

**SHENANDOAH NATIONAL PARK
FISHERIES MONITORING PROTOCOL**

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INTRODUCTION

Shenandoah National Park has had a comprehensive fisheries monitoring program in place since 1982 with emphasis on developing an understanding of eastern brook trout population dynamics. Park streams offer anglers one of the greatest concentrations of nearly pure brook trout streams in the eastern United States. Naturalized populations of brown and rainbow trout are known from only five of the 50 plus recognized trout streams in the park. Considering the popularity of park streams from an anglers perspective, varying degrees of legal and illegal fishing pressure, weather effects, acidification effects and other factors, a monitoring program was clearly needed to increase our knowledge and understanding of this unique fishery resource.

In the developing years of the program, single-pass or qualitative electrofishing techniques were used to obtain relative trout numbers and size classes, and a list of other species present at 132 standard 100 meter monitoring sites located along 46 Park streams. Smaller streams such as Dry Run in Page County had as few as one monitoring site and larger streams including the Rapidan River and Jeremy's Run had a total of six sites each. The park wide monitoring effort was stratified such that approximately half of the sites were sampled each year. Generally, the order of stream electrofishing proceeded from south to north and included primarily west slope streams in even numbered years and east slope streams in odd numbered years. This strategy resulted in a two year sampling frequency for most streams. Eight small, drought prone streams were sampled at a frequency of four years and two streams (Land's Run and Hazel River) were sampled annually. The decision to monitor Land's Run and Hazel River annually were based on preliminary results of data from initial monitoring efforts on these streams.

This monitoring approach was adopted to collect relative trout population data and distribution data from other fish species in all reasonably accessible park streams known to contain brook trout. The principal assumption was that a broadly applied qualitative approach would adequately address park management needs. The principal pitfalls of the program included poor coordination with Virginia Department of Game and Inland Fisheries (VDGIF) staff on streams of mutual monitoring interest and the use of dissimilar electrofishing techniques from those used by the State of Virginia and other agencies. The potential of a quantitative monitoring component was not realized during the development of the park's fisheries program due to the lack of a staff fisheries biologist.

During the 1994 season, quantitative or multi-pass depletion sampling was tested in many of the boundary transects on west slope streams. The principal benefits realized included more reliable methods of assessing the condition of and annual variation of brook trout populations, and an actual population estimate of the other fish species present. These findings combined with a multi-agency review of the program resulted in a number of timely revisions including collocated sites with the Virginia Department of Game and Inland Fisheries and the use of multi-pass electrofishing techniques on a core suite of

streams sampled annually to determine population density and biomass estimates for trout and all other fish species present.

The revised program represents a loss of three streams and 58 sites from the original program. Many of the original transects were too closely spaced on individual streams. The revised program includes 43 streams and 74 sites split between quantitative and qualitative components. The quantitative component includes 36 sites sampled annually along 15 streams (Appendix C) stratified across the Park's three dominant bedrock geologic formations and associated water chemistry ranges. Stream and transect selection for inclusion in the annual component were based on the three principal park research streams including Paine Run, Piney and Staunton Rivers. Additional streams having the same bedrock and water chemistry characteristics as the three primary streams were selected in an attempt to identify gross fish population trends across the three principal bedrock substrata. Other stream and site selection considerations included linkages with and locations of other monitoring efforts including VDGIF fisheries monitoring sites, University of Virginia (UVA) water chemistry monitoring sites and the park's aquatic macroinvertebrate monitoring sites. Where possible, sites were collocated in an attempt to provide linkages and/or partnerships with other monitoring efforts. An additional five qualitative sites (Appendix C) located either at uppermost section of the main stem or along major tributaries of the quantitative streams are also included in the annual sampling schedule. The resulting range of streams selected include a mix of small and large streams on the eastern and western slopes of the park, stratified from north to south in all of the three administrative districts

The remaining 25 streams and 34 transects (Appendix D) represent the "other qualitative" component which are sampled on a five year rotation. Selection criteria were based on monitoring data from the pilot years of the program. In summary, the revised program allows a fine grained view of fish population dynamics in response to flood or drought events, problems associated with stream acidification as well as concerns over fishing pressure in a large suite of park streams including all of those that are open for the legal harvest of trout.

A case in point is the dramatic fish community and population dynamics that have been observed since the massive flood events of 1995 in two Park watersheds. The lower section of the Rapidan River, immediately downstream from the confluence with the Staunton was known from pre-flood data as having high species diversity and associated high biomass. A post-flood, multi-pass electrofishing sample produced no trout and only 19 individual fish representing three species. One year later in July of 1996, the same site produced a total of 2030 fish representing 13 species which did not include any trout. The July, 1998 sample produced a record total of 3355 fish representing 16 species including the first five brook trout observed at this site since the flood. Similar patterns were observed on the North Fork of the Moorman's River near Charlottesville, VA. The post-flood assessment of July, 1995 in the lower site produced only six individual fish including one large adult brook trout. This was down from a known total of 824 fish representing 13 species just three weeks earlier. The July, 1996 sample from this site produced 1859 fish representing 10 species and the July, 1998 sample produced 2499 fish

representing 11 species. Unlike the lower Rapidan, a small population of brook trout has managed to maintain a presence in the lower Moorman's since 1995.

The monitoring site on the lower Staunton remained devoid of fish until the July sample of 1998 produced 53 juvenile brook trout. Fish populations including brook trout in mountain stream habitats have incredible resiliency to sudden dramatic losses brought about by natural events due to the highly prolific nature of most species present. Population stability is maintained by annual spawning and the typically large percentage of surviving juvenile fish. Factors that contribute to high survivorship of the summer and fall spawners include mild winters without excessive water flows. The winter of 96/97 was nearly ideal for juvenile brook trout. Juvenile brooks accounted for 85% of the park wide total catch from electrofishing in the summer of 1997. In 1998, only 26% of the park wide catch were juveniles, but the class of 97 was well represented and approaching adulthood by 1999/2000. Although trout population data from Shenandoah streams can swing between large ranges in the short term, long term averages demonstrate a pattern of stability and sustainability in the trout population. Long-term monitoring is one of the most important available tools for detecting changes in and understanding the complexities of fish population dynamics in this park.

OBJECTIVES

1. Document the change in abundance of trout and non-game fish within selected stream sites annually.
2. Document the abundance of exotic trout in relation to the abundance of native brook trout at selected stream sites annually where both species are known to occur.
3. Examine the cause of sudden or gradual observed changes in trout and non-game fish populations.
4. Identify necessary research and management actions needed to further understand and properly manage park fishery resources.

PROTOCOL DESIGN

Following eleven years of qualitative electrofishing from the original 46 streams and 132 sites described above, these preliminary data were summarized and compiled by stream and site resulting in the *Fisheries Management and Data Report* completed in 1994. This document contains narrative descriptions of each stream included in the original electrofishing effort and stream by stream data summaries highlighting the monitoring results. The stream narratives provide summaries of the number of individual sites, the electrofishing frequency, status of trout populations based on electrofishing data and known or projected threats, management recommendations and, major watershed

geologic substrata present. The stream data summaries include brook trout numbers from electrofishing ordered by age class, site, the sum of sites and a list of other fish species by site. These data summaries assisted with the site selection process that resulted in the revised program.

