COMPONENTS OF PROTECTED INSTREAM FLOW CRITERIA

MARCH 2024

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

NH Protected River

WD-24-01

COMPONENTS OF PROTECTED INSTREAM FLOW CRITERIA

Prepared by

Wayne Ives, P.G.
Instream Flow Specialist
and
Lauren Zielinski
Instream Flow Environmental Technician

Watershed Management Bureau, Water Division
New Hampshire Department of Environmental Services

Robert R. Scott
Commissioner

Rene Pelletier. P.E., Director
Water Division

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

New Hampshire Department of Environmental Services
PO Box 95, Concord, NH 03302-0095
des.nh.gov | (603) 271-3503

March 2024

1. Protected Instream Flow Criteria

This document provides a brief overview of how instream flow criteria are described. More details on the development of the process can be found in the Report of the Instream Flow Pilot Program.

1.1. The Natural Flow Paradigm

In New Hampshire, the protected instream flow criteria are designed to maintain the range and variability of natural stream flow conditions. This goal follows the "natural flow paradigm" described by Prof. LeRoy Poff and others in 1997 (Poff et al. 1997).

The natural flow paradigm recognizes that wildlife, plants, habitats and most human uses are best supported by maintaining natural stream flow variability. Floods and droughts have important roles in natural river environments, as do the flows in between. Substantial difference from the natural flow pattern is shown to cause ecosystem impairment including habitat loss, mortality or loss of function.

The natural flow paradigm also recognizes that the natural flow pattern requires variability of flow across several timescales. A single flow cannot describe the flows that support fish and other species living in and near a river. The natural flow paradigm says that a stream's flow pattern needs to be described using several flow components to capture the complexities of stream flow variability. The description of natural stream flow variability is most completely expressed by combining several flow characteristics: magnitude, timing, frequency, duration, and rate of change.

The protected instream flow criteria that are developed for designated rivers in New Hampshire are specific to times of the year and they describe magnitudes and associated durations based on frequency analysis. The protected instream flow criteria define a stream flow pattern that allows high, intermediate and low flows to occur with their natural frequencies. As a result, the protected instream flow criteria describe a pattern of stream flows that allow high and low flows appropriate within biologically significant periods of the year. This pattern is what is needed to avoid impairments for flow under the water quality standards. Once the flow pattern has been established using a scientific approach, management actions are then applied to maintain or achieve this pattern.

1.2. Description of Protected Instream Flow Criteria

The following section describes generic protected instream flow criteria. Protected instream flow criteria are made up of the timing, magnitude and duration parameters that define the natural flow pattern that protects flow-dependent uses. These uses included: 1) fish and aquatic life, 2) riparian wildlife and vegetation and 3) recreational boating. The criteria for aquatic life are used to define short-term flow protections. Fish cannot survive for many days under severe stresses from low flows, and as such, these protections are applied over the course of days and weeks. Riparian species from high quality wetlands, to stream bank hemlock forests, and exemplary natural communities in between, have protected instream flows that were established using longer-term flood flow requirements. Riparian plants are supported by higher but less frequent flow events – flows that occur within a period of years to decades. Protections for recreational flows rely on maintaining the frequency of suitable boating conditions to maintain the opportunities for boating. Trends in the timing and duration of both riparian flows and suitable recreational flows are tracked over years and decades. An example of how protected instream flow criteria are presented can be found in Table 1-1.

Table 1-1 - Example Protected Instream Flow Criteria for aquatic and riparian life and recreational flow preferences.

