# Waynesville Watershed: Aquatic Life Assessment

## Background and Objectives:

The tributaries to the Allen Creek reservoir are designated as WS-I streams in reference to their water quality. A NCDENR (1998) macroinvertebrate study of Shiny Creek in 1997 rated the stream as Exellent. Further, Cherry Cove Creek, Shiny Creek, and Old Bald Creek were recently (2001) found to meet trout waters regulation criteria (Tracy 2001).

The primary objectives of this study were to provide a current assessment of the water quality as indicated by stream fishes and macroinvertebrates, to expand on previous sampling to other stream reaches, and to assess the quality of the brook trout population in the watershed. The protocols employed, and the data generated may then be used as baseline information for any future monitoring.

## Methods:

Traditionally, inventories of habitat and fish populations have been conducted using the representative reach approach. In this approach, biologists measure habitat and fish populations in a particular section or sections of a stream (previous studies in the Waynesville Watershed used 600 ft) chosen as representative, based on the professional experience and intuition of the biologist. Results from the representative reach are then extrapolated to the rest of the watershed. The primary shortcoming of such an approach is that the estimates produced are only accurate for fairly homogenous watersheds. But, because a representative reach is selected purposely, it is impossible to establish the accuracy of the extrapolated estimates (Hankin 1984). Further, the selected representative reach may not include all habitat types present.

Basinwide habitat and population estimates were introduced in an effort to correct the problems associated with the representative reach approach. This approach uses a habitat survey of the entire fish-supporting portion of each stream. Habitat units are then systematically sampled for fish to ensure that all habitat unit types are adequately represented. The downfall is that surveys of extensive watersheds can be very time consuming, as the upstream extent of fish support must be determined prior to, or during the habitat survey.

Given the topography and the extent of the Waynesville Watershed, we were unable to survey each stream from the reservoir to the headwaters in the time available. The approach we adopted for habitat and fish assessment was to survey the habitat of approximately 1 km of the lower end of each of the four major tributaries (Old Bald Creek, Cherry Cove Creek, Shiny Creek, and Deep Gap Creek) to the water supply reservoir. The access road around the reservoir intersects three of the four streams included in the study and the culvert conducting water under the road provided a discontinuity such that for Old Bald Creek, Cherry Cove Creek, and Shiny Creek we broke the study into that portion between the reservoir (or confluence) and the road, and another portion that began above the culvert. This approach did not get around problems associated with extrapolation to the entire watershed, but it did expand the length of stream sampled and increased the probability of including a greater diversity of habitat.

**Habitat Survey:** The habitat survey was completed by having a team of 2 people walk up the thalweg of each stream, classifying habitat unit types and measuring the length of each habitat unit to the nearest 10th of a meter using a surveying rope. The average width of each habitat unit was visually estimated. Further, dominant substrate was recorded, as was incidence of woody debris. Presence of large woody debris was noted by counting the incidences of individual pieces, numbers of root wads, or presence of complexes producing debris dams following the recommendations of Dolloff et al. (1993). Before beginning the habitat survey for each stream a random number generator was used to determine which habitat units would be selected for fish sampling. Our intent was to electrofish no more than 20% of each stream section, so we randomly chose which of the first 5 habitat units of each type would be electrofished, then we marked that habitat unit and every 5th habitat unit of that type in a systematic fashion for later fish sampling.

Habitat units were classified as belonged to one of 4 categories: Units with a steep slope, small pockets of water interspersed among exposed boulders, or steep runs of water over a single large boulder or bedrock were classified as ***cascades***. Units with an obvious deep spot and little surface disturbance were classified as ***pools***. Units with little surface disturbance, but no obvious deep spot (more homogeneous depth throughout) were classified as ***glides***. Units with a more gradual slope than that of cascades, of more or less homogenous depth, but with considerable surface disturbance, were classified as ***riffles***. In situations where there were split channels, each channel was surveyed separately. Clearly, this process relies heavily on the subjective opinion of the habitat surveyor, so care was taken to have the same person do the habitat classification on all streams.

**Fish Survey:** Fish were sampled using a single battery powered backpack electrofishing unit. The three-pass depletion method was used to estimate fish number in each sampled habitat unit. All estimates were calculated using the maximum likelihood routines employed in MicroFish (MicroFish Software, Moscow, ID). Upon capture, each fish was anesthetized using clove oil, then length and wet weight were measured. Fish were then placed in a recovery container for later release back into the habitat unit from which they were removed after the third electrofishing pass. We saw no sampling mortality.

After each habitat unit was electrofished, the width of the habitat unit was measured at three evenly spaced locations along the unit. The average width from these three measures was later regressed against the visual estimates for those same units to provide a correction for any systematic errors in the visual estimates made during the habitat survey for similar habitat units not included in the fish sampling.

Population estimates for each stream section were constructed by converting the estimates for each habitat unit into density estimates using the estimated surface area of the habitat unit (unit length X average width). These densities were then average within habitat type. The area of each habitat type within the stream reach was then used to construct weighted averages of the fish density for the stream reach.