In August, 1995, National Park Service biologists and natural resource managers from the Washington Office (WASO), Shenandoah National Park (SHEN) and the Great Smoky Mountains National Park (GSMNP), and biologists from the Virginia Department of Game and Inland Fisheries (VDGIF) met to review and revise the park's fisheries monitoring program. The primary objectives of this meeting were to establish the goals and objectives for monitoring and managing fish populations in the park, and to design a monitoring program that utilized standardized techniques to sample fish populations in a suite of large, medium and small streams, stratified according to the park's three predominate acid neutralizing capacity (ANC) or alkalinity levels. Secondary objectives included selecting a suite of joint sites with the VDGIF on streams of mutual interest and the use of combined crews and equipment to produce data that met the specifications of both agencies.

Stream and site selections for inclusion into the annual or core monitoring effort described above were based on a number of criteria including stream size and type, ANC as influenced by dominant underlying geologic formations in the watershed, the presence of other research or monitoring sites within the watershed or along the stream, individual site characteristics, the degree of recreational fishing use, the presence of exotic trout species and, in some cases, data from the pilot monitoring effort (1982 - 1994). Additional efforts were made in an attempt to stratify sites between the three administrative districts and along the eastern and western slopes of the park.

East slope streams tend to be larger and more dendritic, fed by one or more perennial tributaries and a number of associated springs. In contrast, west slope streams tend to be more linear and are fed by fewer springs as most originate from much dryer south and west facing ridges. The number of fish species present is largely influenced by the degree of ANC, and to some extent by habitat quality and water temperature. Stream water ANC is primarily influenced by the differing compositions and weathering properties associated with watershed bedrock. Streams with the lowest ANC values have alkalinity ranges from 0 - 25 ueq/L (milliequivalents per liter), are influenced by large sandstone or siliciclastic formations in the watershed, are all located along the southern half of the western slope and have the fewest number of fish species. Moderate ANC streams have alkalinity ranges from 50 - 100 ueq/L, are influenced by granitic formations, are more evenly distributed park wide and tend to have intermediate numbers of fish species present. Streams with higher ANC have alkalinity ranges from 150 - 200 ueq/L, are influenced by basaltic bedrock, are also fairly well distributed throughout the park and tend to have the highest number of fish species.

Primary site selections for inclusion in the core monitoring component were based on the three principal research streams in the park (Paine Run, Staunton and Piney Rivers) which have corresponding low, moderate and higher degrees of ANC. These three

streams and associated watersheds have been the focus of intensive stream water chemistry research by the University of Virginia and Virginia Tech in an attempt to develop predictive models of the factors that influence water chemistry and the effect that changing water chemistry has on fish and other aquatic fauna. Two to three additional streams each with ANC values similar to Paine, Staunton and Piney were added to the core monitoring component to assist in tracking gross trends in fish populations across the ANC gradient. All selected streams occur within watersheds that have at least 50 % of their area in one of the three principal bedrock categories and likewise correspond to one of the three ANC ranges noted above.

The next level of selection criteria beyond ANC was the presence of other research or monitoring sites including aquatic macroinvertebrate sites, VDGIF fish sites and/or water chemistry monitoring sites. Attempts were made to prioritize streams with multiple monitoring components in place. All five streams (N.F. Moorman's, Rapidan, Rose, N.F. Thornton and Jeremy's) of mutual interest between the park and VDGIF were selected for the establishment of collocated monitoring sites. Additionally, all streams known to contain exotic trout species were selected to monitor any effects on the cohabitant brook trout population. Other criteria considered in the stream selection process included the degree of recreational fishing pressure (light, moderate or heavy) and the inclusion of several small drought prone streams to measure the resiliency or lack-there-of in trout populations frequently subjected to water flow extremes. The sum of the selection process resulted in a suite of 18 streams as noted above.

Of the remaining 28 streams from the original program, 25 were selected for the qualitative sampling or optional component. Generally, these streams were left over from the selection process outlined above but continue to support populations of trout and other fish. Rather than drop these streams entirely from the electrofishing schedule, a decision was made to sample fish populations there periodically using much less intensive techniques. The three streams that were dropped from the electrofishing schedule entirely were all tributary streams occurring within large watersheds having established monitoring sites along the main stem. These included Eppert Hollow and Rocky Mountain Run within the Big Run watershed and Runyon's Run within the Hazel River watershed. Both watersheds had seven and six established electrofishing sites respectively including the tributary sites.

Individual monitoring sites were largely established from the original pilot program consisting of 132 sites described above. Site selection or retention for the revised monitoring program followed several criteria including the results of monitoring data from the pilot years of the program. Boundary sites were retained on most streams due to the diversity of fish species encountered in these predominantly lower elevation areas. In many cases, the boundary sites also overlapped aquatic macroinvertebrate and/or water chemistry monitoring sites. Up to three additional upstream sites were retained on the larger streams as needed to obtain fish population estimates along mid and upper sections of individual streams. Retained sites were generally well distributed spatially along mid and upper stream section, had single channels and had adequate year around water flows. In the case of separate VDGIF and park sites occurring on the same stream, sites were

adopted accordingly that maintained good upstream spatial distribution, met the other criteria as described and satisfied the needs and expectations of both agencies.

Sites that were readily eliminated included those that were closely spaced along a particular section of stream, sites with badly braided or split channels and in a few cases, sites that were devoid of fish. The revised monitoring program included 41 sites along the 18 core streams and 34 sites along the 25 optional streams.

SAMPLING STRATEGY AND METHODS

Number of Personnel Required

Most of the Shenandoah streams and sites can be optimally sampled with an electrofishing crew of nine technicians and volunteers. Since most Shenandoah streams are most efficiently sampled with two electrofishing units, this total crew size allows for a stream crew of six to eight and a shore crew of one to three. The stream crew consists of two shocker operators, three to four netters and one or two bucket carriers as determined by the fisheries program manager or the lead biological technician. The shore crew consists of one to three individuals responsible for sorting, measuring and weighing fish and for maintaining fresh water in the buckets. This arrangement of available crew maximizes the efficiency of three pass electrofishing by minimizing the down time of the stream crew. Otherwise, the shocking is suspended between runs until all of the fish from individual runs are sorted and processed.

When sampling larger streams and sites, most of which are joint sites with the VDGIF, crew sizes may approach 20 or more. In the case of the two large stream/high species sites (lower Moorman's and lower Rapidan), the crew partitions according to the needs of both the stream crew and the shore crew. These sites both have at least 10 fish species that occur in very large numbers within the respective sites. These situations can require four to five people just to assist with sorting and processing. These sections also typically require three shocker units which raises the stream crew needs to 12 or 14 individuals. Otherwise, there are typically sufficient crew sizes on the joint NPS/VDGIF streams to partition both people and equipment such that two sites can be sampled simultaneously. This works well under the condition that there is sufficient oversight of both crews by the fisheries program manager and the lead biological technician.

