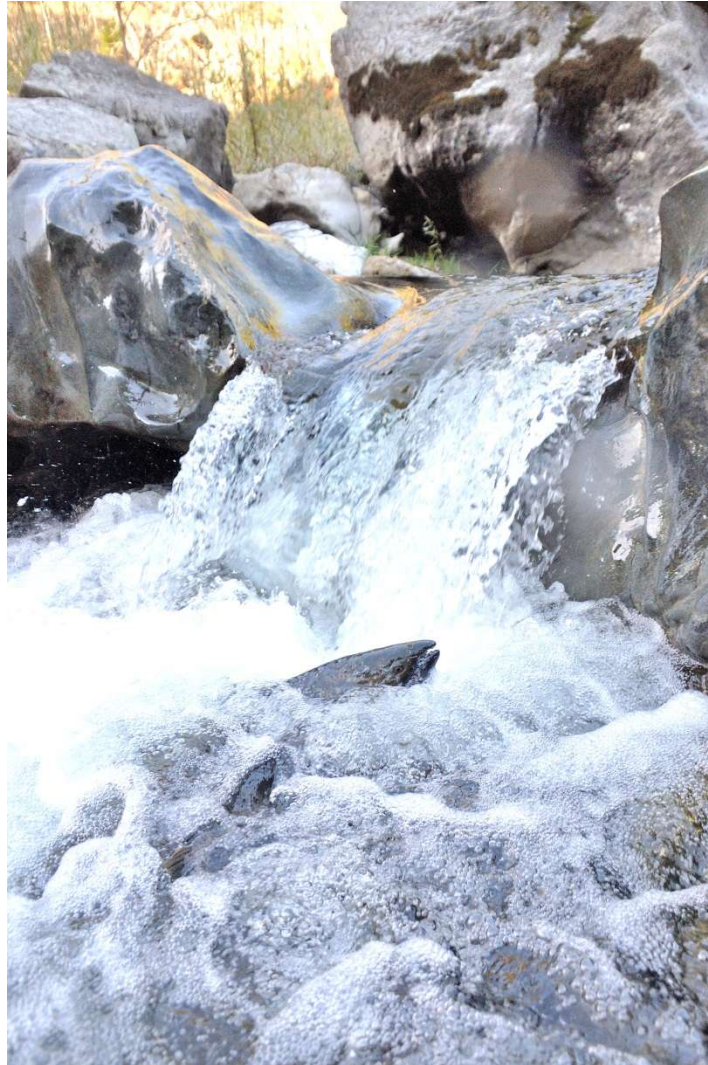# INTERIM INSTREAM FLOW CRITERIA FOR THE PROTECTION OF FISHERY RESOURCES IN THE SCOTT RIVER WATERSHED, SISKIYOU COUNTY

Prepared By

California Department of Fish and Wildlife

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Cover photo: Low flow barrier to upstream migrating Chinook Salmon in the Scott River Canyon November 20, 2015.

1. Introduction

This document describes the methods and results of an analysis using historical flow data and regional regression relationships to develop interim instream flow criteria suitable for anadromous fish in the Scott River watershed in Siskiyou County. The Scott River watershed provides aquatic habitat for four species of anadromous fish; Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), steelhead trout (*O. mykiss*), and Pacific Lamprey (*Lampetra tridentata*). Specifically, the Scott River is one of the most important Coho Salmon spawning and rearing tributaries in the Klamath River watershed.

Instream flow requirements can be generated from flow standard setting techniques or from the results of site specific studies. The interim instream flow criteria presented for the Scott River were developed using flow standard setting techniques. Stream flow standards derived from standard setting techniques are designed to identify the environmental resource in need of flow protection, identify biologically significant criterion that can be used to measure potential flow related impacts, and specify the amount of flow required to protect the resource. Most individual standards evaluate only one or more, but not all the criterion needed to fully evaluate the flow needs of an aquatic species. This limitation can lead to prescribing a single minimum threshold or "flat-line" affect (Poff et al. 1997). The seasonal and inter-annual variability in the hydrograph must be maintained to protect stream ecology and provide an ecosystem based standard (Annear 2004).

To account for the seasonal and the inter-annual hydrologic variability of the Scott River, the Department applied a detailed hydrologic analysis along with application of three standard setting methods to evaluate the life history flow needs of salmonids in the Scott River near Fort Jones. Adult fish passage was estimated using the equation developed by R2 Resources (R2 2008) for the State Water Resources Control Board's (SWRCB) North Coast Instream Flow Policy (SWRCB 2014), spawning and juvenile rearing were evaluated using the Hatfield and Bruce regional equations (Hatfield and Bruce 2000), and the results were adjusted monthly based on estimates of unimpaired hydrology using Tessmann's adaptation (Tessmann 1980) of the Tennant or Montana Method (Tennant 1975).

2. Background

Coho Salmon were listed as "threatened" in the Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) under the federal Endangered Species Act (ESA) in 1997 (Federal Register 1997). In 2014, NOAA- Fisheries released the *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon.* The highest priority Coho Salmon recovery actions identified for the Scott River watershed includes, "increase instream flows." Specifically, the Coho Salmon recovery tasks identified in Table 1 below address the need to identify instream flow needs and implement a flow needs plan for the Scott River watershed. Low summer and fall streamflow is a major factor limiting survival of juvenile Coho Salmon (CDFG 2004).

Table 1. SONCC Coho Recovery Plan Tasks related to instream flow in the Scott River.

NOAA-Fisheries SONCC Coho Recovery Plan Task ID	Description
SONCC-ScoR.3.1.68.1	Conduct study to determine instream flow needs of coho salmon at all life stages
SONCC-ScoR.3.1.68.2	If coho salmon instream flow needs are not being met, develop plan to provide adequate flows. Plan may include water conservation incentives for landowners and re-assessment of water allocation.
SONCC-ScoR.3.1.68.3	Implement coho salmon instream flow needs plan.

Coho Salmon were also listed as "threatened" by the California Fish and Game Commission (Commission) for the area from Punta Gorda north to the California/Oregon border under the California Endangered Species Act (CESA) in 2005. In 2004, the Department of Fish and Wildlife (Department) published the *Recovery Strategy for California Coho Salmon* which identifies restoration activities necessary to protect and recover Coho Salmon populations to a sustainable level (CDFG 2004). Developing target instream flows for the Scott River was identified as a priority recovery task (Recovery Task WM-9) that needs to be implemented to improve Coho Salmon rearing habitat, fish passage, and stream connectivity.

Public Resources Code (PRC) 10000-10005 mandates the Department to identify instream flow needs for the long-term protection, maintenance and proper stewardship of fish and wildlife resources. The Scott River in Siskiyou County appears on the Department priority stream list for Instream Flow Assessments (CDFG 2008). The Department has participated in a comprehensive effort to develop study plans that would provide the scientific information needed for PRC recommendations for the protection of aquatic resources in the Scott River watershed

3. Scott River Watershed

The Scott River is located in Siskiyou County and is part of the Klamath Mountains Province (Figure 1). The Scott River is one of four major tributary streams to the Klamath River. The watershed drains an area of approximately of 812 square miles. The mainstem Scott River is approximately 58 river miles in length and begins at the confluence of the East Fork Scott River and South Fork Scott River. The lower 21 miles of the Scott River flows through a relatively steep mountainous canyon reach which is primarily owned and managed by the Klamath National Forest. Elevations in this reach range from approximately 1,538 ft. (469 m) at the mouth to 2,635 ft. (803 m) at river mile (RM) 21 near the United States Geological Survey (USGS) stream gage station USGS 11519500 SCOTT R NR FORT JONES CA (USGS 115195500). By contrast, the upper reach that flows through Scott Valley has low stream gradients. The upper reach begins at RM 58 near the town of Callahan and flows north to RM 21 near USGS 115195500. Elevations in this reach range from 2,635 ft. (803 m) at RM 21 to 3,140 ft. (958 m) at RM 58 near Callahan to the north. The headwater tributaries originate in the high mountain ranges of the Trinity Alps Wilderness Area, Russian Wilderness Area, and Marble Mountain Wilderness Areas located to the south and west of Scott Valley. The major tributary streams that contribute to the Scott River around Scott Valley include the East Fork

Scott River, South Fork Scott River, Sugar Creek, French Creek, Etna Creek, Kidder Creek, Shackleford Creek, Patterson Creek, and Moffett Creek.

The watershed has a Mediterranean type climate characterized by warm dry summers and cold wet winters. Rainfall is the primary source of precipitation along the lower elevations present on the valley floor and adjacent lower elevation hill slopes. Snowfall is predominant at higher elevations (>5,000 ft.) along the mountain ranges to the south and west side of Scott Valley. The mountains to the south and west of the valley capture most of the precipitation receiving about 60 to 80 inches of precipitation annually. The mountains along the east side of the valley lie within the rain shadow of higher elevation mountain ranges to the south and west, and only receive about 12 to 15 inches of precipitation annually.

There are two rainfall stations located within Scott Valley, Callahan and Fort Jones, which provide a long history of precipitation data dating back to 1943 and 1944, respectively. Annual rainfall amounts recorded at the Callahan station range from a low of 9.75 inches in 1977 to a high of 36.5 inches in 1958 and averages 20.8 inches. Annual rainfall amounts recorded at the Fort Jones station range from a low of 7.62 inches in 1955 to a high of 35.3 inches in 1958 and averages 21.5 inches.