Bioperiod & Date Range	Common Flow (cfs)	Common Flow (cfsm)	Common Allowable Duration (days)	Common Persistent Duration (days)	Common Catastrophic Duration (days)	Critical Flow (cfs)	Critical Flow (cfsm)	Critical Allowable Duration (days)	Critical Persistent Duration (days)	Critical Catastrophic Duration (days)	Rare Flow (cfs)	Rare Flow (cfsm)	Rare Allowable Duration (days)	Rare Persistent Duration (days)	Rare Catastrophic Duration (days)
Bioperiod 1 Dec 1 – Feb 28/29	70	0.94	0 - 49	50 - 73	74+	40	0.538	0 – 24	25 - 42	43+	15	0.20	0 - 10	11 - 14	15+
Bioperiod 2 March 1 – April 15	125	1.68	0 - 24	25 - 36	37+	65	0.87	0 – 12	13 - 19	20+	40	0.54	0 - 7	8 - 11	12+
Bioperiod 3 April 16 – May 15	100	1.34	0 - 11	12 - 19	20+	70	0.94	0 – 9	10 - 17	18+	55	0.74	0 - 3	4 - 6	7+
Bioperiod 4 May 16 – July 7	60	0.81	0 - 23	24 - 47	48+	22	0.30	0 – 9	10 - 24	25+	10	0.13	0 - 5	6 - 7	8+
Bioperiod 5 July 8 – Sept 21	20	0.27	0 - 39	40 - 62	63+	8	0.11	0 – 14	15 - 24	25+	4	0.05	0 - 4	5 - 11	12+
Bioperiod 6 Sept 22 – Nov 30	55	0.74	0 - 29	30 - 63	64+	16	0.21	0 – 14	15 - 22	23+	8	0.11	0 - 5	6 - 9	10+

Note: Flow rates provided are linked to a long-term stream flow monitoring station that provides daily measurements.

Retain the following flow event frequencies for riparian species:

- >3,500 cfs, every 10 to 25 years.
- 3,490 to 2,710 cfs every 10 years.
- 1,080 to 1,920 cfs every 2 years.

Retain the following flow event frequencies for recreation:

- 850 to 1,020 cfs every spring.

1.2.1. Protected Instream Flow Criteria for Aquatic Life

Protected instream flow criteria for aquatic life are defined using the stream flow components of ***timing***, ***magnitude***, ***duration*** and ***frequency*** to describe a stream flow pattern that is supportive of aquatic life specific to the river. The protected instream flow criteria are typically, but not always, comprised of six bioperiods. Each bioperiod has three flow magnitudes and each flow magnitude has three sets of durations. The purpose of using these components is to adequately define the stream flow variability to create a flow pattern with enough flexibility to encompass the wide range of possible flows envisioned by the natural flow paradigm. Together, these components define criteria that allow for some periods of very low flows while managing to prevent conditions of acute or frequent conditions of chronic stress for aquatic species.

The first component of protected instream flow criteria is the ***timing*** of flows, which are defined by **bioperiods.** Bioperiods are biologically significant periods of the year for a variety of aquatic species. The appropriate aquatic species for defining bioperiods are identified from target fish communities developed by Gomez and Sullivan in 2018 for most of New Hampshire's designated rivers. A change in bioperiods represents an important change in flow needs for life stages of aquatic species in the river (i.e., spawning, feeding, migrating, etc.). The start and end dates of the bioperiods are identified based on the river's hydrology and the life stages of target aquatic species. An example graph of the annual distribution of bioperiods and the life cycle stages they represent is shown in ***Figure 1-1*.**