Personnel Training

By the onset of the fisheries monitoring field schedule in early June, a core group of biological technicians and volunteers will have been trained on and be proficient in the use of water chemistry and stream flow meters, having recently completed the field component of the park's annual aquatic macroinvertebrate monitoring program. By late May, the full compliment of biological technicians and volunteers will have arrived in the park for the summer field season. The full crew will undergo two to three days of

training in the principles, use and safety of electrofishing gear, fish identification, taking fish measurements and recording data and, the collection of habitat data from fish monitoring sites, prior to the start of the annual monitoring schedule. All individuals are further instructed in the use of the Hydrolab to measure water chemistry parameters and flow meter equipment to measure stream discharge.

Each person on the crew will be provided the opportunity to operate an electrofishing unit under close supervision. Individuals will be instructed on the basic techniques and strategies of capturing fish with the units, operating both independently and in multiples where more than one unit is required to adequately sample a site. During this initial crew workup exercise, individual crew members will be evaluated for overall aptitude in the operation of the electrofishing units. Typically, the top three to five individuals in terms of demonstrated proficiency and/or potential will be selected at the discretion of the fisheries program manager or the lead biological technician to be the principal operators of the electrofishing units for the duration of the field season. This is necessary to maintain the consistency of effort and results from all of the park wide monitoring sites.

Following this initial phase, actual monitoring begins on a range of small to medium streams. Most of the streams surveyed during the first two to three weeks are small, fairly shallow, and are limited to two or three fish species. Several mid-sized streams with six to ten fish species and slightly more complex habitats are also included in this extended training period. During this two to three week period, the crew are closely supervised and further instructed in all aspects of the field techniques and data collection. Upon the completion of this period and prior to monitoring medium, large and joint NPS/VDGIF streams, each member of the crew will be proficient at all of the routine tasks and will be expected to anticipate work tasks and follow through with the completion of those tasks with or without specific instruction from the supervisors.

Personnel Safety

Electrofishing in mountain stream habitats ranks among the most hazardous work activities performed by biological technicians and volunteers at Shenandoah National Park. The concept of generating and applying high voltage electric current to a body of water in which the operator and a number of fellow crew members are standing seems to constitute a serious breach in fundamental operational safety. This is compounded somewhat by the long hikes over rough and steep terrain while transporting pack loads of up to sixty pounds in conditions of heat and humidity extremes just to access some of the sites. There are also venomous reptiles present, namely the northern copperhead and the timber rattlesnake, a number of biting and stinging insects and an abundance of poison ivy. With adequate preparation, training, the use of personal protective gear and by being ever mindful of potential hazards during the course of the workday, all of the tasks associated with electrofishing can be accomplished in a manner that is safe to all individuals involved.

Prior to the beginning of the fisheries monitoring field schedule, most if not all of the crew will attend a one day first aid/CPR training session. This will provide each

individual with basic first responder training for dealing with a number or minor incidents as well as a functional knowledge of CPR. Other training that will be provided in addition to the use and safety of the electrofishing gear will be a session on the use, function and procedures of park radios. Each individual on the crew will know how to call for assistance in the case of an emergency and which radio channels will work best in a given location. During the field season, the crew will always have two functional portable radios on hand at all times in addition to the dash mounted vehicle radios.

In terms of the actual electrofishing operation, each person participating or assisting the stream crew will be required to wear the rubber gloves supplied to guard against electric shock. Further, the entire crew will be required to wear the appropriate hip boots or waders supplied during the course of electrofishing runs. These rubberized or neoprene items guard against electric shock while crew are operating in the stream. The felt outer soles provide more anti-slip protection when negotiating wet rocks and other stream bank strata than do conventional hiking boots or other footwear. Wearing the hip boots while assisting with fish sorting, measuring or data recording also adds to an individuals flexibility by shortening the response time to assist with other tasks. The hip boots also serve the important functional duty of keeping the shore crew dry while handling large volumes of water and fish.

The stream operation itself is a noisy and somewhat hazardous work environment. The person or persons operating the backpack electrofishing units directs the activity of all associated netters and bucket carriers. This can at times be complicated by the ambient noise produced by the stream, the noise from the electrofishing units themselves and from the combined vocal chatter of the crew. As the crew works upstream against the stream flow and up, over or around rocks or other obstacles it is the responsibility of the primary netters to assist the person shocking in negotiating obstacles and to generally help them to maintain their balance throughout each run. In the frequent scenario of stunned fish becoming lodged in rock crevices or other substrates, it is imperative to let the operator(s) know to raise the probes out of the water before attempting to dislodge the fish by hand. The operator(s) must remain alert to the fall of a crewmember or themselves and be prepared to break the power flow through the probes and get them out of the water if possible.

All crew members are responsible for maintaining situational awareness with respect to what is going on around them. This includes being watchful for, identifying and letting others know about potential safety hazards. This also includes providing a personal safety zone about oneself and generally avoiding direct body contact with a fellow crewmember. Getting too close to the right side of an operator can result in a muffler burn. Getting too close in behind a team of netters can result in being struck by a net handle. When carrying buckets full of water and/or fish, it is important to take the time necessary to ensure adequate footing to prevent a fall which could result in personal injury and/or the loss of a number of fish and associated data.

There is also no substitute for good personal preparedness at the beginning of the season and at the beginning of each day. Prior to the beginning of each field season, it is

imperative that crewmembers inform their supervisor(s) and each other of special considerations including known reactions to bee stings or other potentially impeding physiological conditions and most importantly, how to respond to or treat the condition should an emergency arise in the park's backcountry. Each person on the crew is responsible for packing an adequate supply of food and water for the anticipated conditions of the day. It is particularly important to plan ahead for the longer hikes and to anticipate personal food, water and clothing needs accordingly.

Sampling Conditions and Times

The field component of the fisheries monitoring program typically begins in early to mid June and ends by late July to mid August. Starting and ending dates are largely determined by the frequency of rain events, the amount of total rainfall and associated water levels in the streams. Optimal conditions include low to average water flows of clear condition. Moderate to high water flows should be avoided due to increased turbidity and riffling which dramatically decreases the ability to observe and capture fish with electrofishing gear.

Individual streams should be sampled within the same general period of time each year to facilitate comparisons of density and biomass between years. A sampling differential of two to three weeks is acceptable from one year to the next but streams that are typically sampled in June should not be sampled in August and vice versa. Prior to the start of each field season, a detailed sampling schedule will be completed by the fisheries program manager which lists the order of streams, transects, tentative sampling date(s), sampling strategy and anticipated crew size.

Required Equipment

Equipment associated with the fisheries monitoring program (Appendix A) is stored in three general locations. Electrofishing units, probes, gas/oil mix, nets, buckets and tubs are stored in the shed at the far end of the Inventory and Monitoring (I&M) building parking lot. Wading gear, packs, flow meters, measuring tapes and boards, electronic balances, gloves and glasses are stored in the block building adjacent to the fuel pumps. GPS units, Hydrolabs and accessories, radios, batteries, clipboards, datasheets, site directions and MS-222 are stored within the I&M building.