Aquatic habitat for anadromous fish species within the Scott River basin has been altered by numerous human activities, affecting both instream conditions and adjacent riparian and upland slopes. Alterations to habitat and changes to the landscape include historic beaver trapping, road construction, agricultural practices, river channelization, dams and diversions, timber harvest, mining/dredging, gravel extraction, high severity fires, groundwater pumping, and rural residential development (NOAA-Fisheries 2014). These impacts, along with natural factors such as floods, erosive soil, and a warm and dry climate, have simplified, degraded, and fragmented anadromous fish migrating, spawning, and rearing habitat throughout the Scott River basin (NOAA-Fisheries 2014).

Water rights on the Scott River and its tributaries have been fully adjudicated in the Superior Court of Siskiyou County through three separate decrees, the Shackleford Creek Decree (No. 13775) in 1950, the French Creek Decree (No. 14478) in 1958, and the Scott River Decree (No. 30662) in 1980. The Scott River Decree (SWRCB 1980) describes the water allocations for the vast majority of the watershed. There is presently no watermaster service for this decree or the Shackleford Creek Decree.

A minimum baseflow of 30 cubic feet per second (cfs) during the summer months was allotted to the Klamath National Forest (USFS) for the "instream use for fish and wildlife" within the 1980 Scott River Decree. Additionally, USFS has a right to flow measured at USGS 115195500 for instream uses, but this right is junior to other first priority rights in the decree area. The minimum base flow of this junior right is an additional 32 cfs. USGS gage records at Fort Jones show summer discharge frequently falling below 30 cfs, and often falling below 10 cfs in critically dry water years. Flows failed to meet the USFS water right of 30 cfs in at least nine years since 1977 (QVIR 2011).
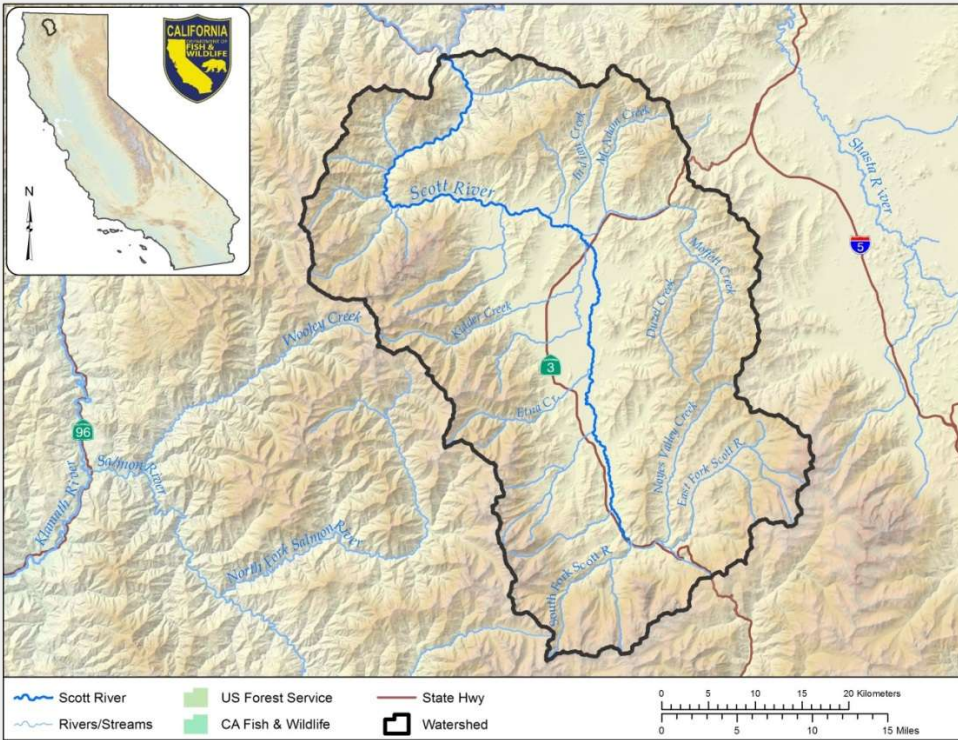
Figure 1. Scott River Watershed in Siskiyou County, California.

Van Kirk and Naman (2008) found that late summer baseflows in the Scott River were 40.3% lower in the recent past (1977 to 2005) than in the historic period (1942 to 1976). Sixty one percent of this drop in discharge is caused by factors other than regional-scale climate change (Van Kirk and Naman 2008). Currently, valley-wide agricultural water diversions, groundwater extraction, and drought have all combined to cause surface flow disconnection along the mainstem Scott River. Figures 2 and 3 illustrate the increase in the frequency of low flow conditions in the Scott River over time. These conditions restrict or eliminate available rearing habitat, elevate water temperature, decrease fitness and survival of over- summering juvenile salmonids, and sometimes result in juvenile fish strandings and mortality.

Agriculture and related activities are the major land use within the Scott Valley. Starting in 1953 there has been an increase in irrigation withdrawals in the Scott Valley of 115% (Van Kirk and Naman 2008). This increase in irrigation withdrawals was accompanied by an 89% increase in irrigated land area (Van Kirk and Naman 2008). Another important shift in the recent past was the change from flood to sprinkler irrigation, which increased efficiency and reduced groundwater recharge (Van Kirk and Naman 2008). Currently, a large proportion (80% or more) of water used for irrigation comes from ground water (Van Kirk and Naman 2008). During the summer, large portions of the mainstem Scott River become completely dry, leaving only a series of stagnant isolated pools inhospitable to salmonids (Figure 4).
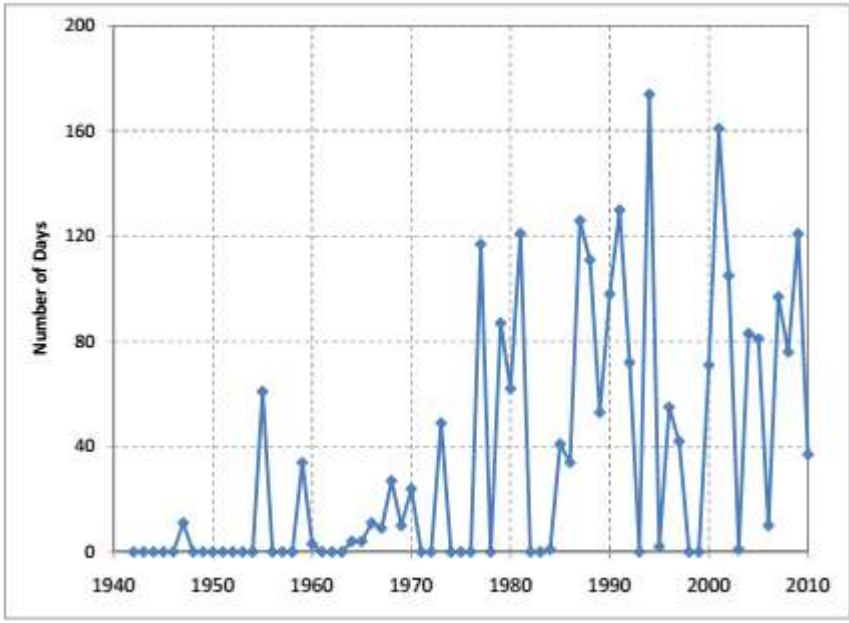
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Figure 2. Number of days with flow at Fort Jones below 40 cfs (excerpted from: S.S. Papadopulos & Associates, Inc. 2012)
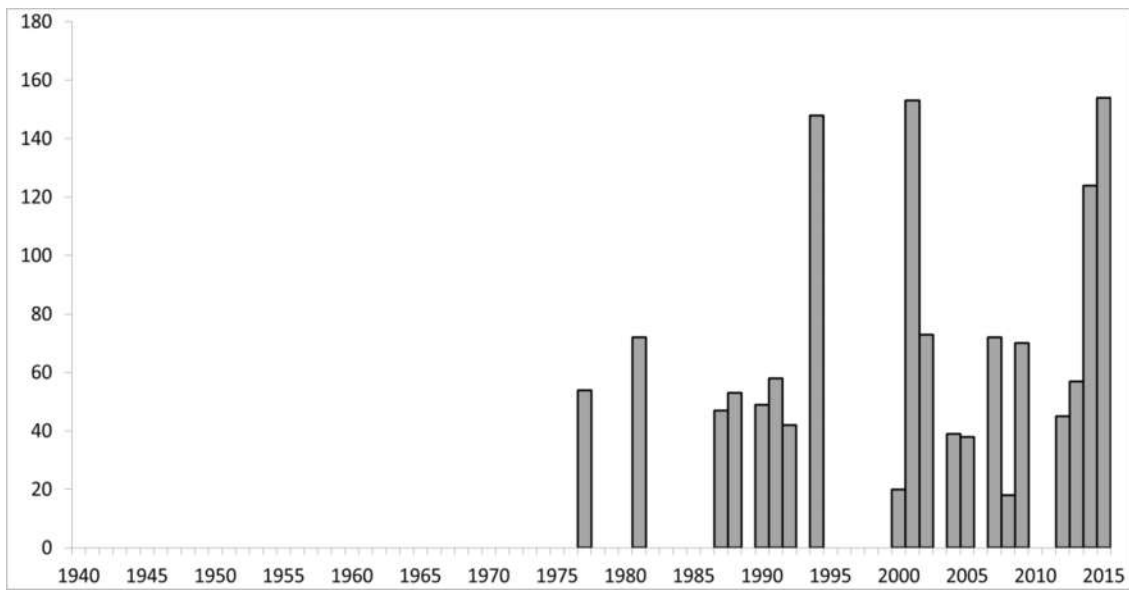

Figure 3. Continuous days of average daily flows less than 15 cfs on the Scott River at the Fort Jones gage (prepared by Steven Stenhouse 2016).

