succession, and extended inundation in floodplains and overbank areas	Biological	Magnitude, duration, frequency
Limit vegetation encroachment and non-native aquatic species via disturbance	Biological	Magnitude, frequency

Hollow Tree Creek
MENDOCINO COUNTY

Table 4. SPRING RECESSION FLOW metrics and ecosystem-function-associated benefits to ISWs and GDEs based on the CEFF Technical Report.

SUPPORTED ECOSYSTEM FUNCTION	TYPE OF ECOSYSTEM FUNCTION	ASSOCIATED FLOW CHARACTERISTIC
Sorting of sediments via increased sediment transport and size-selective deposition	Physical	Magnitude, rate of change
Recharge groundwater (floodplains)	Physical	Magnitude, duration
Increase lateral and longitudinal connectivity	Physical	Magnitude, duration
Decrease water temperatures and increase turbidity	Biogeochemical	Duration, rate of change
Increase export of nutrients and primary producers from floodplain to channel	Biogeochemical	Magnitude, duration, rate of change
Provide hydrologic cues for fish outmigration and amphibian spawning; support juvenile fish rearing	Biological	Magnitude, timing, rate of change
Increase hydraulic habitat diversity and habitat availability resulting in increased algal productivity, macroinvertebrate diversity, arthropod diversity, fish diversity, and general biodiversity	Biological	Magnitude, timing, rate of change, duration
Provide hydrologic conditions for riparian species recruitment (e.g., cottonwood)	Biological	Magnitude, timing, rate of change, duration
Limit riparian vegetation encroachment into channel	Biological	Magnitude, rate of change

Table 5. DRY-SEASON BASEFLOW metrics and ecosystem-function-associated benefits to ISWs and GDEs based on the CEFF Technical Report.

SUPPORTED ECOSYSTEM FUNCTION	TYPE OF ECOSYSTEM FUNCTION	ASSOCIATED FLOW CHARACTERISTIC
Maintain riparian soil moisture	Physical	Magnitude, duration
Limit longitudinal connectivity in ephemeral streams; limit lateral connectivity to disconnect floodplains	Physical	Magnitude, duration, timing
Maintain longitudinal connectivity in perennial streams	Physical	Magnitude
Maintain water temperature and dissolved oxygen	Biogeochemical	Magnitude, duration
Maintain habitat availability for native aquatic species (broadly)	Biological	Magnitude, duration, timing
Condense aquatic habitat to limit non-native species and support native predators	Biological	Magnitude, duration
Support primary and secondary producers	Biological	Magnitude

CDFW Groundwater Program

As trustee for the State's fish and wildlife resources, CDFW has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species (Fish & Game Code §§ 711.7 and 1802). CDFW has an interest in sustainable groundwater management, as many sensitive ecosystems and public trust resources such as streams, springs, riparian areas, and wetlands are dependent on groundwater and interconnected surface waters.

Thoughtful groundwater planning can maintain or improve groundwater conditions for GDEs that provide essential forage and refuge. Conversely, poor groundwater management that disregards fish and wildlife needs can take water away from habitat, stressing terrestrial and aquatic species. Accordingly, CDFW values and supports groundwater planning that carefully considers and protects GDEs.

In response to the passage of the Sustainable Groundwater Management Act (SGMA), CDFW developed a Groundwater Program to ensure fish and wildlife resources reliant on groundwater are addressed in groundwater sustainability plans, and to support compliance with regulatory requirements on CDFW-owned lands and facilities in groundwater basins subject to SGMA.

For further information on SGMA, CDFW's role in groundwater management, and fish and wildlife groundwater planning consideration, please visit the CDFW Groundwater Program webpage.

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Other Tools and Resources

California Department of Fish and Wildlife

[Fish&Wildlife Groundwater Planning Considerations]

[Fish&Wildlife Groundwater Planning Considerations: Freshwater Wetlands]

The California Department of Fish and Wildlife INSTREAM FLOW PROGRAM

[Watershed-Wide Instream Flow Criteria]

[CDFW Functional Flows Fact Sheet]

CALIFORNIA DEPARTMENT OF WATER RESOURCES

[SGMA Portal: Find your GSA/GSP]

[SGMA Data Viewer: Explore Statewide Groundwater Data]

[California's Groundwater Live]

The Nature Conservancy

[Critical Species LookBook]

[GDE Pulse]

[Plant Rooting Depth Database]

Other Links:

[Groundwater Exchange Website]

[California's Groundwater Update 2020]

[Natural Communities Commonly Associated with Groundwater]

[USGS Technical Report: Streamflow Depletion by Wells]

REFERENCES

Barlow, P.M., and S.A. Leake (2012). Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376, 84 pp.

CDFW (2021). California Department of Fish and Wildlife, Functional Flows Fact Sheet. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=193620&inline

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