All of the equipment associated with fisheries monitoring is supplied and maintained by the National Park Service. Equipment needs will vary somewhat from day to day depending on site parameters and crew size. The GS-5s are responsible for ensuring that all necessary equipment is packed and loaded in the morning prior to departure for the stream(s). This process should include consulting the stream summary tables in the *Fisheries Management and Data Report* of 1994 to determine the number and type of fish species present at specific sites. Using these tables as a reference tool, the crew can plan for and pack the number of tubs and buckets that will be required from day to day. The type of species present in individual streams or sites will determine the most

appropriate electronic balances to pack for any given day. Generally, where eels, brown trout, white suckers or other large species are found the larger scales of 1200 or 6000g capacity will be required. The larger scales will also be required at all streams and sites having high volumes of nongame fish.

Each individual on the crew is responsible for ensuring that their own hip boots and personal gear are packed and loaded each day. Personal gear includes proper clothing, small packs, prescribed medicines, lunches and water. The specific food and water needs of individuals is especially important as specified in *Personnel Safety* above. All personal gear will be accounted for by each person prior to the end of each day. It is expected that refuse from lunches will be removed from all NPS vehicles and disposed of at the end of each day. Each person will likewise be responsible for stowing or removing all of their own water bottles, leftover lunches and lunchboxes or packs prior to leaving work for the day.

Site Characteristics

Fish monitoring sites consist of ± 100 meter stream sections that generally have single channels, a mix of pool and riffle habitats and well defined endpoints. Section lengths range from 75 to 120 meters as defined by the distance between major streambed features or suitable endpoints. Major streambed features that limit section lengths on some streams include split or braided channels, side tributaries, pools more than 1.5 meters deep, waterfalls or other features which seriously compromise electrofishing success and/or personnel safety.

Most of the park's monitoring sites begin and end at distinct habitat breaks such as the beginning or end of a pool. Due in large part to the small size of most park streams, existing habitat breaks suffice to impede the emigration or immigration of fish during electrofishing runs. Some sites require additional measures such as the construction of temporary dams from adjacent cobble or small boulders. The largest sites (lower Rapidan and lower Moorman's) require the use of block nets across the downstream end of the section to adequately impede fish movements in or out of the site. The upstream endpoints of the largest sites coincide with habitat breaks sufficient to impede fish movements.

Individual site characteristics have changed and will continue to change over time. Islands may form, channels may shift, dominant habitat features may change etc. etc. Rather than continually moving and/or adjusting sites locations for the sake of convenience, the value of fisheries data paired with a specific site through time is realized in providing park staff with a more precise view of fish population dynamics relative to major changes in the quality and type of habitats available.

Locating Sites in the Field

The endpoints of all monitoring sites are referenced by tagged live trees located on the adjacent stream bank and most have now been GPS'd. Site tags are 1 ½" X 6" metal strips that have "SNP Fish Monitoring" and the specific site number stamped on them, all of which have been painted bright yellow. All tags face the stream and are located approximately five feet above the ground on fairly dominant or prominent live trees. To facilitate the location of tag trees in the field, tags also face the direction of most likely approach.

Specific site directions are maintained for each stream and monitoring site in the park and are organized with respect to east versus west slope locations. Site directions include a written description of the location of each site by number and the type, diameter and specific location of both tag trees. Upper (UTT) and lower (LTT) tag trees are further referenced in the directions as to the side of the channel, left hand side (LHS) or right hand side (RHS) and direction up or downstream from the specified point of approach to each site.

Site directions also include written descriptions of specified road and trail routes and a U.S. Geological Survey (USGS) topographic map of the stream with clearly marked site locations. In the event that access to the stream changes or tags and/or tag trees are lost, the associated site directions need to be revised accordingly. In the event that individual monitoring sites are rendered unrecognizable by floods, fire or otherwise, the original site endpoints can be relocated using the navigation feature of the GPS or PLGR units.

Water Chemistry Sampling

All water chemistry sampling associated with the fisheries monitoring program is conducted with Hydrolab® multiparameter water quality monitoring units. These units provide rapid and accurate values of water temperature, pH, conductivity, dissolved oxygen, and total dissolved solids. Hydrolab multi-parameter units have five primary components including the multi-sensor unit, data display system, cable, water storage cup and weighted sensor guard. These units have proven to be rugged and highly reliable in the park's backcountry where many of the water chemistry measurements are taken. These units are also easy to calibrate and once calibrated, tend to maintain calibration consistency for ten days following. To ensure data quality, the units require calibration at the beginning of each week during the field season. Procedures for calibrating the units are listed in Appendix F.

When not in use, the water storage cup filled with tap water must be securely attached to the unit to protect the sensors from damage, especially from drying out. To prevent serious damage to the sensors, **Never store sensors in distilled water.** Stream water may be used in the interim if the tap water is spilled while in the field but it should be replaced with tap water at the earliest possible convenience back at the lab. Water from park streams have much lower conductivity than tap water. Periodic maintenance should be scheduled during the field season as specified in the operators manual to further

enhance the service life of the sensors. The cable likewise requires careful handling and storage and should not be coiled tighter than 12 inch loops or kinked in any way. Always keep the cable coiled on the spool for transport and storage. It is also important to keep the two rubber plugs secured in place when the unit is not in use. The unit should always be handled with care and never dropped or tossed carelessly about.

The following sequence should be followed when using the Hydrolab in the field:

- 1.) Confirm that the unit has been calibrated within the last week.
- 2.) Transport all unit components to a secure location adjacent to the intended sampling point.
- 3.) Remove the two pin covers (rubber plugs) and secure in a safe location.
- 4.) Remove water storage cup and replace with weighted sensor guard.
- 5.) Attach cable to data display system.
- 6.) Attach opposite end of cable to the multi-sensor unit.
- 7.) Place the multi-sensor unit in a riffle of sufficient depth to completely cover the sensors and make sure that the sensors face upstream.
- 8.) Turn on the data display system.
- 9.) Wait three to five minutes prior to recording data on the field sheets.
- 10.) Turn unit off and detach cable.
- 11.) Reconnect the two rubber plugs and coil cable on protective spool.
- 12.) Disconnect the weighted sensor guard and replace with full water storage cup.
- 13.) Stow all of the unit components in one of the packs to ensure that nothing is left at the site.

It is important to note that the Hydrolab should only be placed in a riffle area of the stream with sufficient flow and depth to completely cover the sensors which should always face upstream. Hydrolab measurements should be taken prior to any of the other monitoring activities at the site that involve personnel in the stream. When placing the unit, take care not to step into the stream in the vicinity of the unit or otherwise disturbing the streambed. These considerations are necessary to capture the natural water chemistry measurements at each site prior to the disturbances that follow electrofishing runs.

For sites that are influenced by the presence of a tributary, the unit should be placed at least five meters below the confluence to ensure adequate mixing of the two water sources. Larger streams or streams with increased flow rates may dictate that the unit be placed at least 15 meters downstream from any confluence. Following the water chemistry measurements taken from the main branch, measurements should also be taken from the main branch and the tributary above the confluence. In these cases, make sure that the unit is placed well above the confluence to avoid potential mixing within the zone of confluence. In these cases, it is very important to note the location of each measurement on the data form such that data from the main branch can be distinguished from data from the tributary or from the main branch above the tributary.