Figure 4. The Scott River at Horn Lane Bridge (photo taken on August 13, 2014 by Chris Adams).

4. Anadromous Fishery Resources

The Scott River provides habitat for four species of anadromous fish species; Chinook Salmon, Coho Salmon, steelhead trout, and Pacific Lamprey. The Department's Klamath River Project (KRP) has been monitoring the escapement of adult anadromous salmonids into the Klamath Basin, including the Scott River, since 1978. Although most of this monitoring effort is focused towards fall-run Chinook Salmon, information regarding Coho Salmon and steelhead trout is also collected as these fish are encountered (Knechtle and Chesney 2016). Unfortunately, high flows and lack of adequate funding has sometimes prevented the collection of complete run size data for either Coho Salmon or steelhead trout and little information exists for Pacific Lamprey.

In 1999, the Department began implementation of the Anadromous Fish Research and Monitoring Program the primary objective of which is to monitor status and trends of juvenile salmonid populations. The original focus for this program was directed towards steelhead trout however, the focus of the program was officially expanded to include the other anadromous salmonid species in 2003. Monitoring of juvenile salmonid emigration from the Scott River was first conducted in the spring of 2000 and has been conducted annually ever since. These two programs combined provide information regarding the relationship between adult returns and juvenile production which improve our understanding of population dynamics and environmental factors that may impact survival of these fish.

A. Chinook Salmon

Status

Chinook Salmon in the Scott River watershed are part of the federally-designated Upper Klamath and Trinity Rivers Chinook ESU, which includes all populations upstream of the confluence of these two rivers. Upper Klamath – Trinity River Chinook Salmon were proposed for federal listing in 1998, but listing was determined to be not warranted.

Life Cycle

The life history patterns of Chinook Salmon vary among runs. The Scott River currently supports only fall-run Chinook Salmon (NRC 2004). Adult Chinook Salmon typically enter the Scott River watershed between mid-September and late-December (Knechtle and Chesney 2016). Chinook Salmon tend to spawn in lower gradient reaches than Coho Salmon, primarily in rivers and larger streams. The timing and distribution of Chinook Salmon spawning within the Scott River watershed has been documented annually during cooperative spawning ground surveys since 1992 (Meneks 2015). Chinook Salmon primarily utilize the mainstem Scott River from its confluence with the Klamath River to approximately Fay Lane. However, Chinook Salmon have been documented in some years spawning in habitat above this point and in the lower portions of some major Scott River tributaries when access is available (M. Knechtle pers. comm.). Spawning distribution within the mainstem can be limited during periods of low flow. Sometimes adult Chinook Salmon are unable to swim upstream of the Scott Canyon reach due to a lack of streamflow. The majority of juvenile Chinook Salmon spend only a few months rearing in freshwater before outmigrating in the spring and early summer. A small proportion of the total juvenile Chinook Salmon production rears in the Scott River for a full year prior to emigrating as age 1 juveniles in late winter/early spring. Peak smolt outmigration from the Scott River typically occurs from April through June (Jetter and Chesney 2016).

Habitat Requirements

Although the life history patterns of Chinook Salmon differ from that of Coho Salmon, the overall habitat requirements of the two species are fairly similar. Like Coho Salmon, Chinook Salmon require adequate flows, cool temperatures, water depths and velocities, appropriate spawning and rearing substrates, and availability of instream cover and food.

Adult Chinook Salmon are particularly dependent on adequate streamflows in the fall, prior to the cessation of irrigation and the onset of significant precipitation, to enable successful migration to their spawning sites. In low flow years like 2015, most of the adult Chinook Salmon were unable to get upstream of the canyon reach during the spawning period. The majority of the observed redds were constructed in the canyon and were subject to a high flow event in March of 2016. The term "redds" refers to the nests that the female salmon digs in the gravel to deposit her eggs.

Water temperatures under 14 °C are optimal for adult Chinook Salmon migration and chronic exposure of migrating adults to temperatures between 17 °C and 20 °C can be lethal (National Research Council [NRC] 2004). Most juvenile Chinook Salmon leave freshwater habitat in the spring and are therefore not as susceptible to the high water temperatures and low streamflows that are common in the Scott River watershed during summer and early fall (Jetter and Chesney 2016). The optimal rearing water temperature range for juvenile Chinook Salmon is approximately 7.2 °C to14.5 °C (Carter 2005).

Population Trends

Prior to the 1950s, there are no estimates of Chinook Salmon populations available for the Scott River watershed. In the mid-1960s, fall-run Chinook Salmon run sizes in the Scott River were estimated at approximately 10,000 fish (CDFG 1965). Fall-run Chinook Salmon escapement estimates for the Scott River watershed have been made annually since 1978 (Figure 3). Since 1978, the Chinook Salmon run in the Scott River has ranged from 14,477 fish (1995) to 497 fish (2004) and has averaged 5,413 fish (Knechtle and Chesney 2016).
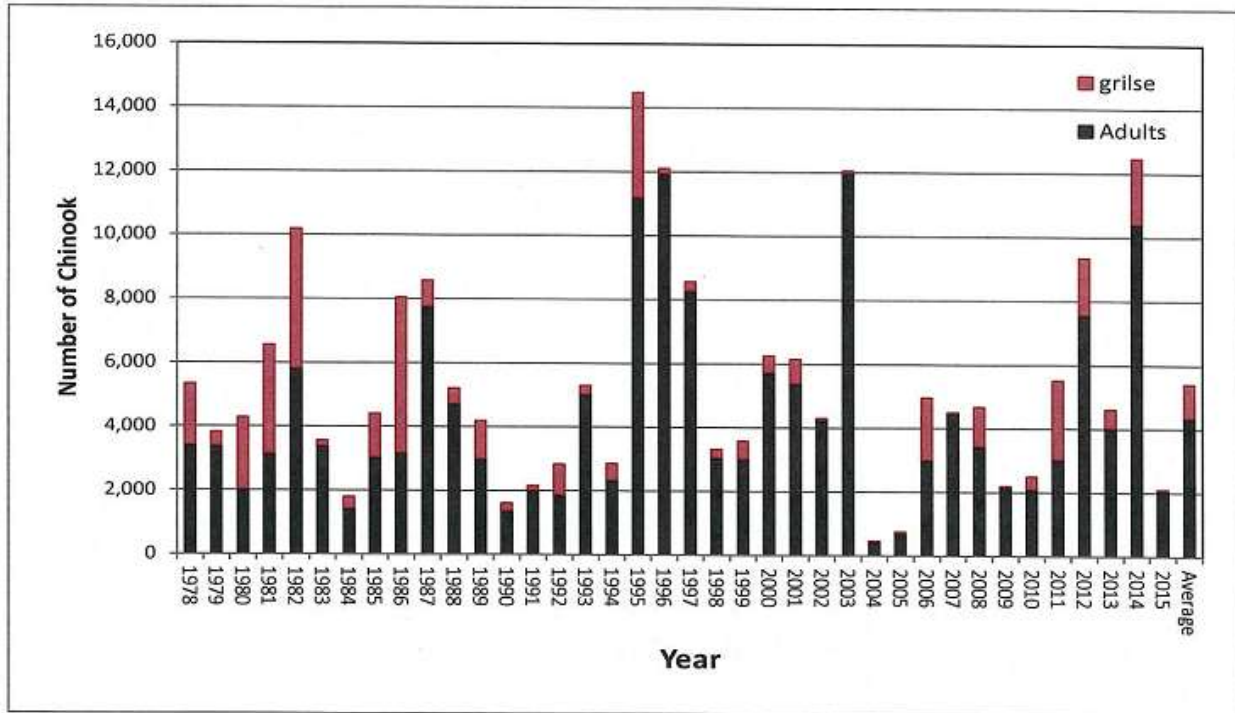
Figure 3. Estimated escapement of Fall-Run Chinook Salmon returning to the Scott River from 1978-2015.

B. Coho Salmon

Status

Coho Salmon in the Klamath River watershed are part of the federally-designated SONCC ESU, which includes all Coho Salmon stocks between Cape Blanco in southern Oregon and Punta Gorda in northern California.

