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# Pisgah Forest State Fish Hatchery IFIM Summary and Proposed Operating Protocols

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North Carolina Wildlife Resources Commission,  
Inland Fisheries Division

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## Introduction

The North Carolina Wildlife Resources Commission (NCWRC) is presenting this summary of an Instream Flow Incremental Methodology (IFIM) study undertaken on the Davidson River and Grogan Creek at the Pisgah Forest State Fish Hatchery (Pisgah hatchery). The study has been completed, and Jim Mead of the Division of Water Quality has summarized the data and made recommendations in a paper which is attached as Appendix 1. This summary prepared by the NCWRC describes proposed procedures that the Pisgah hatchery will undertake to meet the flow requirements of the affected streams. This summary also provides some background on the Pisgah hatchery operations and describes some mitigating circumstances regarding operation of the Pisgah hatchery.

The IFIM study was undertaken by the Division of Water Resources and the NCWRC from 1994 to 1997. The study was analyzed, compiled and summarized from 1997 to 2005. The proposal presented by the NCWRC addresses the concerns and recommendations of the IFIM study. Some important conclusions of the study were that Grogan Creek is at more risk of habitat reduction than is the Davidson River, and therefore hatchery operations will be modified to use relatively more water from the Davidson River and less water from Grogan Creek during periods of low flow. Secondly, the amount of habitat (or number of habitat units) in the affected stretch of Grogan Creek is substantially less than the amount of habitat in the affected stretch of the Davidson River. Therefore, even if there is a high percent of habitat loss on Grogan Creek, the actual loss of habitat units is relatively small compared to the potential for loss of habitat in the combined hatchery bypass reaches.

## Proposed Hatchery Operating Protocols

As a result of the Instream Flow Incremental Methodology (IFIM) study undertaken on Grogan Creek and the Davidson River at the Pisgah Forest State Fish Hatchery (Pisgah hatchery), the NCWRC proposes to modify operations at the Pisgah hatchery as described herein. The IFIM study indicated that habitat loss due to hatchery withdrawals was primarily an issue during the months of July to October, particularly September and October, when water flows in the streams are typically at a minimum. In addition, the IFIM study indicated that Grogan Creek is more likely to be severely impacted by water withdrawals than the Davidson River. Therefore, our proposal attempts to minimize water withdrawals from Grogan Creek and our proposal attempts to respond to low water flow conditions by minimizing withdrawals during periods of low flow.

We propose to place staff gauges at each of the two water intakes of concern. The gauges will be marked to indicate water flows within various ranges as indicated in Table 1 below. We will then restrict water intake from each stream according to Table 2 (Davidson River) and Table 3 (Grogan Creek).

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**Table 1. Stream flows (cfs) that determine the operating protocol.**

Stream	Low Flow Protocol	Intermediate Low Flow Protocol	Intermediate High Flow Protocol	High Flow Protocol
Davidson River	<10 CFS (<4,488 gpm)	10 - 15 CFS (4,488 – 6,732 gpm)	15 - 20 CFS (6,732 – 8,976 gpm)	>20 CFS (>8,976 gpm)
Grogan Creek	<3.5 CFS (<1,570 gpm)	3.5 - 4.5 CFS (1,570 – 2,020 gpm)	4.5 - 6.0 CFS (2,020 – 2,693 gpm)	>6.0 CFS (>2,693 gpm)

**Table 2. Proposed monthly intake flows (in gpm) from the Davidson River intake as determined by the operating protocol.**

Month	Low Flow Protocol	Intermediate Flow Protocol	High Flow Protocol
January	2,440	2,553	Unrestricted
February	3,040	3,043	Unrestricted
March	3,040	3,043	Unrestricted
April	3,040	3,043	Unrestricted
May	3,045	3,135	Unrestricted
June	3,045	3,229	Unrestricted
July	2,610	2,777	Unrestricted
August	2,610	2,870	Unrestricted
September	2,610	2,777	Unrestricted
October	2,610	2,683	Unrestricted
November	2,580	2,600	Unrestricted
December	2,440	2,553	Unrestricted