Water Flow Sampling

Stream flow velocities are important variables at each site since minor daily or seasonal variations affect the nature and composition of fish habitats and the specific area of each monitoring site. There are currently two flow meters in the park's equipment inventory, a Marsh-McBirney (MMB), model 2000 "Flo-Mate™" that serves as the primary unit and an older MMB, model 201D which serves as a backup unit when the Flo-Mate is out of service. Each unit consists of four components including the display box, cable electromagnetic sensor (probe) and a USGS top setting (metric) wading rod. All but the wading rod are permanently connected. The probe should be attached to the wading rod for operational use only. Although shock resistant and generally durable, it is important to remember that while the Flo-Mate is waterproof, the 201D unit is not. **When operating either of the units, never lift the probe attached to the wading rod out of the water when the unit is switched on.** Doing so will require that the probe be re-calibrated. While the Flo-Mate can be re-calibrated following instructions in the operator's manual, the 201D needs to be shipped to the manufacturer and re-calibrated at a cost of \$250.00.

One of the most critical factors in measuring water flow is selecting the appropriate stream cross section. The ideal cross section is a single channel where flow is restricted and relatively uniform, similar to a weir. Avoid cross sections with split channels, obvious subterranean flows, exposed boulders or other substrates, areas with large subsurface obstructions or sections where the center of the stream is flowing at a much faster rate than the edges. At some sites, optimal locations do not exist, especially during low flow conditions. In these cases, it may be necessary to temporarily modify the streambed or channel by removing rocks to ensure a more uniform and measurable flow.

Measurements must be taken from at least ten evenly spaced intervals at the selected cross section, perpendicular to stream flow. In selecting the interval spacing, start by dividing the entire cross section into tenths. Select an interval that is easy to compound across the channel to the nearest 0.1m. Consider the example of a cross section with a total width of 3.7m. Dividing by ten would result in intervals of 0.37. In a case like this, round down to 0.30. This would result in a total of 15 intervals rather than ten including 0, 0.3, 0.6, 0.9, 1.2, 1.5, 1.8, 2.1, 2.4, 2.7, 3.0, 3.3, 3.6, and 3.7m. More than ten intervals is permissible, fewer than ten is not.

Once the location for measuring flow has been established, do the following:

- 1.) Stretch the 30m tape from left to right across the stream channel, perpendicular to the direction of flow. Pull any slack out of the tape and secure it at both ends.
- 2.) Measure the waterline to waterline width. Record width to the nearest 0.1m in the space provided in the "Discharge Measurements" section of the cover form (Appendix G). From the measured channel width, determine workable sample intervals following the criteria outlined above.

- 3.) Once the sampling intervals have been determined, attach the probe to the wading rod with the available thumbscrew.
- 4.) Start by placing the wading rod at the first interval beyond the “0” distance, and make sure the flow meter bulb is in the water facing upstream. The first and last measurements (corresponding to the two stream banks) will always be zero depth and zero flow.
- 5.) Turn the flow meter on and read/record the depth on the flow staff. **Note: It is not necessary to switch the unit on and off for each measurement, just keep the probe submerged throughout the entire sequence as noted above.**
- 6.) Set the wading rod for the depth at that location according to the instructions below. **Always stand on the downstream side of the probe to avoid interfering with the readings.**
- 7.) Once the probe is in position facing upstream, allow the reading in the display box to stabilize (at least six seconds) before calling out the value to the data recorder. The resulting number represents flow in meters per second at that point. Repeat steps 4 through 8 until flow measurements at all of the subsequent intervals has been completed.

The wading rod or flow staff is calibrated to utilize the 6/10ths flow measuring technique recommended by the USGS (Buchanan and Somers 1969) and the U.S. Forest Service (Platts et al. 1983). By aligning the sliding decimeter scale with the fixed centimeter scale at the top of the rod, the probe can be rapidly set to 6/10ths of the recorded depth at all of the sampling intervals. The fixed portion (octagonal shaped) of the rod is graduated in 0.02m increments. Each 0.02m increment is designated by a single line, the first of which is located above the base plate or stand. From the stand, each 0.10 increment is designated by a double line and each 0.50m increment is designated by a triple line. To set the probe at 6/10ths depth, read the water depth as determined from the single, double or triple lines. At a depth of 0.15m (2 ½ single lines above the first set of double lines) for example, align the “1” on the sliding scale between the “4” and “6” on the fixed scale and the probe will be set at 6/10ths or approximately 0.07m above the streambed. The two scales are aligned by depressing the button at the top of the rod and sliding the small (round) rod up or down to the appropriate setting.

Habitat Sampling

Habitat sampling includes a combination of actual measurements (stream width, site length, depth and gradient) and visual estimates (riparian cover, stream substrates and habitat features). The most critical values generated from the habitat measurements are the incremental stream widths and the total site length (from start point to endpoint) at each site. These measurements are used annually for each of the quantitative sites to calculate the total area (m²) of each site. Total site area is one of the principal components of the formulas used to calculate fish density (# fish/100m²) and biomass

(kg/ha) estimates. The remaining habitat variables are generally used to characterize each site and to provide an account of major changes that occur over time.

Site gradient or the percent slope at each site has the greatest degree of year to year stability among all of the measured or estimated habitat variables since gradient is directly linked to dominant landscape level features in the watershed. Experience in the mostly small streams at Shenandoah has demonstrated that all of the other habitat variables (riparian cover, stream substrates and depth) are more likely to change over the short term. The most dramatic annual variations occur due to differences in stream flow volume from year to year. Annual changes in water volume within streams account for major differences in the incremental width measurements, the subsequent total area measurement and the ratio of pools and riffles observed each year. Experience has also demonstrated that the visual estimates are the most variable elements of habitat sampling due to differences in perception between individuals and/or crews.

The following procedures for measuring and estimating habitat variables should be implemented at each site in an attempt to create the same basic sampling profile for each individual and to limit the differences of perception between individuals to the extent possible. Habitat measurements are typically taken either between or following electrofishing runs. The timing with respect to other tasks will be largely determined by the number of crew available and the complexity of individual sites. At times, crew sizes are sufficient such that a “habitat” crew of three can follow behind the electrofishing crew on their third run. This strategy does not work as well on large or high fish volume sites due to demands on all available crew during the electrofishing runs.

Habitat measurements always start at the downstream habitat break that comprises the start point for electrofishing at each site. A crew of three including a data recorder and two measurers is optimal. Required equipment includes two spooled measuring tapes (30m and 100m), a depth staff, a clinometer, a clipboard and a habitat data form (Appendix J). At the downstream habitat break, stretch the 30m tape from left to right across the stream channel, perpendicular to the direction of flow. Pull any slack out of the tape and measure the waterline to waterline width. Record width to the nearest 0.1m on the habitat data form in the first row that corresponds to “zero meters” (0) in the “Distance” column. Stream widths will be recorded at each 10m interval up to and including the habitat break at the upstream end of the monitoring site

Next, the person holding the end of the tape on the left hand stream bank (facing upstream), enters the stream and uses the tape as a guide for measuring water depths and estimating substrate types at the $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ points from left to right across the stream channel. At each point ($\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$), the water depth is recorded to the nearest .01m using the depth staff and the dominant substrate encountered at the point where the staff contacts the streambed is visually estimated according to the substrate classification chart on the habitat data form.