Based on its review of the status of Coho Salmon north of San Francisco, the Department concluded that California Coho Salmon have experienced a significant decline (CDFG 2002). The Department also concluded that Coho Salmon populations have been individually and cumulatively depleted or extirpated and that the natural linkages between individual populations have been fragmented or severed. For the California portion of the Coho Salmon SONCC ESU, an analysis of presence-by-brood-year data indicated that Coho Salmon occupied about 61% of the streams that were previously identified by others (e.g., Brown and Moyle 1991) as historical Coho Salmon streams (i.e., any stream for which published records of Coho Salmon presence could be found). Based on this information, the Department concluded that Coho Salmon populations in the California portion of the SONCC ESU are threatened and will likely become endangered in the foreseeable future in the absence of special protection and management efforts required by CESA. In response to these findings, the Commission adopted amendments to § 670.5 in title 14 of the California Code of Regulations on August 5, 2004, adding California Coho Salmon populations between Punta Gorda and the northern border of California to the list of threatened species under CESA, effective as of March 30, 2005. The Commission adopted the *Recovery Strategy for California Coho Salmon* (CDFG 2004) the previous year.

The NOAA-Fisheries conducted a similar status review of the SONCC Coho Salmon populations in 1995 (Weitkamp et al. 1995). They arrived at similar conclusions as the

Department regarding the likelihood that Coho Salmon in this ESU may become endangered in the foreseeable future if observed declines continue. NOAA-Fisheries listed the ESU as threatened under ESA on May 6, 1997, and designated critical habitat[1] for the ESU on May 5, 1999. The critical habitat designation encompasses accessible reaches of all streams and rivers within the range of SONCC Coho Salmon, including the Scott River. NOAA-Fisheries published the *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionary Significant Unit of Coho Salmon* in 2014.

Life Cycle

Adult Coho Salmon enter freshwater from the ocean in the fall in order to spawn. In the Klamath River watershed, Coho Salmon begin entering in early to mid-September and the migration reaches a peak in late September to early October. Arrival in the upper tributaries such as the Scott River generally peaks in November and December. The majority of the Coho Salmon spawning activity in this area occurs mainly during these two months.

The Department has been operating a video fish counting station on the Scott River at RM 19.8 since 2007. In addition, joint interagency and volunteer spawner surveys have been conducted on the Scott River and tributaries since 2001. During the 2007 season, Coho Salmon redds were observed in Scott River canyon, east and south forks, Scott River tailings and the following tributaries: Etna, French, Miners, Kelsey, Kidder, Mill, Patterson, Shackleford and Sugar Creeks (Walsh 2008). Data shows a correlation between increased flows and Coho Salmon moving through the counting station (Knechtle pers comm).

Females usually choose spawning sites near the head of a riffle, just below a pool, where the water changes from a smooth to a turbulent flow. Spawning sites are often located in areas with overhanging vegetation. Medium to small-sized gravel is essential for successful Coho Salmon spawning. After fertilization, the eggs are buried by the female digging another redd just upstream, which carries streambed materials a short distance downstream to the previous redd. The flow characteristics of the redd location usually ensure good aeration of eggs and embryos, and the flushing of waste products.

In California, Coho Salmon eggs generally incubate in the gravels from November through April. However, stream temperatures affect the timing of fry emergence and in the Scott River and its tributaries, incubation may extend into May. After hatching, the hatchlings, called "alevins," remain within the gravel bed for two to 10 weeks before they emerge as fry into the actively flowing channel between February and June. The fry seek out shallow, low velocity water, usually moving to the stream margins, where they form schools. As the fish feed heavily and grow, the schools generally break up and individual fish set up territories. At this stage, the juvenile fish are called "parr". As the parr continue to grow and expand their territories, they move progressively into deeper cooler water until July and August, when they inhabit the deepest pools. Rearing areas used by juvenile Coho Salmon include low-gradient coastal streams, lakes, sloughs, side channels, estuaries, low-gradient tributaries to large rivers, beaver ponds, and large slackwaters. The most productive juvenile habitats are found in smaller streams with low-gradient alluvial channels, containing abundant pools formed by large woody debris (LWD) such as fallen trees.

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[1]   The Endangered Species Act requires the federal government to designate "critical habitat" for any species it lists under the Act. "Critical habitat" is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

Juvenile Coho Salmon typically rear in freshwater for an entire year before ocean entry (Table 2). This necessitates appropriate habitat conditions for juvenile Coho Salmon in streams through the summer and winter months. Flows throughout Scott River watershed are reduced dramatically during the summer months due to surface water diversions, ground water pumping, drought conditions and climate change. These conditions typically result in salmonids being trapped in isolated pools. Fish relocation efforts have been conducted by the Department for decades, moving salmonids from their natal streams prior to dewatering. Inland winter streamflows are characterized by periods of cold low flows interspersed with freshets and possibly floods. Juvenile Coho Salmon require areas of velocity refuge during periods of high flows. Potential habitats offering velocity refuge during winter include off-channel habitats and beaver ponds.

Table 2. Generalized life stage periodicity of Coho Salmon in California watersheds. Gray shading represents months when the life stage is present, black shading indicates months of peak occurrence. (excerpted from CDFG 2002)

Life stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult migration	gray								gray	gray	black	black
Spawning	black	gray								gray	black	black
Egg Incubation	black	black	gray								gray	black
Emergence/ Fry		gray	black	black	black	gray						
Juvenile rearing	black	black	black	black	black	black	black	black	black	black	black	black
Out-Migration			gray	black	black	black	gray					

After spending one year in fresh water, the majority of the juvenile Coho Salmon hatched during the previous spring begin migrating downstream to the ocean in late March/early April through June. Juvenile salmonids migrating toward the ocean are called "smolts." Upon entry into the ocean, the immature salmon remain in inshore waters, congregating in schools as they move north along the continental shelf. After 18 months of growing and sexually maturing in the ocean, Coho Salmon return to their natal streams as three-year-olds to begin the life cycle again.

This three-year cycle is fairly rigid among Coho Salmon as they rarely spend less than two years in the ocean.[2] Since all wild female Coho Salmon are typically three years old when spawning, there are three distinct and separate maternal brood year lineages for each stream. For example, almost all Coho Salmon produced in 2015 were progeny of females produced three years earlier in 2012, which in turn were progeny of females produced three years earlier in 2009, and so on (Table 3).

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[2] Some Coho Salmon return to spawn after spending only 6 months in the ocean. These fish are referred to as grilse or jacks.

Table 3. Coho Salmon brood year lineages

Brood Year Lineage I	2006	2009	2012	2015
Brood Year Lineage II	2005	2008	2011	2014
Brood Year Lineage III	2004	2007	2010	2013

Loss of one of the three Coho Salmon brood years in a stream is referred to as brood-year extinction or cohort failure. Brood year extinction may occur for reasons including, inability of adults to return to their place of origin, productivity failure, or high mortality (CDFG 2004). This life cycle is a major reason for Coho Salmon's greater vulnerability to catastrophic events compared to other salmonids. Should a major event, such as El Niño floods or anthropogenic disturbance severely deplete Coho Salmon stocks during one year, the effects will be noticed three years later when few or no surviving female Coho Salmon return to continue the brood year lineage.

Habitat Requirements

Suitable aquatic habitat conditions are essential for migrating, spawning, and rearing Coho Salmon. Important components of productive freshwater habitat for Coho Salmon include a healthy riparian corridor, presence of LWD in the channel, appropriate substrate type and size, a relatively unimpaired hydrologic regime, low summer water temperatures, and relatively high dissolved oxygen concentrations. The importance of these habitat parameters is further described below, based on a summary provided in the Department's Recovery Strategy (2004).

Riparian vegetation provides many essential benefits to stream conditions and habitat. It serves as a buffer from sediment and pollution, influences the geomorphology and streamflow, and provides streambank stability. The riparian buffer is vital to moderating water temperatures that influence spawning and rearing by providing the canopy, which protects the water from direct solar heating, and the buffer, which provides a cooler microclimate and lower ambient temperatures near the stream. The riparian canopy also serves as cover from predators, and supplies both insect prey and organic nutrients to streams, and is a source for LWD.

LWD within the stream channel is an essential component of Coho Salmon habitat with several ecological functions. It stabilizes substrate, provides cover from predators and shelter from high water velocities, aids in pool and spawning bed establishment and maintenance, and provides habitat for aquatic invertebrate prey.

The channel substrate type and size, and the quantity and distribution of sediment, have essential direct and indirect functions at several life stages of Coho Salmon. Adults require gravel of appropriate size and shape for spawning (building redds and laying/fertilizing the eggs). Eggs develop and hatch within the substrate, and alevins remain there for some time for protection and shelter. An excess of fine sediment such as sandy and/or silty materials is a significant threat to eggs and fry because it can reduce the interstitial flow necessary to regulate water temperature and dissolved oxygen, remove excreted waste, and provide food for fry. Fine sediments may also envelop and suffocate eggs and fry, and reduce available fry habitat. The substrate also functions as habitat for rearing juveniles by providing shelter from faster flowing water and protection from predators. Furthermore, some invertebrate prey inhabit the benthic environment of the stream substrate.

The characteristics of the water and geomorphology of the stream channel are fundamentally essential to all Coho Salmon life stages. Important characteristics include water velocity, flow

volume, water depths, and the seasonal changes and dynamics of each of these (e.g., summer flow, peak flow, and winter freshets). Appropriate water temperature regimes, in particular, are critical throughout the freshwater phases of the Coho Salmon life cycle. Water temperature affects the rate and success of egg development, fry maturation, juvenile growth, distribution, and survival, smoltification, initiation of adult migration, and survival and success of spawning adults. Water temperature is influenced by many factors including streamflow, riparian vegetation, channel morphology, hydrology, soil-geomorphology interaction, solar radiation, climate, and impacts of human activities. The heat energy contained within the water and the ecological paths through which heat enters and leaves the water are dynamic and complex.