**Table 3. Proposed monthly intake flows (in gpm) from Grogan Creek intake as determined by the operating protocol.**

Stream	Low Flow Protocol	Intermediate Low Flow Protocol	Intermediate High Flow Protocol	High Flow Protocol
January	1,160	1,403	1,647	Unrestricted
February	1,160	1,508	1,857	Unrestricted
March	1,160	1,508	1,857	Unrestricted
April	1,160	1,508	1,857	Unrestricted
May	1,020	1,415	1,810	Unrestricted
June	880	1,322	1,763	Unrestricted
July	740	1,123	1,507	Unrestricted
August	600	1,030	1,460	Unrestricted
September	740	1,123	1,507	Unrestricted
October	880	1,217	1,553	Unrestricted
November	1,020	1,310	1,600	Unrestricted
December	1,160	1,403	1,647	Unrestricted

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These water flow restrictions represent our best effort to balance the impacts of aquatic habitat loss against the needs of the fish hatchery based on the IFIM study. Note that in tables 2 and 3 we have indicated maximum water intake to the hatcheries under the low flow protocol. This is the maximum withdrawal allowed. The actual intake to the hatchery may be less if the total amount of water available from either intake is less than indicated in the table. Stream flows will be measured by staff gauges at the intakes. Water use in the hatchery is measured by use of notched weir boards in the outdoor raceways and by adding the estimated water flow to the hatchery building. The proportion of the water coming from Grogan Creek is estimated as the amount of creek water flowing in the hatchery building plus an estimated proportion of water entering the head box of the outdoor raceways. This is the same method for determining water flows as was used for the IFIM study.

In order to better explain the potential impacts of the proposed water withdrawals on the Davidson River, we have analyzed the range of water flows that may be left in the river during periods of low flow. The table presented below (Table 4) presents both the range of water flow that will be left in the bypass reach during periods of low flow and the probability that the maximum withdrawal will be taken leaving as little as 25 gpm of flow in the bypass reach. There will always be a minimum flow of 25 gpm in the bypass reach due to the design of the intake and leakage around the dam.

**Table 4. Percent of time in low flow protocol, median flow remaining and percent of time withdrawing entire low flow allocation in the bypass reach of Davidson River as determined by the operating protocol. The expected percentage of time is based on historic flow data recorded at the Davidson River USGS gage.**

Month	Expected percentage of days in the low flow protocol	Projected range of flows remaining in the Davidson River during low flow protocol (gpm)	Expected percentage of days withdrawing entire low flow protocol allocation
January	0.2 %	1,545 – 2,048	0.0 %
February	0.0 %	>1,448	0.0 %
March	0.0 %	>1,448	0.0 %
April	0.0 %	>1,448	0.0 %
May	0.0 %	>1,443	0.0 %
June	0.0 %	>1,443	0.0 %
July	1.1 %	1,223 – 1,878	0.0 %
August	4.5 %	25 – 1,878	0.1 %
September	10.4 %	25 – 1,878	1.0 %
October	12.8 %	25 – 1,878	1.0 %
November	6.7 %	25 – 1,908	0.2 %
December	1.4 %	930 – 2,048	0.0 %

## Monitoring and reporting

Stream flows will be monitored at each of the two staff gauges weekly. The results of the weekly monitoring will be recorded and the flow to the hatchery will be adjusted if needed.

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The resulting flow taken from each stream for use in the hatchery will be recorded. A record of weekly stream flow measurements and weekly water usage from each stream in the hatchery will be maintained at the site and will be available for inspection by Forest Service staff. Any deviation from the prescribed water usage under this proposal will be immediately reported by phone and by email to the Pisgah Forest Ranger.

## Background on Pisgah Forest State Fish Hatchery

The NCWRC took over operation of the Pisgah hatchery from the USFWS in 1983. Prior to that time the hatchery had been operated by the USFWS to produce fish for stocking in the public waters of North Carolina since the mid 1950s, or for over 25 years. Since the NCWRC took over operation of the hatchery, it has produced Brook, Brown and Rainbow trout for stocking in public waters of North Carolina. The USFWS handed over the Pisgah hatchery property to the USFS in 1983 when the USFWS ceased operation of the hatchery. The NCWRC operates the hatchery under a special use agreement between the NCWRC and the USFS.