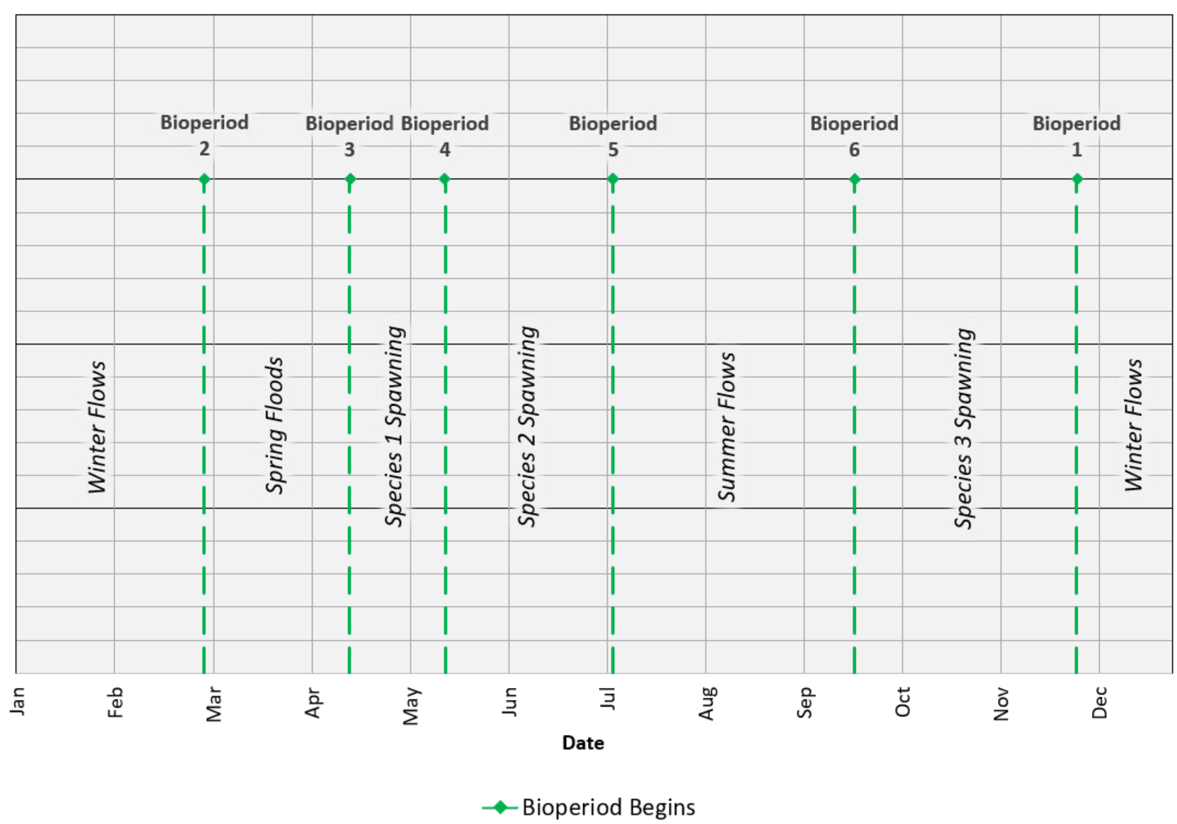

Figure 1-1 – Example of bioperiods in a year with typical life cycles of aquatic species.

The life cycles of target fish community species identified for each designated river are modeled to assess protected instream flow criteria for aquatic life. Three biologically significant flow ***magnitudes*** are defined for each bioperiod: **Common**, **Critical** and **Rare.** ***Figure 1-2*** illustrates three generic flow magnitudes within one of the bioperiods. These three levels of magnitudes describe the thresholds between moderate to low flows, low to very low flows, and very low to severely low flows, respectively. Each magnitude represents an important threshold in the amount and types of habitats available at that flow. Stream flows below each of these magnitudes represents a more rapid loss of habitat and consequently increased levels of stress for fish and aquatic life.