The optimal water temperature range for juvenile Coho Salmon is 10 °C to15.5 °C (Stenhouse et al. 2012). When water temperatures exceed 20.3 °C they become detrimental (Stenhouse et al. 2012). Juveniles exposed to temperatures in excess of 25 °C experience high mortality rates (Sandercock 1991). However, duration of exposure is an important factor regarding the effects of water temperature on salmonids. Additionally, environmental conditions in specific watersheds may affect the normal range and extreme end-points for any of these temperature conditions for Coho Salmon. The water temperature requirements for Coho Salmon are dependent on their metabolism, health, and food supply. These factors also need to be considered together when trying to understand the habitat needs of Coho Salmon in a particular watershed or river system.

An adequate level of dissolved oxygen is necessary for each life stage of Coho Salmon and is affected by water temperature, instream primary productivity, and streamflow. Fine sediment concentrations in gravel beds can also affect dissolved oxygen levels, impacting eggs and fry. Dissolved oxygen levels in streams and rivers are typically lowest during the summer and early fall, when water temperatures are higher and streamflows lower than during the rest of the year. Dissolved oxygen concentrations of eight mg/L or higher are typically considered ideal for rearing salmonids including Coho Salmon. Rearing juveniles may be able to survive when concentrations are relatively low (e.g., less than five mg/L), but growth, metabolism, and swimming performance are adversely affected (Bjornn and Reiser 1991).

C. Steelhead/Rainbow Trout

Status
Steelhead within the Scott River basin are part of the federally-designated Klamath Mountains Province Distinct Population Segment (DPS). Listing of this DPS under ESA was determined not to be warranted by NOAA- Fisheries on April 4, 2001. Summer-run steelhead within this DPS are a Department recognized species of special concern.

Life Cycle
Steelhead exhibit one of the most complex life histories of any salmonid species. The resident rainbow trout form spends its entire life in freshwater environments, while the anadromous steelhead form migrates between its natal streams and the ocean. Furthermore, two reproductive forms of steelhead are recognized, the summer-run (stream-maturing) and winter-run (ocean-maturing), which describes the level of sexual development following return to the freshwater environment. Some researchers further divide the winter steelhead into early (fall-run) and late (winter-run) (e.g., Hardy and Addley 2001), but the two forms have similar life histories (NRC 2004) and are treated together here as winter-run steelhead. In addition, the Klamath River Basin is distinctive in that it is one of the few basins producing "half-pounder" steelhead. This life history type refers to immature steelhead that return to fresh water after only

two to four months in the ocean, generally over-winter in fresh water, then outmigrate again the following spring (Federal Register 2001).

Unlike salmon, steelhead are iteroparous, meaning they can spawn more than once before they die. In California, females commonly spawn twice before they die. Adult winter-run steelhead typically enter the Klamath River from late August to February before spawning, which extends from January through April, peaking in February and March (NRC 2004). Summer-run steelhead enter freshwater as immature fish from May to July, migrate upstream to the cool waters of larger tributaries, and hold in deep pools roughly until December, when they spawn (NRC 2004). Juvenile steelhead rear in freshwater for one to three years (mostly two) before migrating downstream toward the ocean in spring, primarily during the months of March through May. They then typically reside in marine waters one to three years prior to returning to their natal stream to spawn as three- or four-year olds.

Habitat Requirements

The overall habitat requirements of the various salmonid species are fairly similar. Like Coho Salmon, steelhead require adequate flows, temperatures, water depths and velocities, appropriate spawning and rearing substrates, and availability of instream cover and food. The importance of these habitat parameters are described above for Coho Salmon.

Notable differences in habitat preferences include the fact that while juvenile Coho Salmon prefer pools with low average velocities and are not as common in riffles with high current velocities, juvenile steelhead tend to occupy riffles, as well as deep pools with relatively high velocities along the center of the channel (Bisson et al. 1988). Similar to spring-run Chinook Salmon, adult holding areas are of particular importance to summer-run steelhead who must reside in the freshwater streams and rivers throughout the summer. The thermal tolerance of steelhead is generally higher than that of most other salmonids. Preferred temperatures in the field are usually 15 °C to 18 °C (59-64 °F), but juveniles regularly persist in water where daytime temperatures reach 26 °C to 27 °C (79-81 °F) (Moyle 2002). Long-term exposure to temperatures continuously above 24 °C, however, is usually lethal (NRC 2004; Moyle 2002).

5. Scott River Flows

The primary source of instream flow information for the Scott River is provided by the operation of USGS gage 11519500 located downstream of the town of Fort Jones at the northern end of Scott Valley (RM 21). Additional USGS flow data is available for a few of the tributary streams located around Scott Valley. However, the period of record for most of these gages are generally limited to only a few years (Table 4). USGS 11519500 is the only gage within the watershed that provides a continuous historical record of flows dating back to October 1, 1941. The data from USGS 11519500 was used to estimate instream flow criteria using standard setting techniques. The applicability of the criteria is limited to monitoring and compliance of flow levels at USGS 11519500.

Table 4. Stream gaging stations in the study area.

River and Tributary	Data Source (Period of Record)	Complete Water Years Recorded
Mainstem		
Scott River	USGS #11519500 (1942-present)	73+
West Side Tributaries		
South Fork Scott River	USGS #11518200 (1959-1960)	2
Sugar Creek	USGS #11518300 (1958-1960)	3
Cedar Gulch (Nr Callahan)	USGS #11518310 (1967-1973)	7
French Creek	DWR Data Library (2005-2007)	3
Kidder Creek	Siskyou RCD Flow Data (2009-2005, 2007)	4
Shackleford Creek (Nr Mugginsville)	USGS #11519000 (1957-1960)	4
East Side Tributaries		
East Fork Scott River	USGS #11518050 (1960-1974)	15
Moffett Creek (Nr Fort Jones)	USGS #11518600 (1959-1967)	9
East Fork Scott River (Nr Callahan)	USGS #11518000 (1911)	1
East Fork Scott River (Ab Kangaroo)	USGS #11517950 (1971-1972)	2
East Fork Scott River (Bl Houston)	USGS #11517900 (1971-1972)	2

Typical of streams located along the interior of California, flows in the Scott River are characterized by a snowmelt driven hydrologic pattern with fairly consistent high flows occurring in the spring (Figure 4). Occasional flood flows occur during the winter months as a result of heavy rainfall or rain on snow events. The average annual discharge is 455,994 acre-feet (AF) and the mean annual daily discharge is 631 cfs. The driest water year (WY) on record occurred during the 1977 WY when the total annual discharge was only 54,106 AF. The wettest year on record occurred during the 1974 WY when the total annual discharge was 1,081,013 AF. It is important to note that even though USGS 11519500 has a fairly long period of record, the entire record represents an impaired state to varying degrees due to the long history of agricultural diversions that exist within the basin. Given the lack of diversion data through time it is extremely difficult to develop a reasonable description of unimpaired flow conditions for the historic flow data available at the USGS gage, let alone for each of the tributary streams.
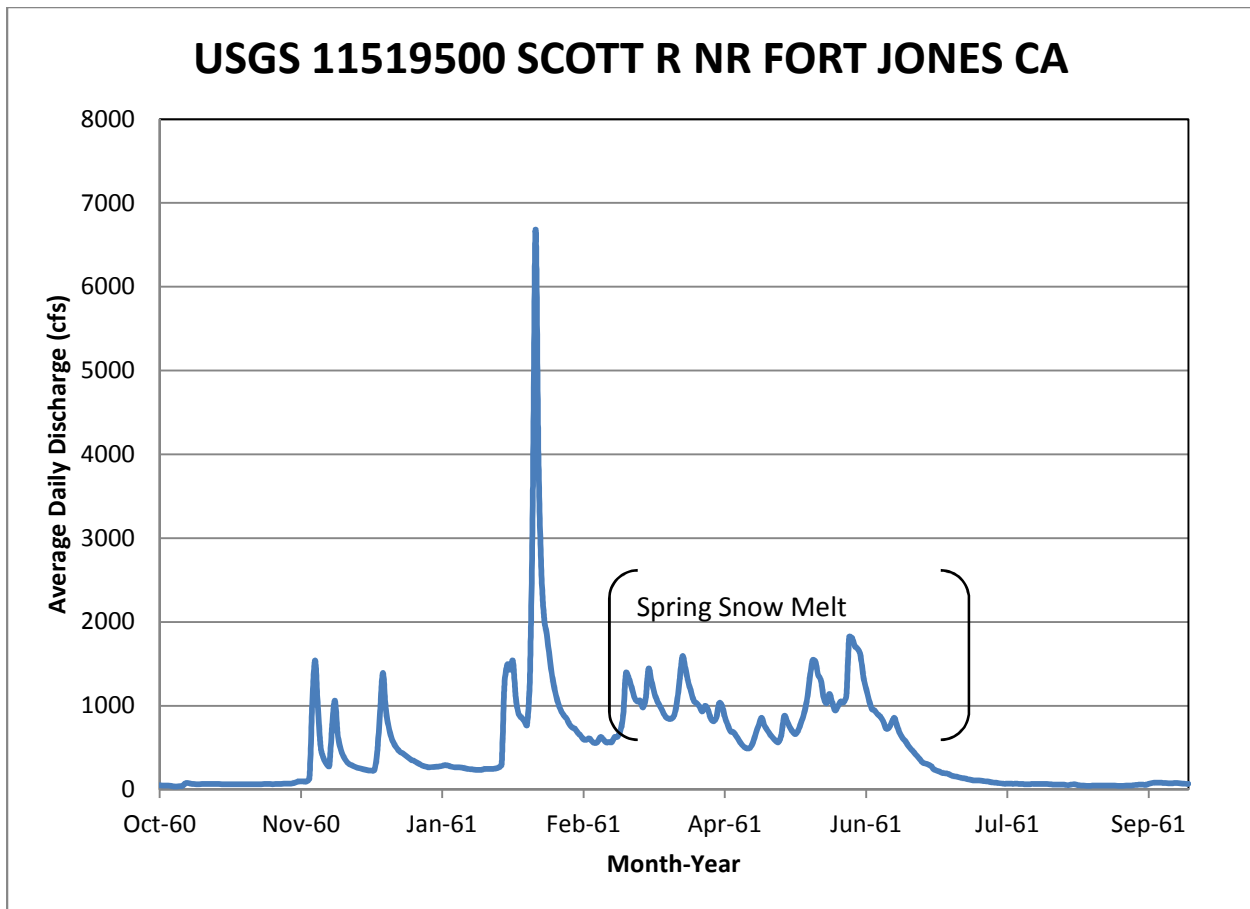
Figure 4. Typical annual hydrograph for the Scott River depicting the influence of large winter storms, spring snow melt, and summer base flows. The data displayed are for the 1961 WY as recorded at USGS 11519500.