**Macroinvertebrate Sampling**: Stream invertebrates are typically monitored as surrogates for more specific water quality analysis. Because our primary water quality concern in the

Waynesville watershed is sediment, and we have a strong program to monitor changes in sediment load (discussed elsewhere in this document), we placed less emphasis on the macroinvertebrate sampling. Our approach was to replicate and expand upon the invertebrate sampling conducted by NCDENR in 1997. In 1997, NCDENR sampled Shiny Creek at one location using their standard EPT sampling protocol. We used the same EPT sample protocol as described in the NCDENR Standard Operating Procedure manual (NCDENR 2006), but sampled each of the four major tributaries to the reservoir (Old Bald Creek, Cherry Cove Creek, Shiny Creek, and Deep Gap Creek). The EPT method focuses just on three orders of aquatic insects, the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). But, in small headwater streams these three orders account for the overwhelming majority of stream macroinvertebrates found. The sample protocol involves collecting three samples at each sample site: a single “kick” sample, a single “leaf-pack” sample, a single “sweep” sample, and a visual inspection of larger cobble/boulders and woody debris. The kick sample is conducted by holding a sample net downstream and disturbing the substrate upstream of the net, allowing the current of the stream to carry any disturbed invertebrates into the sample net. Leaf-packs are sampled by selecting larger grouping of leaves and other small detritus that have collected on rocks or snags and washing the invertebrates from them into a mesh collector. Sweep samples are collected by using a triangular sample net dragged over the surface of the substrate along or under banks. Visual inspections are to look for invertebrates that may strongly attach themselves to larger substrate so that they are not sampled adequately with the other techniques. While NCDENR standard protocol calls for removing no more than 10 individuals of each species, we returned all individuals so sampled to the laboratory for identification and enumeration.

## Results

**Habitat Survey:** Habitat surveys were conducted in July of 2006. We surveyed a 1.2 km reach of Old Bald Creek beginning at the concrete culvert that carries the stream water into the reservoir and proceeding upstream to the culvert that conducts the stream under the access road (643 m). We then continued the survey beginning at the mouth of the first tributary to Old Bald Creek and continued upstream for another 666 m. We found that pools represented the most abundant habitat type (measured as stream surface area) in the lower 643 m section of this sample reach and that riffles were common. This situation was unique compared to all the other sample sections (Table Fish.1) and was due to a considerably reduced stream gradient in the lower stream section. The upper section of Old Bald Creek was very similar to the other stream reaches as cascades dominated it and riffles were much reduced.

We surveyed a 1.1 km reach of Cherry Cove Creek beginning at the confluence of Cherry Cove Creek and Shiny Creek then continuing upstream to the culvert conducting the stream under the access road (468 m). The sample reach was continued for another 638 m beginning approximately 150 m upstream of the culvert at the upstream end of a braided area of the stream. The stream gradient for Cherry Cove Creek was higher than for Old Bald Creek. Cascades dominated the stream habitat accounting for nearly twice as much surface area of the stream as pools, the next most common habitat type. We found no riffles.

We surveyed 1.02 km reach of Shiny Creek beginning at its confluence with Cherry Cove and continuing upstream for 381 m to the culvert at the access road. We continued the survey starting at the remnants of a concrete low-head dam approximately 500 m upstream of the road crossing. We surveyed upstream approximately 306 m when we encountered a large debris slide covering approximately a 60 m stretch of the stream. Within the slide the stream became extremely braided and in spots flowed under piles of large boulders. We decided to move above the slide area to continue the survey, as it would be impossible to sample fish within the slide area. Upstream of the slide we surveyed another 336 m of stream.

We found Deep Gap Creek to be a considerably smaller stream. We surveyed a 439 m reach beginning at the point where the access trail first intersects the stream. While it is smaller than the other streams surveyed, it proved to be very similar in respect to the distribution of habitat types.

Large woody debris (LWD) loading can contribute to fish habitat, nutrient retention and to geomorphologic processes. We found stream sections to differ considerably in both amounts and type of large woody debris present (Table Fish.2). Old Bald Creek appears to have had a considerably higher LWD loading than the other streams surveyed. Further, the number of root wads present is nearly double that of other streams. This may be indicative of lower bank stability allowing undercutting and eventual washout of trees. We also noticed that stream sections downstream of the access road appeared to have a different distribution of LWD than upstream sections. We tested this using a chi-square test of homogeneity for the distribution of observations among the four classes of individual pieces of LWD (classes II, III, V, and VI). We found that there was a statistically significant difference (P=0.043), particularly due to lower counts of longer and/or larger diameter pieces of LWD in the stream sections downstream of the access road relative to counts from upstream.

Fish Survey: When the NCDENR conducted the Richland Creek Reclassification Study in 2001, they found 5 species of fish in Old Bald Creek, but only brook trout and longnose dace in Cherry Cove Creek and Shiny Creek (Table Fish.3). Our fish survey found a similar pattern (Table Fish.4), particularly between our lower Old Bald Creek sample and their Old Bald Creek sample. But, we estimated considerably larger populations of brook trout for Shiny Creek and Cherry Cove Creek than they estimated.