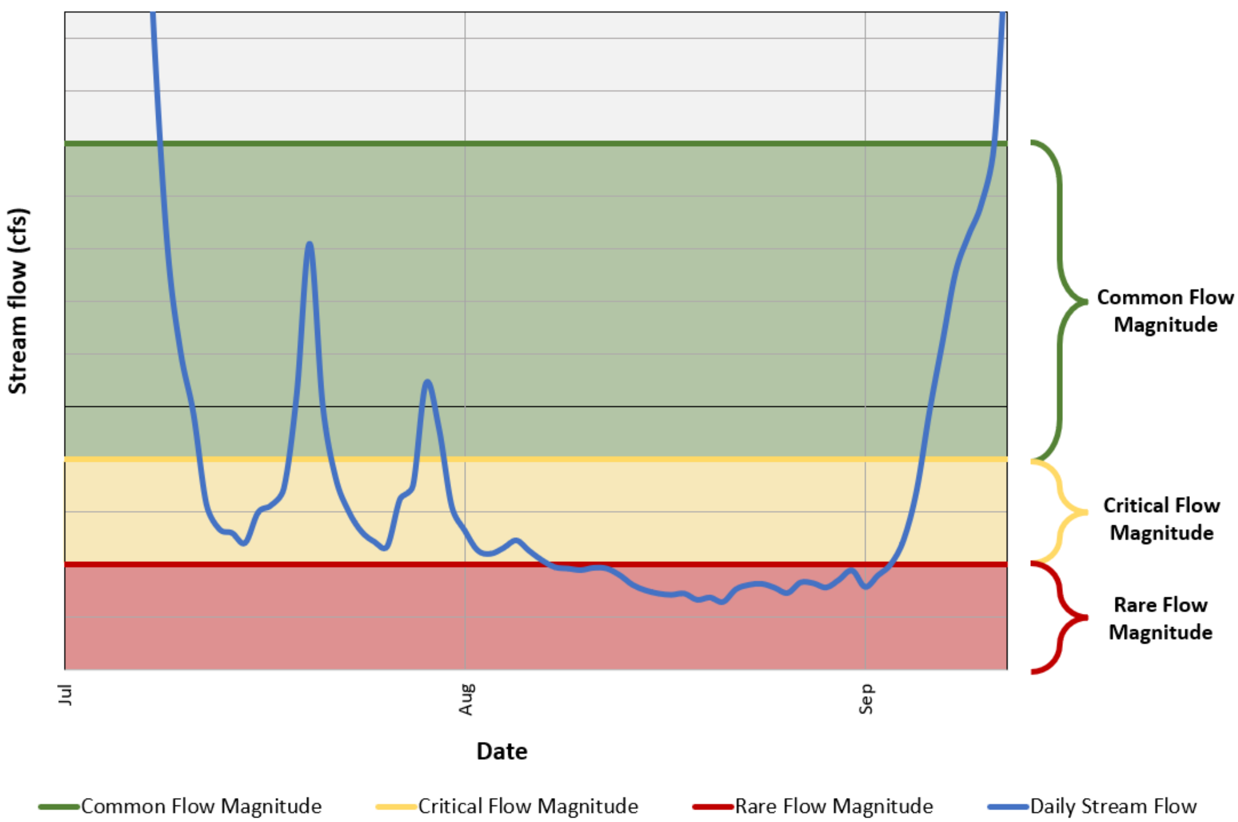

Figure 1-2 – Illustration of Common, Critical and Rare Flow Magnitudes within one bioperiod with example daily stream flows.

Biological stress during low flows occurs naturally, but typically only lasts for a short amount of time. As such, flows that are too low for too long can cause excessive stress. Three flow ***durations*** defining stress thresholds were identified for each flow magnitude. The magnitudes and durations were determined using frequency analyses of the relationship between historical flows and the associated amount of aquatic habitat.

The three durations associated with each bioperiod's magnitudes are described as **Allowable**, **Persistent** and **Catastrophic**. The Allowable Duration is the number of days below a flow threshold that occur regularly and typically do not contribute much additional stress to aquatic life. When flows are below a flow threshold within the Persistent Duration, it amounts to chronic stress conditions on instream species. When flows are within the Catastrophic Duration, it represents acute stress conditions. The number of days for each duration category varies for each flow magnitude and bioperiod. Once the flow exceeds a flow magnitude threshold for two average daily flows, the duration is then reset. Figure 1-3 shows how flows would be defined in an example river during a typical late summer as streamflow falls below the common, then critical, and then rare flow magnitudes before rising back above the benchmark values.