Unimpaired flow levels occurring at the north end of the valley were estimated by considering only the first 30 water years of average daily discharges recorded at USGS 11519500, from October 1st, 1942 through September 30th, 1971. Based on historical use information, agricultural demand increased markedly in the 1950's. The period of record used to estimate unimpaired flows represents a period when water supply was changing and is not a completely accurate estimate of unimpaired flows. Due to trends in climate change, estimating current unimpaired flow levels using data from the mid-twentieth century is also flawed. The hydrologic record used represents the best available estimate of unimpaired flows. The total annual flow during this shortened period was 482,162 AF and the mean annual discharge was 666 cfs. The driest WY during this shortened period was the 1955 WY when the total annual flow was only 158,549 AF. The wettest year during this shortened period occurred during the 1958 WY when the total annual flow was 944,053 AF. The instream flow characteristics of the Scott River were described using annual flow duration curve analysis. Two curves were developed: 1) for the entire period of record and 2) for the estimated unimpaired period expressed in terms of probability of exceedance (Figure 5). The discharge level for each percent exceedance increment is provided in Table 5.
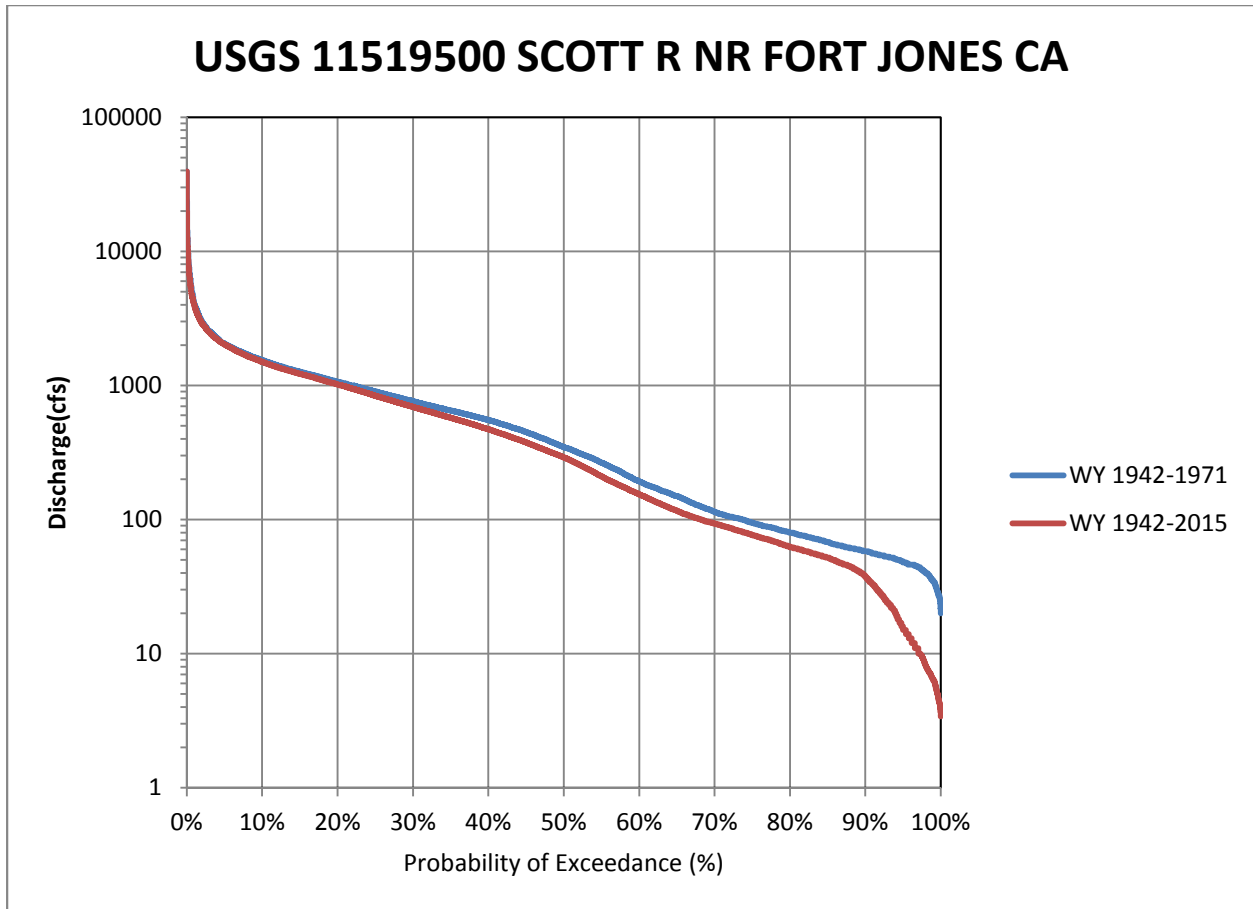
Figure 5. Annual flow duration curves developed for the Scott River (Scott Valley HSA) from USGS 11519500 for WYs 1942 through 2015 (red) and WYs 1942 through 1971 (blue). Water years 1942 through 1971 are assumed to represent an unimpaired condition.

Table 5. Exceedance probability variance between the estimated unimpaired portion of the record (1942-1971) and the full period of record (1942-2015) based on USGS 11519500.

Exceedance Probability	Discharge (cfs)		
	WY 1942 - 1971	Numeric Difference/ Percent Difference	WY 1942 - 2015
90%	58	20 / 66%	38
80%	80	17 / 79%	63
70%	114	21 / 82%	93
60%	192	38 / 80%	154
50%	347	56 / 84%	291
40%	553	82 / 85%	471
30%	763	71 / 91%	692
20%	1070	50 / 95%	1020
10%	1540	40 / 97%	1500

Table 5 illustrates that flows with a higher probability of exceedance from the full period of record were generally found to be lower in magnitude than those from the unimpaired portion, while less likely flow levels were of similar magnitude. The study objectives focus on summer low flow conditions for fishery resources. The use of unimpaired hydrology is necessary to understand the likelihood of flow levels that have historically supported instream resources.

A. Estimated Unimpaired Water Year Types

Water year type classifications were determined from mean annual discharge (MAD) of the unimpaired flow record and segregated by exceedance percentage (Table 6). Classifications were limited to three types due to the shortened period of record, wet (exceedance probability less than 30%), normal (exceedance probability between 30% and 70%), and dry (exceedance probability greater than 70%). The break out years into class types is shown in Figure 6.