The hatchery uses water drawn from in-stream water intakes constructed in the mid-1950s on both the Davidson River and Grogan Creek. This flow is occasionally supplemented by up to 100 gpm of water drawn from an on-site well. Water usage is limited by the intake structure and plumbing of the facility, so that the historic high flows in the hatchery represent the most water that can be drawn through the existing intake and plumbing system. Recent improvements to the facility include the addition of low head oxygenators to the raceways and the construction of a water re-circulation system. Both of these improvements allow the hatchery operators more flexibility in water usage and combined may allow for reduced water withdrawals. Facility upgrades have focused on improving water use efficiency because there are no alternate water sources available to the hatchery (such as large volumes of ground water to pump).

The hatchery maintains an NPDES permit administered by the NC Division of Water Quality. The current permit is COC Number NCG530079. The permit requires monitoring of and maintenance of levels of Total Suspended Solids and Settleable Solids within a set range. The hatchery has no record of violating the prescribed standards.

Total production at the hatchery has increased over the years from about 150,000 pounds per year to a current level of about 250,000 pounds per year. It is unlikely that production could be increased above 300,000 pounds per year with current technology. In addition, the level of visitation to the visitor center has increased over the years. The Pisgah Center for Wildlife Education now has over 120,000 visitors per year. The Education Center also has over 12,000 program participants per year that participate in classroom or program activities beyond just visiting the Center.

### **MITIGATING FACTORS**

The Pisgah hatchery is operated by the NCWRC for the purpose of supporting fisheries management programs. Trout produced at the Pisgah hatchery are stocked into public waters of North Carolina to supplement trout populations and to improve fishing

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opportunities for anglers. In 2004 the Pisgah hatchery stocked 454,170 catchable trout and 46,700 fingerling trout in North Carolina. In 2005 the Pisgah hatchery will stock 108,355 catchable trout in 23 water bodies on USFS property in North Carolina. The stocking will occur in over 63 miles of streams and in 181.5 acres of ponds, lakes and reservoirs on USFS property. The Pisgah hatchery will continue to stock over 100,000 catchable trout on USFS property each year. This supplementation of trout populations in areas with heavy angling pressure mitigates for habitat loss in the streams that the hatchery draws water from.

Since the hatchery was built in the mid 1950s, there has been no substantial change to the intake structures or to the plumbing that delivers water to the raceways. The amount of water that can be withdrawn is limited by the physical design of the intakes and plumbing, and this has not changed for fifty years. Current plans are to continue to operate the existing facilities using water at historic rates. The NCWRC does not propose to increase water withdrawals from either of the affected streams. In fact, the recent improvements made at the hatchery allow for more flexibility in how water usage is managed in the hatchery. The NCWRC currently manages the hatchery with an understanding that there is a need to provide in stream flow in the bypass reaches of the affected streams and an effort is made to balance the needs of the hatchery with the needs of the aquatic community in the streams.