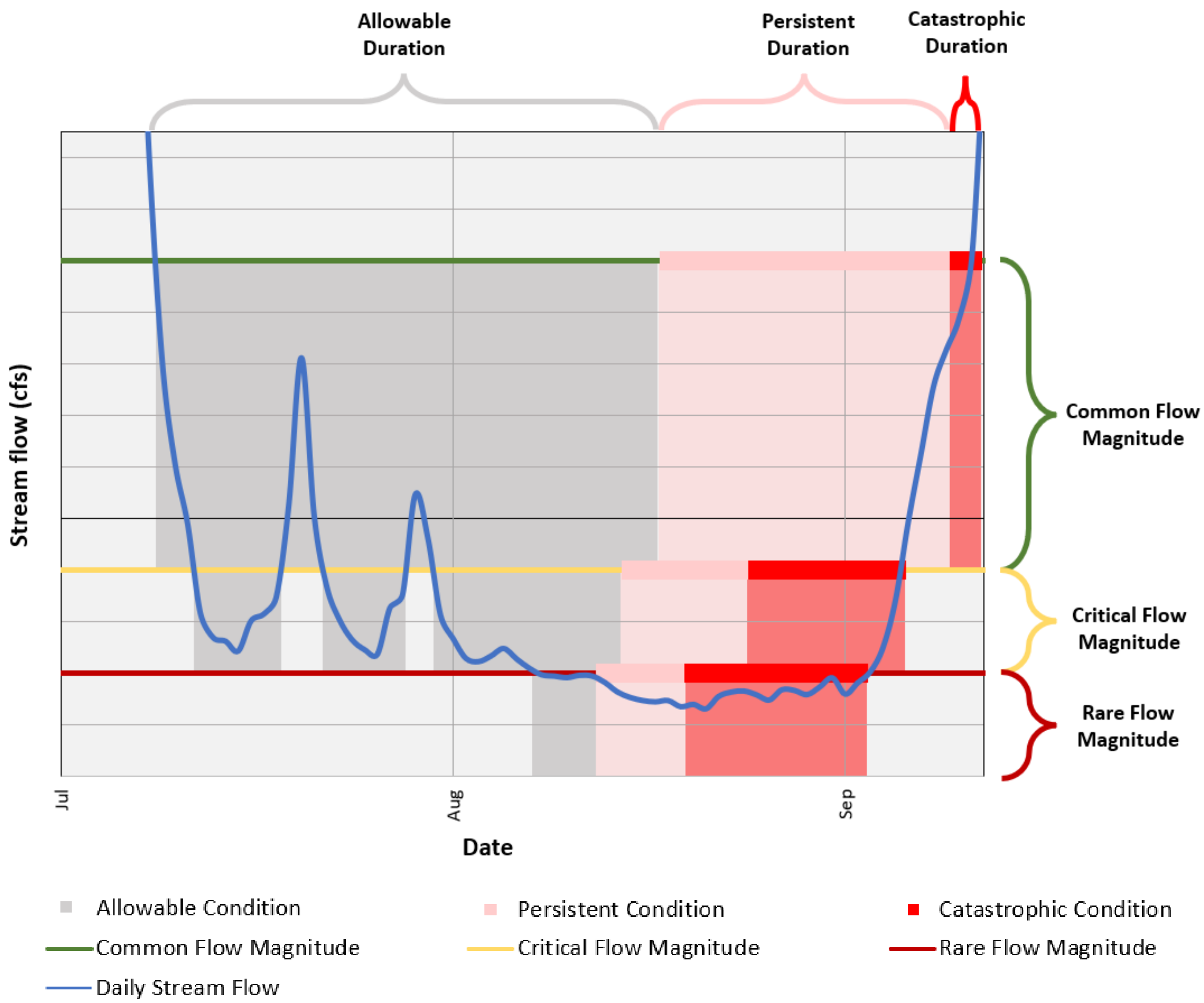

Figure 1-3 – Illustration of a generic example of daily stream flow record versus Allowable, Persistent and Catastrophic durations with respect to flows below the Common, Critical and Rare flow magnitudes within one bioperiod. Exceeding these durations when flow is below a protected flow magnitude results in Persistent and Catastrophic conditions. Two days above a flow magnitude resets the condition.