Table 6. Exceedance probability and water year type based on water years 1942 through 1971.

| Water Year	MAD (cfs)	Exceedance Probability	Water Year Type
1958	1304	3.23%	Wet
1956	1253	6.45%	Wet
1971	1085	9.68%	Wet
1965	1078	12.90%	Wet
1952	1019	16.13%	Wet
1953	955	19.35%	Wet
1951	925	22.58%	Wet
1963	910	25.81%	Wet
1970	863	29.03%	Wet
1943	831	32.26%	Normal
1954	800	35.48%	Normal
1969	785	38.71%	Normal
1942	708	41.94%	Normal
1967	651	45.16%	Normal
1946	632	48.39%	Normal
1957	581	51.61%	Normal
1961	529	54.84%	Normal
1948	488	58.06%	Normal
1966	477	61.29%	Normal
1950	474	64.52%	Normal
1968	446	67.74%	Normal
1964	435	70.97%	Dry
1945	405	74.19%	Dry
1949	399	77.42%	Dry
1962	399	80.65%	Dry
1959	396	83.87%	Dry
1960	389	87.10%	Dry
1947	302	90.32%	Dry
1944	233	93.55%	Dry
1955	219	96.77%	Dry
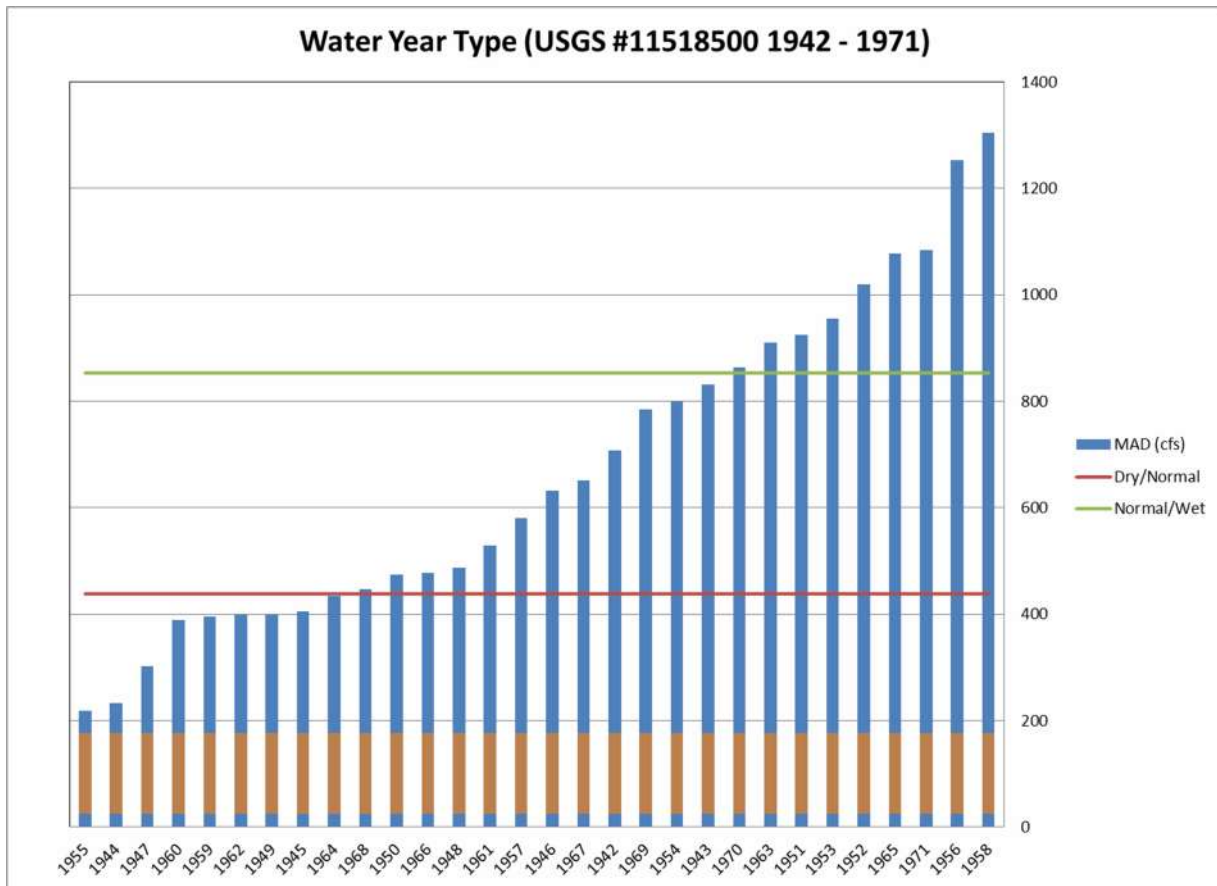
Figure 6. Water year typing for Scott River unimpaired flow near Fort Jones.

B. Stream Assessment Methods

Instream flow assessments fall under three broad categories 1) standard setting hydrology based "desktop" methods that typically do not involved field data collection, 2) single flow monitoring level field surveys, and 3) field data based instream flow studies that develop predictive models that simulate habitat conditions over a range of flows and indicate incremental benefits to resources with changing conditions (Annear et al. 2004). The three categories represent increasing levels of effort, but are also geared towards answering different questions needed to evaluate stream health. For example, incremental studies are designed to answer site and species specific questions by estimating habitat/flow relationships, but not necessarily to provide a flow prescription to protect overall riverine health.

The Department recognizes that interim flow prescriptions are needed for the Scott River while developing and implementing a series of more detailed instream flow study plans. For interim flow determinations, the Department supports the use of the following "desktop" methods, which were developed to support the passage and physical habitat requirements of Pacific salmonids. The main limitation of "desktop" methods is they often prescribe a single minimum flow threshold and do not provide the variable flow regime important for stream health. To avoid the

pitfall of prescribing a single minimum threshold, three different standard setting methods were applied to the Scott River using the long term hydrologic time series recorded at USGS 11519500. Each method was selected to identify flow needs for priority stream functions as follows:

- Q_{fp} fish passage equation (R2 2008);
- Hatfield & Bruce (2000) for spawning and rearing; and
- Tessmann's adaption of the Tennant Method for basin wide hydrology (1980).

The results were combined below depending upon fish species life stage periodicity to develop an annual flow prescription in half month increments.

Interim flows that support fish passage can be developed by applying the Q_{fp} formula contained in Appendix E of R2 Resources (2008), which was prepared to support the North Coast Instream Flow Policy (SWRCB 2014). The Q_{fp} regression formula uses watershed area, mean annual discharge, and minimum passage depth to estimate an appropriate passage flow. This formula was developed using data from Idaho (R2 2004), Deitch (2006) and 22 cross sections collected in 13 streams in Mendocino, Sonoma, Napa, and Marin counties. The authors note "The relation appears to be descriptive of streams over a region broader than the Policy area, and is generally consistent across passage depth requirements."

The Q_{fp} formula is: $$Q_{fp} = 19.3 * Q_m * D_{min}^{2.1} * DA^{-0.72}$$

Where Q_{fp} = the minimum fish passage flow (cfs), Q_m = mean annual flow (cfs), D_{min} = minimum passage depth criterion (feet), and DA = drainage area (mi^2). As reported above, the mean annual discharge was 666 cfs for the less-developed period of water year 1942 through water year 1971. The D_{min} for Chinook Salmon and Coho Salmon and for steelhead trout was selected from the values of CDFG (2012) as noted in Table 7 below:

Table 7. Minimum depths required for passage.

Species	Minimum Passage Depth (ft)
Chinook Salmon (adult)	0.9
Steelhead (adult) Coho Salmon	0.7

Interim minimum flows that support the spawning and juvenile rearing life stages were estimated using the Hatfield and Bruce (2000) regression equations. These equations were developed using the "peak of the curve" results (i.e. optimum flow) from 127 Physical Habitat Simulation (PHABSIM) studies conducted across western North America, with most of the data representing California, Washington, Idaho, and Oregon. The regressions equations use MAD, latitude, and/or longitude to identify appropriate flows for each life stage. Thirteen species were included in the database, but only four had sufficient sample size to be analyzed separately and those included Chinook Salmon, Rainbow Trout, steelhead trout, and Brown Trout. The data

from Coho Salmon streams with PHABSIM results were included in the all species category regression equations. The equations applied in this analysis are provided in Table 8.

Table 8. Hatfield & Bruce equations for Chinook Salmon and Coho Salmon and steelhead trout in the Scott River.

Species	Life stage	Equation
Chinook Salmon	Spawning	Log_e (optimum flow) = -51.71 + 0.682 * $\log_e$(MAD) + 11.042 * $\log_e$(longitude)
	Juvenile	Log_e (optimum flow) = -0.998 + 0.939 * $\log_e$(MAD)
All Species (Coho Salmon)	Spawning	Log_e (optimum flow) = -12.392 + 0.660 * $\log_e$(MAD) + 1.336 * $\log_e$(latitude) + 1.774 * $\log_e$(longitude)
	Juvenile	Log_e (optimum flow) = -6.119 + 0.679 * $\log_e$(MAD) + 1.771 * $\log_e$(latitude)
Steelhead trout	Spawning	Log_e (optimum flow) = -33.064 + 0.618 * $\log_e$(MAD) + 7.26 * $\log_e$(longitude)
	Juvenile	Log_e (optimum flow) = -8.482 + 0.593 * $\log_e$(MAD) + 2.555 * $\log_e$(latitude)

The latitude and longitude of USGS streamflow gage 11519500 were selected for consistency with the hydrology data (latitude = 41.64083°N, longitude = 123.0139°W).

Table 9 presents the results of the application of the Q_{fp} and Hatfield & Bruce regression equations.

Table 9. Hatfield & Bruce results for Chinook Salmon and Coho Salmon and steelhead trout in the Scott River.