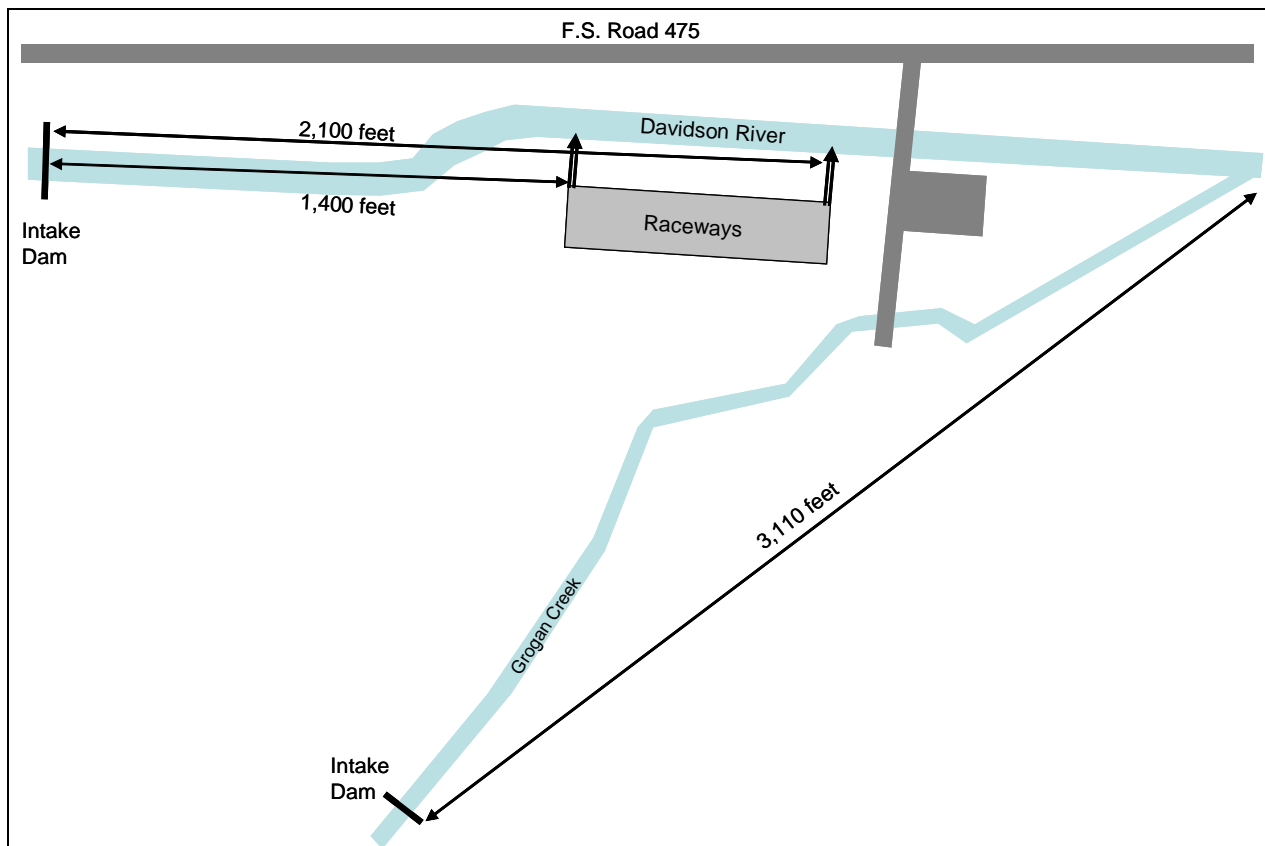
It should be noted that the IFIM study was done based on a bypass reach of 2,096 feet in the Davidson River. In reality, some water is returned to the bypass reach from the hatchery and from several raceway headboxes within this reach, so that about 700 feet of the bypass reach has some water returned to it on a continuous basis. In addition, the re-circulating pump can be used to return some water to the last 700 feet of the bypass reach in some circumstances. Overall, the lower one third of the bypass reach on the Davidson River is less severely impacted than indicated in the study and we can manage to further reduce the impacts in that section.

The Davidson River is a popular fishing destination that provides a large number of angler hours and a diversity of fishing experiences for visitors to the Pisgah Forest. This is largely due to the stocking of the hatchery supported section of the river by the Pisgah hatchery. In addition, heavy angling pressure is present in the Davidson River on the hatchery property and in the Davidson River downstream to Avery Creek. This section is designated as "catch and release, artificial fly only". The "catch and release, artificial fly only" section of the Davidson River is not stocked and is supported by naturally reproducing trout populations and some escapees from the hatchery. The section of the Davidson River on the hatchery property is heavily fished in the bypass reach, at the hatchery outfall, and below the hatchery outfall. The heavy angling pressure indicates that trout are thriving in the bypass reach and downstream of the hatchery outfall. The hatchery property provides excellent angler access and trout populations for the catch and release fishery on the hatchery property.

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## Background on the IFIM Study

The field data collection for the IFIM study was conducted from 1994 to 1997. Analysis of the data has been ongoing from 1997 until July of 2005. Some improvements in models, improved species specific habitat requirements, and water flow data developed since 1997 have been used in the analysis. A detailed summary of the study and analysis of the data collected has been prepared by Jim Mead of the Division of Water Quality and his results are presented in the IFIM Study Summary dated 7/2005 which is attached as Appendix 1.