The ***frequency*** of these low flow periods is also important to track, as multiple chronic conditions can also impact the resiliency of aquatic species. A Persistent or Catastrophic Condition resets after 48 hours above the applicable flow threshold, because these higher flows provide a reprieve from these stressful conditions. Because of this reset mechanism, more than one Persistent or Catastrophic Event can occur in one bioperiod, and such events can be repeated in multiple bioperiods each year. Repeated Persistent Conditions can become a Catastrophic Condition as a result of recurring chronic conditions. As a result, three consecutive years with Persistent Critical or Rare Conditions in a specified bioperiod will result in an acute impact and therefore be considered a Catastrophic Condition.

An example showing daily stream flows in relation to six bioperiods each with their three flow magnitudes is shown in ***Figure 1-4***. Flows can fall below these magnitudes, but only for limited durations before management is applied. Note that Bioperiod 6 continues from the end of one year into the beginning of the next.

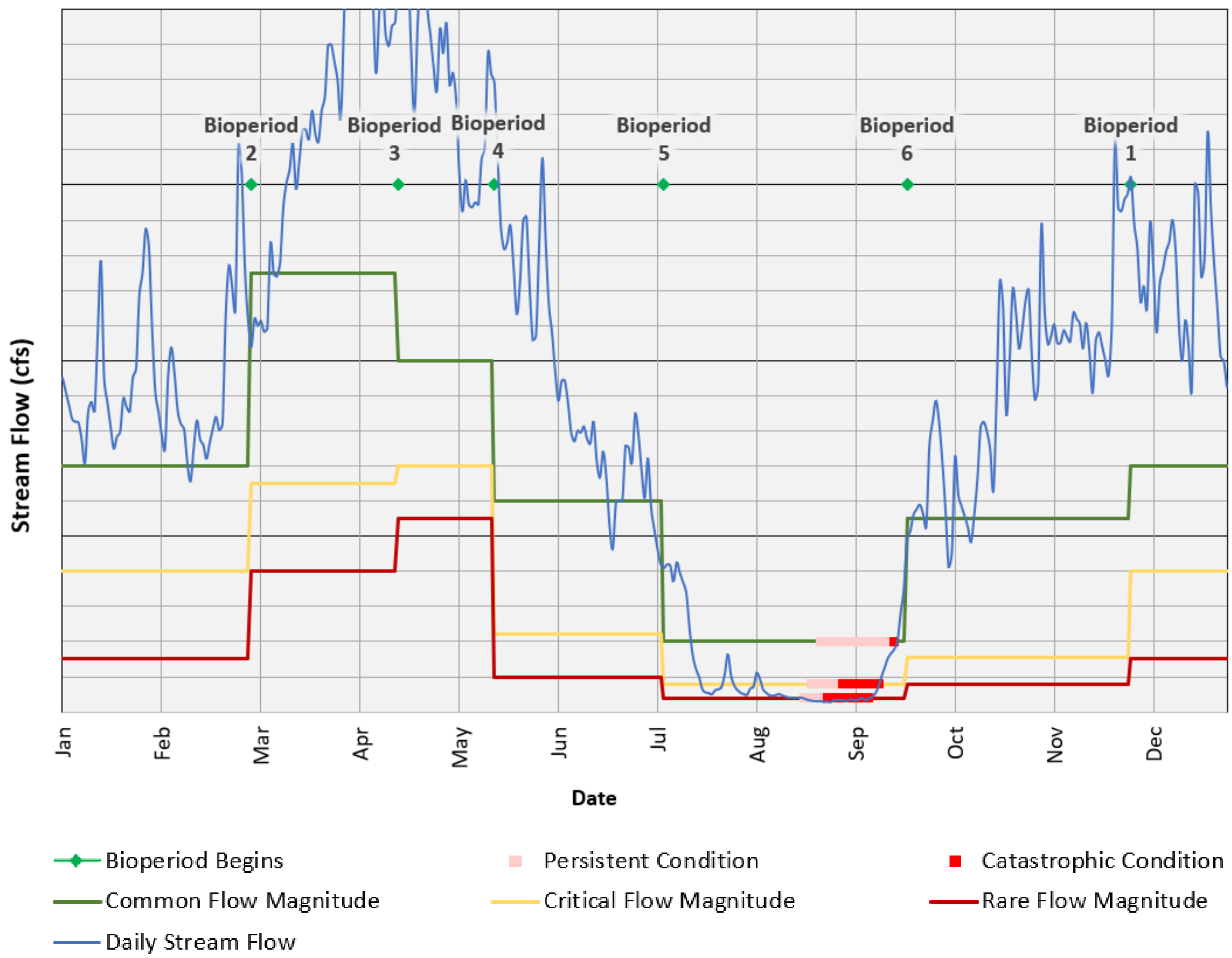

Figure 1-4 – Example graph showing daily stream flows compared to protected flow magnitudes during six generic bioperiods and the occurrences of Persistent and Catastrophic conditions resulting from extended low flows below a bioperiod's flow magnitudes. Each bioperiod has its own set of instream flow requirements for flow duration defining when Allowable, Persistent and Catastrophic conditions occur.

1.2.2. Protected Instream Flow Criteria for Riparian Species

Riparian species living on the riverbanks are adapted to patterns of flooding and drying. Lower elevations on the riverbank are commonly wetted, while higher elevations are wetted only occasionally by larger floods. Higher flows are also required for some riparian species' life cycles since these higher flows can carry seeds downstream to access new habitat, refresh nutrients, and replenish sand and dirt for seeds to germinate.

Elevation surveys of the riverbanks and floodplains are typically conducted identifying the boundaries of riverbank (riparian) plants and their communities. Inundation of these plants is part of their life cycle needs. Using the relationship between a stream's water level and its flow, the flows that will inundate these communities are determined. Studies of species' life cycles are examined to determine the preferred frequency of the inundations, or the historical frequency of the flows required to inundate the plant community were identified. Flow protections are then sorted to simplify the results by eliminating redundancies.