If the streambed and associated cobble, boulder, or bedrock substrates are covered with a layer of silt at the point of contact between the staff and the streambed, then silt or “L” is

called out and entered as the substrate value for that point. If a layer of moss, leaf debris, sticks or woody debris, or a thick layer of algae exists at the point of contact, then organic or “O” is entered as the substrate value for that point. The same rule applies to a layer of sand or pebble/gravel substrates overlaying other substrates on the streambed.

Otherwise, the substrate immediately impacted by the depth staff is recorded at each of the three points across the channel **always from left to right when facing upstream**. Stream depths and substrates will also be recorded at each 10m interval up to and including the habitat break at the upstream end of the monitoring site

Once completed, the person on the right hand stream bank rewinds the 30m tape and the end of the 100m tape should now be secured to the downstream habitat break at the midpoint across the channel width. The metal clip at the endpoint of the 100m tape can often be wedged in between large rocks at the break but a small boulder should be used to anchor the clip to the streambed. Since the metal clip represents “0m” or endpoint of the tape, it is important to secure the clip right at the upstream edge of the habitat break to mark the beginning of the monitoring site.

From a position directly above the endpoint of the tape, the data recorder should look straight up and determine the riparian cover category that exists at that point. This is a visual estimate of the degree of tree canopy cover over the sample point according to the riparian cover chart on the habitat data form. Determine the degree of cover from the three percent ranges in the chart and if the canopy consists of trees, enter a “T” to the right of the cover value. On the data form in the “0” distance row, this value should appear as 1T, 2T or 3T accordingly. In some cases, canopy cover may consist of shrubs in which case an “S” should be used. In some of the flood-impacted sites, there will be no canopy cover and little or no streamside vegetation. The “0N” value should be entered where vegetation is absent on the adjacent stream banks. Riparian cover will also be recorded at each 10m interval up to and including the habitat break at the upstream end of the monitoring site

With the endpoint securely anchored, the 100m tape should now be extended upstream at mid channel. Each 10m interval on this tape is marked with a strip of red electrical tape so that it can be readily distinguished at a distance. Upon reaching the first 10m point, any slack should be pulled out of the tape from the upstream end. The person at the 10m point should now stand directly over the 10m mark at the midpoint across the channel and face the data recorder downstream at the endpoint. Using a clinometer, the data recorder can now determine the gradient of the first 10m section. In using the clinometer, hold the instrument such that the round side-window faces to the left. The instrument is aimed by tilting it up or down until the hairline in the middle of the sight is at the top edge of the point to be measured. For consistency, use the top of the person’s head that is standing at the 10m point. With eye contact established, the data recorder can read the percent scale number that aligns with the hairline sight on the clinometer and then signal to the person upstream when finished.

In most cases, gradient will be a positive number but it can be negative, particularly if the person at the 10m point is standing in a deep pool. **It is important to note that the**

gradient value recorded from the “0” distance point of the monitoring site must be recorded in the “10” distance row on the data form. The space for gradient on the “0” distance row is crossed out for this purpose. Gradient measurements will also be recorded at each 10m interval up to the habitat break at the upstream end of the monitoring site. The 10m offset on the data form will provide a gradient value that corresponds to the last recorded distance measured at the upstream end of the monitoring site.

Next, the data recorder walks upstream through the first 10m section and conducts a visual estimate of the relative amount of pool habitat (deep, still water) and riffle habitat (shallow, flowing water) present. These two habitat features have proven to be the most readily and consistently distinguishable stream habitat features at Shenandoah considering the differences in perception between individual observers. The relative amounts of pools versus riffles for each 10m section should always be two numbers that add up to ten. In some cases the entire 10m section will be a pool in which case a “10” will be entered under “pool” and a “0” will be entered under “riffle” on the data form. More often, there is a mix of pool and riffle habitats within each 10m section that can only be determined by an observer walking through the section and noting the relative amounts of each type present. **Note that pool and riffle habitat data also have a 10m offset on the data form.** The first recorded values for these habitats must be recorded in the “10” distance row on the data form. . The spaces for “pool” and “riffle” on the “0” distance row are crossed out for this purpose. As for gradient, the 10m offset on the data form will provide a set of habitat values that corresponds to each 10m section including the last measured section at the upstream end of the monitoring site.

At this point, the entire habitat crew should be assembled at the “10” distance point along the monitoring site. When stretching the 30m tape across the stream channel, make sure it intersects the 100m tape at each of the 10m intervals as marked with red electrical tape. The same sequence for measuring or estimating stream channel width, depths, substrates, riparian cover, gradient and habitats must be followed at each subsequent 10m distance interval as described above. Monitoring sites almost never end right at a 10m distance interval. It is important to record the total length of the site to the nearest 0.1m in the distance column following the last full 10m section measured. For example, if the last full 10m section was at the “100” distance point and there are still several meters remaining between that point and the actual upstream endpoint, measure to the endpoint and record the total length (ie.104.7) in the “110” distance cell. Be sure to cross out the “110” and record the actual distance just above it in the remaining space within that cell. Gradient and habitat measurements are continued up to the endpoint and channel width, depths, substrates and riparian cover are measured at the endpoint as described above.

An additional important consideration at some of the monitoring sites is the procedure for measuring or estimating habitat parameters around islands. Islands can form or disappear following massive rain events. The remaining chart at the bottom of the habitat data form contains a special set of columns and rows for measuring separate channel widths, island widths and for calculating total channel widths at each affected 10m distance point. Make sure to note the specific distance point(s) where islands are present in the “Dist.”

Column of the island chart. **As for single channels, channels split by islands should always be measured from left to right when facing upstream.** The clip or endpoint of the tape should be positioned on the left-hand stream bank and the tape should be extended to the right as noted above. The left-hand channel will be “channel A” and the right hand channel will be “channel B”. The data recorder should traverse the tightly stretched tape and record the waterline to waterline distance of each channel and the island at each of the affected distance points. The total channel width or the sum of channel A and channel B widths should be recorded in the column provided on the island chart. The total width is also recorded up in the main table for each of the affected distance points. Total widths are used for calculating the area (m²) as noted above.

The 100m tape should always be extended up through the centerline of the most dominant channel. This will provide a consistent reference point for measuring gradient and estimating riparian cover over time and serve as a marker for partitioning depth and substrate measurements in the main channel. Depth and substrate measurements will be taken in the same order across the stream from left to right but will be split between the two channels. One set of depth and substrate measurements will be recorded in the least dominant or side channel regardless of whether it is channel A or B and the remaining two depth and substrate measurements will be recorded in the dominant channel. For recording single values in side channels, take measurements from the center of that channel. The dominant channel should be visually split into thirds with measurements recorded at 1/3 and 2/3 width intervals. **The resulting data are recorded in the main table under the ¼, ½, and ¾ columns as at single channel sites.** At the time of data entry into the main fisheries database, individual channel widths and the island width can be referenced in the “notes” field for each affected distance point.