Inspection of the length distribution of brook trout (Figure Fish.1) shows that there are multiple age classes, demonstrating that there is successful reproduction. Further, if one assumes that the modal length for age 0+ fish is 70 mm, age I+ fish is 110 mm, age II+ fish is 170 mm, and age III+ fish is 220, then we can estimate an instantaneous mortality rate of 0.89 from the catch curve. This corresponds closely with the 0.93 instantaneous mortality rate calculated from the 2001 sample.

The length-weight relationship for the brook trout (Figure Fish.2) sampled nears, but is consistently lower than the standard-weight relationship published by Hyatt and Hubert (2001). Hyatt and Hubert's relationship was based on data for 113 populations of brook trout across the species' geographic range in North America.

We found that brook trout were found more often in pools than any other habitat type. However the variance in brook trout density was considerable (Figure Fish.3). Glides are next in order of brook trout density. Given that glides and pools share many characteristics (with the exception of an obvious deep spot), it isn't surprising that they had similar brook trout densities.

**Macroinvertebrate Survey**: While our fish data was similar to that found by NCDENR workers, our macroinvertebrate survey proved to be quite different. We were unable to sample macroinvertebrates during the summer of 2006 and samples were not collected until the following winter. This timing resulted in many macroinvertebrates being found as "immature" (early instar) larvae resulting in increased difficulty in identification to the level of species. We found similar numbers of mayfly genera and stonefly genera to the 1997 sample. But while caddisflies were the most diverse group found in the 1997 sample with 14 genera, our samples had only 1 or 2 genera (Table Fish.5). Trichoptera are usually easy to sample, and obvious in the sample. So I doubt that the differences between samples are due to sample error. NCDENR personnel have found that Trichoptera are often much reduced during winter months in some, but not all, North Carolina streams (NCDENR 2001). They advise to use a previous sample taken during the summer to correct for systematic seasonal differences. If we take this advice, we would ignore our low diversity of Trichoptera, particularly in light of the similar numbers of Ephemeroptera and Plecoptera genera and conclude that all of the sampled streams exhibited a water quality rating of Excellent.

## Discussion and Conclusions:

**Habitat:** The stream habitat currently found in Waynesville watershed streams is very well suited for coldwater macroinvertebrates and fish. The substrate is largely cobble relatively free of fine sediments. There appears to be sufficient gravel of appropriate sizes for brook trout spawning. The many cascades often lead to plunge pools, a favored habitat for brook trout. Large woody debris loads are similar to that for other headwater steep-gradient streams in second-growth forest. But, due to past land-use and/or the access road restricting LWD recruitment from upstream, the section of each stream between the access road and the reservoir has reduced abundances of larger pieces of LWD. Lower amounts of LWD can result in higher velocities, thus shorter retention rates for the course particulate matter that forms the basis for most biological production in forested streams. Higher velocities may also result in increased erosion of bank material. In these particular streams, given the abundance of large boulders, the retention of material by LWD may be relatively insignificant. But, differences in recruitment and retention of course particulate matter among streams and stream reaches may be an area that we want to investigate further.

**Fish:** Fish diversity in the watershed is low, but low fish diversity is expected in headwater streams. The streams contain healthy, reproducing populations of brook trout. Multiple age classes were found in each stream with a maximum age of perhaps 3 to 4 years. This longevity is consistent with that normally found in the southern Appalachians. The condition of the fish (as compared to standard weight) was near the average for populations across North America. We expect slower growth and lower weight at length for fish living in headwater free-stone streams due to the lower nutrient levels typically found there. Thus the lower condition compared to the published average is expected for these habitats.

Previous studies have found that the brook trout inhabiting Cherry Cove Creek are southern strain brook trout (Jim Borawa, NCWRC, personal communication). Given the lack of barriers to movement among Shiny Creek, Cherry Cove Creek, and Deep Gap Creek, there is a strong likelihood that the brook trout in those streams are also native brook trout. Old Bald Creek is isolated from the others by the reservoir and by a concrete culvert that connects the stream to the reservoir. The genetic identity (hatchery versus southern strain) of the brook trout residing in the other streams as well as the genetic distance among the various subpopulations is an area for future consideration.

Given the limitations of a representative reach approach to fish population surveys (even after our modifications to expand reach length), we cannot extrapolate with confidence outside the study areas. Even if we were to venture to extrapolate, we currently do not know the upstream extent of the brook trout distribution. If at some time in the future acidification becomes a problem in the watershed, we would expect to see a contraction of brook trout habitat to lower altitudes. Given that, it is important that we consider a study to determine the upstream extent of brook trout in the near future.

**Macroinvertebrates:** Our invertebrate samples are indicative of excellent water quality. However, EPT monitoring is relatively insensitive to sediment pollution. As sediment pollution is the most likely future water quality problem, future EPT monitoring should be given less emphasis than direct monitoring and monitoring of brook trout population structure. Brook trout reproduction is very sensitive to fine sediment deposition, so declines in population density, or frequent year-class failure may indicate sedimentation in portions of the watershed not under direct sediment monitoring.

Literature Cited:

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