1.2.3. Protected Instream Flow Criteria for Recreation

Designated rivers are often used for a variety of recreational activities. These can include swimming, boating, fishing, and white-water rafting, among other activities. These activities may have flow requirements applicable to certain times of the year, such as whitewater boating during the spring. Recreational surveys, in-person and online outreach efforts and field observations are typically used to determine flow requirements for recreation. Where recreational criteria exist, they are then assessed against the criteria for aquatic species and riparian vegetation to see if they are already being met by these requirements. Applicable criteria are then added to the protected instream flow criteria.

2. Conclusion

Protected instream flow criteria are developed in New Hampshire recognizing that stream flows are dynamic during and across years. Describing the protected instream flow criteria using the components of the natural flow paradigm avoids prescribing specific flows in favor of a more flexible flow pattern. The pattern supports aquatic and riparian life stages by providing natural flow variability that ranging from high to low. This flow pattern maintains the variability that supports differing aquatic species, within the same environment, that may prefer higher or lower flows. Flows supporting riparian ecosystems are identified to ensure they persist. In addition, identification of recreational flows provides the means to assess conditions that support human use of the river.

3. References

NH Department of Environmental Services, Administrative Rules - Env-Wq 1700: Surface Water Quality Standards, effective 12-1-16.

NH Department of Environmental Services, Administrative Rules - Env-Wq 1900: Rules for the Protection of Instream Flow on Designated Rivers

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., and J.C. Stromberg., 1997. The Natural Flow Regime: A Paradigm for River Conservation and Restoration. BioScience 47(11): 769-784.

Watershed Management Bureau, NH Department of Environmental Services, Report of the Instream Flow Pilot Program. R-WD-15-1. December 1, 2015.

Watershed Management Bureau, NH Department of Environmental Services, Current Cold River Instream Flow Conditions aka Cold River Protected Instream Flow Tracking Tool