Principles of Electrofishing

The efficiency of any electrofishing operation is largely influenced by the conductivity of the water in relation to the conductivity of the fish. Stream water from mountain streams typically has a very low conductivity due to the limited amounts of dissolved ions or salts in those waters. Conductivities in park streams range from a low of 8 - 12 microSiemens/cc to a high of 80 microSiemens/cc. Trout have a conductivity of approximately 1200 microSiemens/cc which results in the fish being much more conductive than the water that they inhabit. This makes the fish very susceptible to stunning as electric current conducts through the fish more readily than it conducts through the surrounding water. In higher conductivity waters such as seawater that can range up to 10,000 microSiemens/cc, the electric current simply bypasses the fish and the fish remain unaffected.

The primary limitation of electrofishing in low conductivity waters is the small size of the electric field produced around the electrode (probe). In the extreme case, a fish may not be affected until it touches the probe at which point the fish receives a high voltage shock and dies. This problem is remedied by increasing the voltage output on the transfer box to produce a larger electric field around the probes.

Fish react to the presence of an electric field in several ways depending on the type of current (AC or DC) and the voltage gradient that they encounter. The outer or peripheral zone of the field is typically very weak and the fish will either remain indifferent or exhibit a fright response and try to escape. As the probes get closer to the fish, the voltage gradient increases within the fish which results in galvanotaxis or forced swimming. Fish in galvanotaxis tend to align themselves perpendicular to the electric field in an attempt to minimize the voltage gradient within their bodies. In many cases, this response will cause the fish to swim toward the anode or positive probe. As the fish approaches the innermost or strongest electric field in a pulsed DC environment, muscle relaxation or galvanonarcosis occurs and the fish roll over and are easily captured. At this point it is important to net the fish as soon as possible to minimize the likelihood of the fish coming into contact with the probes and either being severely burned and/or electrocuted.

The principal unit in use at Shenandoah is the Smith-Root, Model 15-D backpack electrofisher that was designed for use in low to medium conductivity waters. Each unit consists of a Honda model EX350 generator and a transformer mounted on a reinforced nylon backpack frame. The recommended fuel mixture for the generator is 100:1 gas:2-stroke oil. The generator has a voltage output of 120 VAC (volts alternating current). The voltage output is then sent through the transformer where it is rectified and filtered through a DC to DC converter so that the resulting output is DC or direct current. The transformer has two mode switches and a voltage range switch that enables the operator to increase voltage outputs up to a maximum of 1100 and to regulate pulse widths to a desired range that will result in the immobilization rather than the death of the fish. Voltage output settings will be determined according to the conductivity at each site, and in situations where more than one electrofisher is used, voltage settings will be the same on all units.

The collective time and experience of Model 15-D users in low conductivity waters has determined near optimal mode switch settings of J and 2. This allows an output frequency of 70 Hertz or 70 cycles per second and a pulse width of 1 millisecond. The duty cycle or length of time at peak voltage is determined by multiplying the output frequency x the pulse width x 100. At mode settings of J and 2, the duty cycle is 7 meaning that peak voltage output as per the switch setting occurs 7% of the time. The other 93% has a voltage output of zero. This is commonly referred to as pulsed DC which is better than sustained DC because it sustains galvanotaxis or forced swimming towards the anode with less damage to the fish.

All of the monitoring sites will be sampled using backpack electrofishing techniques based on guidelines established in *Standardized Sampling Guidelines for Wadeable Trout Streams* (American Fisheries Society Southern Division Trout Committee 1992). Briefly, these guidelines (Appendix B) specify the use of one backpack unit where mean stream widths do not exceed 4.5 meters or one unit per 3.0 meters to provide reliable data from streams with mean widths in excess of 4.5 meters. All of the 41 sites along the 18 core streams will be sampled annually using the three-pass depletion or quantitative method of population estimation described in Armour et al. (1983) and as summarized

briefly below. The remaining 34 sites along the 25 optional streams will be sampled at least once every five years using single pass or qualitative electrofishing techniques as described below.

Fish Sampling (Quantitative)

Upon arrival at individual monitoring sites, the upper and lower tag trees need to be located and the associated habitat breaks need to be identified and assessed for adequacy as a barrier to fish movements in or out of the site. As noted above, habitat breaks at some of the sites require additional measures such as the construction of temporary dams from adjacent cobble or small boulders. **Before making any modifications to habitat breaks particularly at the upstream end, make sure that all activities associated with the use of the Hydrolab have been completed.** Otherwise, modify each habitat break as necessary to impede fish movements. In many cases, the existing breaks are adequate and the upstream break in particular may need to be temporarily marked. Small rock monuments constructed by stacking several small, flat boulders in a conspicuous location at the upper break has proven to be a useful reference aid to electrofishing crews working upstream. This function can be accomplished expediently by one person in between the Hydrolab sample and the first electrofishing run.

The remainder of the crew should be busy assembling the electrofishing gear and/or setting up a fish processing site. At this point, all personnel assigned to participate in the first electrofishing run should have the appropriate waders or hip boots on and should have located a suitable pair of gloves and polarized glasses. Prior to the first run of the day, it is a good idea to start the generators and allow them to warm up for several minutes before entering the stream. Make sure that the fuel cap lever is set to the ON position. Locate the engine switch on the generator and set it to the choke position. After taking up the slack, pull the starter cord rapidly to start the engine. One or two pulls are usually sufficient. Then, move the engine switch from choke position to ON. The person designated to operate the unit needs to make sure that the probes are securely attached to the transformer box and that the box is plugged into the generator.

Voltage outputs on all units will be set to the same range as determined by stream conductivity. For most of the park's monitoring sites, full generator output capacity is not needed so the output selector switch located above the engine switch should be set to the 150 VA position. All unit settings will be determined by either the fisheries program manager or the lead biological technician. Each unit will be tested briefly at a point downstream from the lower break to evaluate fish responses to the selected outputs. Following any last minute adjustments, the first run begins immediately above the lower habitat break.

On sites where two or more units are being operated together, the operators must work together as a team and remain abreast of each other in the streambed along with associated netters to the extent possible. The line abreast crew formation should methodically shock all habitats along a cross-sectional gradient, covering for each other as appropriate to minimize fish escapes downstream. The operators set the pace of the

entire stream crew and should maintain a constant forward momentum, but not move too fast. The objective is three thoroughly efficient runs of equal effort through the site to generate as sharp of a fish population depletion curve as possible.

All fish encountered within the site should be netted and bucketed as quickly and efficiently as possible. Expect large volumes of fish during the first run in particular. Stunned fish should be netted with a rapid scooping action from below, not from above the fish. Anticipate receiving a large number of fish from the net attached to the anode as the operator will be routinely passing stunned fish to the nearest available netter. The bottom feeders including suckers, sculpin, darters and some dace routinely become lodged in streambed substrates. These fish often have to be extracted by hand and it is imperative to make sure that the operators have cut power to the probes and raised them clear of the water before reaching for a lodged fish.