**Figure 1. Diagram of the Pisgah hatchery site indicating the location and length of the bypass reaches.**

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**APPENDIX 1**



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**Grogan Creek and Davidson River**  
**Pisgah Hatchery Withdrawal and Bypassed Reaches**  
**IFIM Study Summary**  
**7/2005**

DWR and WRC selected representative transects – ten on Davidson River and nine on Grogan Creek. Habitat types and percentage weighting are as follows:

Davidson River – distance from dam to raceway return is 2,096 ft

Pool – 2 transects, 3.8% each

Run – 3 transects, 10.1% each

Low Gradient Riffle – 2 transects, 14.4% each

Medium Gradient Riffle – 2 transects, 14.4% each

Pocket Water – 1 transect, 4.5%

Grogan Creek – distance from dam to confluence with Davidson River is 3,110 ft

Sandy Run – 13.8%

Riffle with some run characteristics – 9.3%

Riffle with small substrate – 9.3%

Run with some riffle characteristics – 13.8%

Run with small substrate – 13.8%

Riffle with large substrate – 9.3%

Pool, upper end – 8.5%

Pool, midpoint – 8.5%

Run with large substrate – 13.8%

Stage versus discharge data was collected at three different flows, and point velocities were collected at all transects at two of these flows. The calibration discharges were: 2, 25 and 80 cfs for Davidson River; and 0.46, 4.9 and 8.0 cfs for Grogan Creek. Point velocities were not collected at the highest calibration flows.

The initial habitat simulation used habitat suitability indices (HSI's) for rainbow and brown trout, blacknose and longnose dace, and general macroinvertebrate diversity in high gradient habitat. A re-evaluation of the study allowed use of newer HSI's for mottled sculpin, northern hogsucker, ephemeroptera, plecoptera, and trichoptera. The habitat versus discharge relationships that were determined for the two sites are included in the attached Excel files.

The time series analysis is a crucial part of any IFIM study. This analysis converts a record of stream flows into a record of habitat events, thus allowing comparison of different flow regimes. Monthly habitat duration plots and exceedance percentages can be used for these comparisons.

Index B and Index C are two metrics that are often used to evaluate different flow regime alternatives. Index B is a trimmed mean – the average of all habitat events between the 10% and 90% exceedance levels. Index C is the average of all habitat events between the 50% and 100% exceedance levels. Either index is usually compared to the unregulated, natural flow/habitat record to evaluate the percentage difference. We often focus on Index C for this comparison because it concentrates on the

lower half of the habitat events. These limiting conditions can play a larger role in aquatic populations than higher levels of habitat that occur less frequently.

The various flow regimes compared in this study are based on daily stream flow records from the USGS gage on the Davidson River near Brevard (station 03441000). These records cover the period from 10/1/1920 through 9/30/1990, and 9/1/1993 through 9/30/2004. This gage has a drainage area of 40.4 square miles. Flows for the Grogan Creek and Davidson River hatchery intake locations were generated by drainage area ratio to 2.5 and 13.8 square miles, respectively. Two tables are attached that show unregulated (“natural”) flow statistics for each of the study sites based on this gage.

The data we collected from the Grogan Creek and Davidson River sites allow hydraulic simulation of habitat conditions up to 24 and 130 cfs, respectively. Habitat simulation was extended further to 30 and 250 cfs by extending the trend of the last two habitat points hydraulically modeled. These upper simulation limits of 30 and 250 cfs cover all but the highest 5% of flows during March - the highest flow month – and even more of the hydrograph for other months. For flows above the 30 and 250 cfs limits, the analysis assumes that the habitat at these higher flows is equal to the amount at the upper simulation limit.