Species	Life stage	Basis	Result
Chinook Salmon	Adult Migration	Q_{fp}	103 cfs
	Adult Spawning	Hatfield & Bruce	351 cfs
	Juvenile Rearing	Hatfield & Bruce	165 cfs
Coho Salmon	Adult Migration	Q_{fp}	61 cfs
	Adult Spawning	Hatfield & Bruce	217 cfs
	Juvenile Rearing	Hatfield & Bruce	129 cfs
Steelhead trout	Adult Migration	Q_{fp}	61 cfs
	Adult Spawning	Hatfield & Bruce	362 cfs
	Juvenile Rearing	Hatfield & Bruce	134 cfs

The results were applied to the seasonal period when the lifestage of each species is expected to occur; Department staff prepared a life stage periodicity chart, Figure 7, based on the most recent experience with the fishery resources in the Scott River.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Chinook Migration																		X	X	X	X	X	X	X	X
Chinook Spawning	X																				X	X	X	X	X
Chinook Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adult Coho Migration	X																	X	X	X	X	X	X	X
Coho Spawning	X	X	X																		X	X	X	X
Coho Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adult Steelhead Migration	X	X	X	X	X	X[1]	X[1]	X[1]	X[1]	X[1]									X[1]	X[1]	X	X	X	X
Steelhead Spawning	X	X	X	X	X	X	X[1]	X[1]	X[1]										X[1]	X[1]	X[1]	X[1]	X[1]	X
Steelhead Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 7. Chinook Salmon, Coho Salmon, and Steelhead trout life stage periodicity chart (X known to occur in Scott River; X[1] may occur due to life history variations, but not used in calculations).

Integrating the flows developed using Q_{fp} and Hatfield & Bruce with the life stage periodicity, and subsequently selecting the highest semimonthly flow, produces the following flow regime for the Scott River. Although the flows in Table 10 below are protective of Coho Salmon life stage requirements, none of the values generated from the All Species category were incorporated into the table because the other categories given in Table 8 resulted in the highest semimonthly flow.

Table 10. Interim annual streamflow criteria for salmonids in the Scott River using Q_{fp} and Hatfield & Bruce methods.

Time Period	Recommended Interim Streamflow
Jan 1 - Mar 31	362 cfs
Apr 1 - Apr 30	134 cfs
May 1 - Jul 15	165 cfs
Jul 16 - Oct 15	134 cfs
Oct 16 - Dec 15	351 cfs
Dec 16 - Dec 31	362 cfs

It is important to note that this flow regime does not directly consider the hydrology of the Scott River watershed – except through application of the mean annual discharge in the Q_{fp} and Hatfield & Bruce regression equations. To ensure that any recommended flow regime is consistent with basin hydrology, the Department applied Tessmann's adaptation of the Tennant Method. As provided in Table 11, the Tessmann adaptation considers a situational analysis of the mean annual flow and the mean monthly flow when determining the proposed minimum monthly flow prescription. For a given month, if the mean monthly flow is less than 40% of the mean annual flow, the prescribed flow is set at the mean monthly flow. If the mean monthly flow is greater than 40% of the mean annual flow and 40% of the mean monthly flow is less than 40% of the mean annual flow, the prescribed flow is set at 40% of the mean annual flow. If 40% of the mean monthly flow is greater than 40% of the mean annual flow, then the prescribed flow is set at 40% of the mean monthly flow. The results of the application of the Tessmann Adaptation are presented in Table 12.

Table 11. Tessmann situational flow analysis and proposed flow prescription response.

Situation	Minimum Monthly Flow
MMF < 40% MAF	MMF
MMF > 40% MAF and 40% MMF < 40% MAF	40% MAF
40% MMF > 40% MAF	40% MMF

Table 12. Tessmann Adaption of flow data from USGS 11519500.

Month	Mean Monthly Flow	Tessmann Flow[3]	Month	Mean Monthly Flow	Tessmann Flow
October	139 cfs	*139 cfs*	April	1,081 cfs	*432 cfs*
November	328 cfs	*266 cfs*	May	1,235 cfs	*494 cfs*
December	880 cfs	*337 cfs*	June	771 cfs	*308 cfs*
January	1,118 cfs	*447 cfs*	July	202 cfs	*202 cfs*
February	1,249 cfs	*500 cfs*	August	77 cfs	*77 cfs*
March	885 cfs	*354 cfs*	September	62 cfs	*62 cfs*

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[3] This application of Tessmann's adaptation of the Tennant Method assumes a mean annual flow of 666 cfs.

6. Recommended Interim Flow Criteria

The recommended interim minimum instream flow criteria for the Scott River was developed by applying the lesser of the minimum flow developed using the Q_{fp} and Hatfield & Bruce regression equations and the monthly flow determined using Tessmann's adaptation of the Tennant Method. The interim flow criteria in Table 12 are intended to be thresholds measured at USGS 11519500. If the flow level falls below the interim criteria, the natural flow level would be maintained instream allowing for natural recession of the hydrograph. This approach provides interim protection for the migration, spawning and rearing life stages of salmon and steelhead while considering basin specific hydrology. The recommended interim flow regime is provided below in both graphic (Figure 8) and tabular form (Table 13).
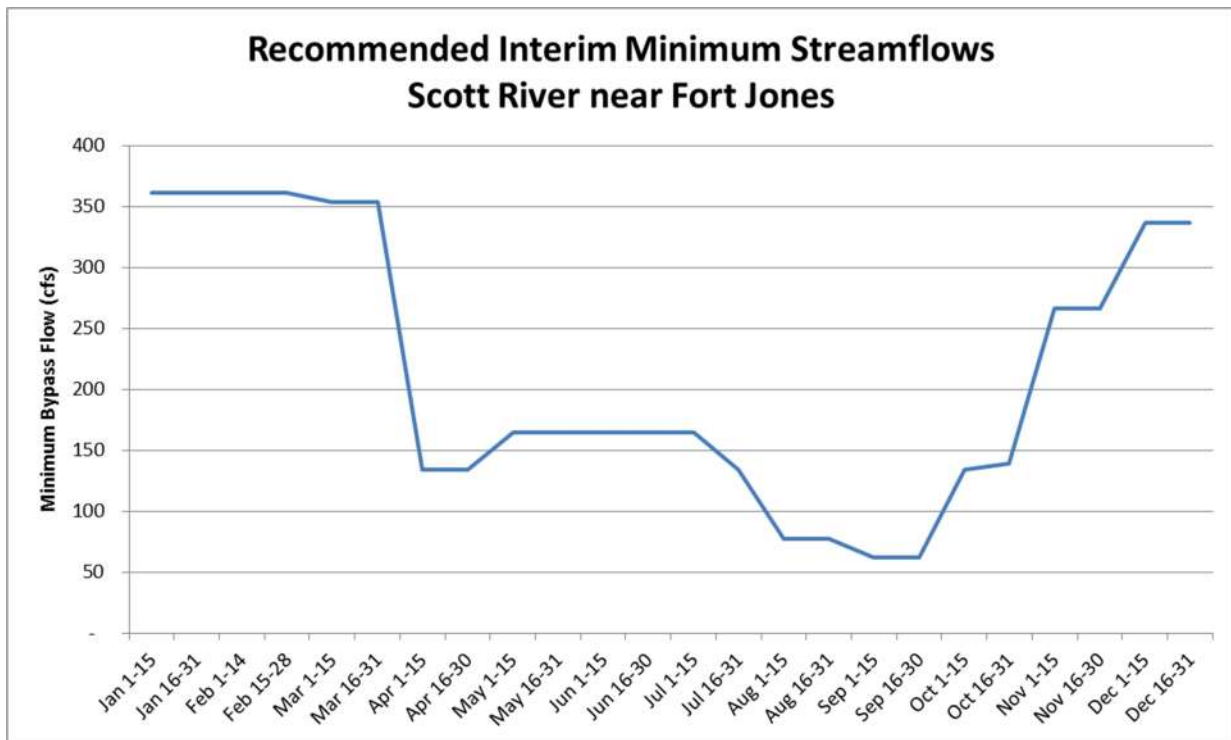

Figure 8. Annual hydrograph of recommended interim flow criteria for the Scott River at the Fort Jones gauge.

Table 13. Scott River Recommended Interim Flow Criteria measured at USGS 11519500.

Time Period	Recommended Flow	Time Period	Recommended Flow	Time Period	Recommended Flow
Jan 1 – 15	362 cfs or NF	May 1 – 15	165 cfs or NF	Sep 1 – 15	62 cfs or NF
Jan 16 – 31	362 cfs or NF	May 16 – 31	165 cfs or NF	Sep 16 – 30	62 cfs or NF
Feb 1 – 14	362 cfs or NF	Jun 1 – 15	165 cfs or NF	Oct 1 – 15	134 cfs or NF
Feb 15 – 28	362 cfs or NF	Jun 16 – 30	165 cfs or NF	Oct 16 – 31	139 cfs or NF
Mar 1 – 15	354 cfs or NF	Jul 1 – 15	165 cfs or NF	Nov 1 – 15	266 cfs or NF
Mar 16 – 31	354 cfs or NF	Jul 16 – 31	134 cfs or NF	Nov 16 – 30	266 cfs or NF
Apr 1 – 15	134 cfs or NF	Aug 1 – 15	77 cfs or NF	Dec 1 – 15	337 cfs or NF
Apr 16 – 30	134 cfs or NF	Aug 16 – 31	77 cfs or NF	Dec 16 – 31	337 cfs or NF

*NF = Natural Flow

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