WRC staff provided data for historic withdrawals from the two intakes, as well as their best estimate of the minimum needed from Grogan Creek to operate the hatchery and provide flow distribution among the raceways. These were used to evaluate two initial scenarios – maximum and minimum withdrawals. Each of these is somewhat unrealistic in that they assume a constant minimum or maximum level of withdrawal, rather than an amount that varies with available stream flow. However, they are useful for establishing the upper and lower bounds of potential impact, determining what species and lifestages are most responsive to changes in flow, and developing additional flow alternatives. Note that the minimum scenario for Davidson River is harder to determine, since it is driven by whatever is available from Grogan Creek during a given period, in order to meet a total combined minimum. For Davidson River, we substituted a constant 5 cfs minimum release for the minimum withdrawal scenario – giving the minimum release priority over withdrawals.

Based on this first-cut worst and least case comparison and discussion with WRC staff, two additional flow alternatives were developed for each intake. Both of these guarantee a withdrawal equal to the minimum needed for operation, or inflow, whichever is less. They also allow the maximum historic withdrawal when inflows are above a certain trigger point, and they include two intermediate levels of withdrawal depending on inflows. The two alternatives for each site differ in the level of inflow that triggers changes in withdrawal. Tables outlining the two alternatives for each site are included in the following pages.

Plots and tables of the Index B and C comparisons for the two flow alternatives are attached. The spawning and fry life stages of the two trout species were not a focus of this analysis because of the contribution of the hatchery to increasing stocks in the streams of western North Carolina.

DWR also performed an analysis of water intake availability for the same two flow alternatives. This took the form of an exceedance percentage for different withdrawal amounts, by month. Plots and tables are attached that show the amounts of water in gallons per minute (gpm) that would be available individually from Grogan Creek and Davidson River.

The effects on aquatic habitat for the various species and life stages are summarized below. **It is important to remember that although the summary describes an effect on a particular species and lifestage, it actually represents a wider suite of organisms that use similar types of habitat.** It would be incorrect to interpret the results as applying to only a particular species/lifestage.

#### Davidson River

The species/lifestages showing the greatest change in Index C compared to the natural flow regime are longnose dace adult/juvenile/spawning (LNDC), stonefly nymph (STON), high gradient macroinvertebrate general diversity (HBUG), and northern hogsucker adult and juvenile (HOGA and HOGJ). All other species and lifestages show an Index C value that is 70 to 80% of natural, which is in the range of effect that is usually deemed acceptable.

For the more responsive lifestages, the most noticeable impact is in the months of September and October.

Note that the magnitude of the amount of Index B and C weighted usable area (WUA) under natural flow conditions for the northern hogsucker adult and juvenile lifestages is small compared to WUA magnitudes for other species. As a result, small changes in flow and WUA can have relatively large effects on the percentage difference when compared to the natural flow regime. This indicates that the habitat in this section of the Davidson River may not be that well suited for adult and juvenile northern hogsucker (or other organisms with similar habitat preferences), and that these lifestages should receive less consideration when developing flow recommendations.

GROGAN WITHDRAWAL IN GPM				
MONTH	MAX HISTORICAL	HIGH INTERMEDIATE	LOW INTERMEDIATE	MINIMUM
JAN	1890	1646.7	1403.3	1160
FEB	2205	1856.7	1508.3	1160
MAR	2205	1856.7	1508.3	1160
APR	2205	1856.7	1508.3	1160
MAY	2205	1810.0	1415.0	1020
JUN	2205	1763.3	1321.7	880
JUL	1890	1506.7	1123.3	740
AUG	1890	1460.0	1030.0	600
SEP	1890	1506.7	1123.3	740
OCT	1890	1553.3	1216.7	880
NOV	1890	1600.0	1310.0	1020
DEC	1890	1646.7	1403.3	1160
TRIGGERS:				
		ALT 1	ALT 2	
MAXIMUM		>= 6.0 CFS	>= 8.0 CFS	
HIGH INTERMEDIATE		<6.0 CFS, >= 4.5 CFS	<8.0 CFS, >= 6.0 CFS	
HIGH TO LOW INTERMEDIATE		<4.5 CFS, >= 3.5 CFS	<6.0 CFS, >= 4.0 CFS	
LOW INTERMEDIATE TO MINIMUM		<3.5 CFS	<4.0 CFS	
ALWAYS WITHDRAW MINIMUM OR INFLOW, WHICHEVER IS LESS				

MONTH	DAVIDSON WITHDRAWAL IN GPM			
	MAX HISTORICAL	HIGH INTERMEDIATE	LOW INTERMEDIATE	MINIMUM
JAN	2610	2553.3	2496.7	2440
FEB	3045	3043.3	3041.7	3040
MAR	3045	3043.3	3041.7	3040
APR	3045	3043.3	3041.7	3040
MAY	3180	3135.0	3090.0	3045
JUN	3320	3228.3	3136.7	3045
JUL	2860	2776.7	2693.3	2610
AUG	3000	2870.0	2740.0	2610
SEP	2860	2776.7	2693.3	2610
OCT	2720	2683.3	2646.7	2610
NOV	2610	2600.0	2590.0	2580
DEC	2610	2553.3	2496.7	2440
TRIGGERS:		ALT 1	ALT 2	
MAXIMUM		>=20 CFS	>= 30 CFS	
HIGH INTERMEDIATE		<20 CFS, >= 15 CFS	<30 CFS, >= 20 CFS	
HIGH TO LOW INTERMEDIATE		<15 CFS, >= 10 CFS	<20 CFS, >= 15 CFS	
LOW INTERMEDIATE TO MINIMUM		<10 CFS	<15 CFS	
ALWAYS WITHDRAW MINIMUM OR INFLOW, WHICHEVER IS LESS				

From an instream habitat perspective, there is no significant difference between flow alternatives 1 and 2. This can be explained by the small difference between the maximum and minimum monthly withdrawal levels under both ALT 1 and ALT 2. Note that the minimum withdrawal was determined by subtracting the minimum needed from Grogan Creek from the combined minimum withdrawal needed. So as stream flows drop, and withdrawals from Grogan Creek are reduced, the amount of withdrawal needed from Davidson River may actually increase – resulting in a very narrow range from maximum to minimum withdrawal. This may not be the way the hatchery intakes are operated at the present time, but would reflect changes made in operating the intakes to try to reduce impacts to Grogan Creek.

The water availability analysis is also similar for ALT 1 and ALT 2, but ALT 1 does provide a little more water during some months. Given the small differences in instream habitat at the Davidson River site produced by the two alternatives, ALT 1 may be the preferable choice. This would allow slightly more water to be withdrawn from Davidson River, and slightly less from Grogan Creek.

#### Grogan Creek

Almost all species and lifestages show significant impacts on aquatic habitat from reduced flows in the bypassed reach below the Grogan Creek intake. Those that are most responsive to changes in flow are: brown trout adult (BRTA); blacknose dace juvenile (BNDJ); longnose dace adult/juvenile/spawning (LNDC; mottled sculpin adult/juvenile; northern hogsucker adult and juvenile; plecoptera (STON); ephemeroptera (MAYF); and high gradient macroinvertebrate diversity (HBUG).

As with the Davidson River site, the magnitude of the amount of Index B and C weighted usable area (WUA) under natural flow conditions for the northern hogsucker adult and juvenile lifestages is small compared to WUA magnitudes for other species. As a result, small changes in flow and WUA can have relatively large effects on the percentage difference when compared to the natural flow regime. This indicates that the habitat in this section of the Davidson River may not be that well suited for adult and juvenile northern hogsucker, and that these lifestages should receive less consideration when developing flow recommendations.

Similarly, the magnitude of plecoptera habitat is smaller than that for the other macroinvertebrates evaluated.

The ALT 2 flow regime does produce 5% to 10% improvements in Index C compared to ALT 1, depending on the month and species. While ALT 2 does reduce water availability from Grogan Creek, the minimum amount needed for hatchery operation is always guaranteed. From the standpoint of aquatic habitat, ALT 2 is preferable to ALT 1, although significant impacts to habitat are still present.

Any enhancements to habitat in Grogan Creek will need to be contrasted with the impact on hatchery operations.

It is also important to note that the relative amounts of habitat in Grogan Creek compared to Davidson River are significantly smaller. The unregulated Index C WUA values for Davidson River compared to those for Grogan Creek—excluding hogsucker YOY and longnose and blacknose dace fry—are 240% on average, and range from 102% to 1908%.