Those persons carrying and transporting buckets are responsible for the welfare of the captured fish. Moderate volumes of live fish in the buckets should be routinely transported to the processing site. **Always manage to prevent overcrowding in the buckets and overheating of the bucket water.** During the first run, on sites of high fish volume, or at sites with water temperatures in excess of 16 °C, transports from the stream crew to the processing site may necessarily be as frequent as every ten minutes. In most cases, there will be additional personnel on site that can serve in this role. At this point, water management and the prevention of overcrowding in the buckets is the key to fish survival. On sites or runs where fish volumes are not as great, the water in individual buckets should be changed and replaced with fresh water from the stream about every ten minutes prior to transport to the processing site. In these cases, do the water changes at a convenient habitat break so that the operators can momentarily stop. Water changes should not be done over the stream to prevent accidental escapes. Rather, move to a convenient location on the adjacent stream bank, pour the fish into one of the large dip nets and then dump the fish into a bucket of fresh water. If any fish manage to flip out of the net or bucket during the transfer over land, they can quickly be recovered.

At the processing site, there will be at least one and possibly three or four large plastic tubs each containing 15 to 18 gallons of fresh stream water. On high fish volume sites or runs, it is most convenient to sort fish from one or two of the large tubs. To keep the water in the tubs fresh and relatively free of debris, any transported fish should first be poured into a large dip net and then dumped into the tub(s). On sites or runs having relatively low fish volumes, it is often more convenient to sort from the five gallon buckets, exchanging buckets with fish for empty buckets as needed for transport. Trout should be sorted into, processed from and recovered in the plastic tubs since they tend to be the larger fish, both in terms of body size and total volume in the sample. The same principle should be applied to other species as well when large volumes of individual species are captured. The large tubs in these cases are the best line of defense against additional stress and/or mortality. Otherwise, the typically smaller volumes of other fish species can be easily accommodated by species in five-gallon buckets.

In situations where there are enough personnel for a separate processing crew, trout processing can begin once the first of the transported buckets has been sorted. To the tub containing the trout, pour a partial to full cap of the clove oil/ethanol mix. This functions as an anesthetic to the fish and greatly expedites data processing. Gently stir the water to which the clove oil has been added to allow for appropriate mixing and begin to process the fish in the order that they begin to succumb. Individual fish will typically begin to roll onto their side as the anesthetic takes effect. Some of the fish will arrive at the processing site in a stressed condition. In these cases, do not subject stressed individuals to the clove oil. **Always process the most obviously stressed fish first.** Getting them processed and back into fresh water will maximize their chance of survival.

All trout are individually measured to the nearest 1.0mm and weighed to the nearest 0.1g. For measuring total lengths, place fish on the measuring board nose first such that their nose is in contact with the wooden stop at the “0” end of the ruler. Record the total length out to the absolute tip of the caudal or tail fin. Next, make sure that the electronic balance has been tared to “0” for the container being used, place the fish in the container on the balance and record the total weight. Due to water accumulations in the container, or wind, or other variables, the balance may need to be tared after each fish. Immediately following both measurements, the fish should be returned to a tub containing fresh water and designated as the recovery bucket. Following each run, hatch out an entire row on the gamefish data form (Appendix H). This will greatly expedite distinguishing the runs during data entry.

Once the entire run has been completed and all of the nongame species sorted, the entire catch by species needs to be counted. After the total count has been recorded on the nongame data form (Appendix I), determine the smallest and largest fish of each species and record or call out the length of each. Also record or call out the total number of morts or dead fish by species. **Make sure that the data recorder acknowledges the receipt of each record since there may be several people processing the nongames simultaneously.** The data recorder needs to make sure that each entry for a particular species corresponds to the current run being processed. Once all of the count and length data have been recorded for an individual species, a mass weight needs to be determined on the balance. Use a larger container for this since some species will occur in large numbers particularly during the first run. **Clove oil is not generally applied to containers of nongame fish species with the notable exception of American eels. Rather, individual lots of nongame species are dipped into tubs or buckets containing the appropriate water/clove oil mix to induce mild anesthesia prior to obtaining the mass weights of each species present.** This reduces the tendency of fish to flip themselves out of the container while the lot is being weighed. Record total mass weights for each species to the nearest 0.1g. As the fish processing for each species including the trout are completed, have them immediately transported to holding cages located in the stream. All fish from all runs will be held in the holding cages until the site is completed.

Runs two and three and the associated transport and fish data processing will be done in the same way as the first run. The primary difference is that fish volumes should

dramatically decrease with each successive run. In the event that more trout are captured during the third run than during the second, a fourth run will be conducted to reestablish the depletion curve. Maintaining equal effort between runs is difficult due to operator fatigue and proficiency. Experience has demonstrated that it is not advisable to take a prolonged break such as lunch between the second and third runs or to have a more proficient or experienced operator on the third run than on the second. At the conclusion of all runs, all live fish are released back into the stream in the approximate proportions and habitats from which they were captured. All morts are separated out during processing and disposed of well away from the stream bank.

Fish Sampling (Qualitative)

All of the setup procedures are the same for qualitative as for quantitative sites. The principal difference is the degree of electrofishing effort (one pass instead of three) and the total lengths are measured on all trout and other gamefish but no weights are recorded. During the electrofishing run, all fish are netted as above to increase the likelihood of detecting low density species. Since most of the qualitative sites tend to be located on small streams of limited fish species diversity, all species present are typically readily encountered and accounted for during the run. There are however a few boundary sites of moderate to high species diversity including Naked Creek-West Branch, Hazel River, Thornton River-South Fork, White Oak Canyon Run, Doyles River and Big Run. These sites all require the use of multiple backpack units as specified above and the same degree of netting diligence to provide a fairly accurate account of species relative abundance.

At the processing site, all fish are sorted by species and only those fish (most typically gamefish) that will be individually measured are anesthetized in a tub or bucket containing clove oil as noted above. Only total lengths are recorded for each gamefish captured which are recorded on gamefish data form(s). In a like manner, all of the data fields on the nongame fish form will have recorded values except for total weight. The nongame fish data includes a total count by species, a size range (min and max values) and a mortality count (fish that did not survive the sampling procedure). For both types of data forms, there should be a short note at the top of the first page that identifies the data as “Qualitative”. Upon the completion of data processing, all fish should be released and all morts should be disposed of as noted above.

DATA MANAGEMENT

As noted above, crew communication during the data calling and recording process is extremely important. When calling data to a data recorder, make sure that the data recorder acknowledges the receipt of each record called. It is the responsibility of the data recorder to seek clarification on any unclear or questionable records. In any situation where clarification or questionable issues cannot be resolved, consult the program manager or the lead biological technician. **It is critically important that the data recorder have good penmanship as the written records need to be clearly legible.** Any corrections that need to be made to any data form in the field should be

completely erased before attempting to add correct values. Gamefish data will most often require multiple pages of the gamefish data form at each site. **Make sure that each page is numbered sequentially in the space provided prior to recording any data on the next or new page.**

At the conclusion of recording gamefish data from each site, the total number of gamefish pages should be determined and entered accordingly on each page in the space provided. It is the responsibility of the field supervisor present (either the program manager or the lead biological technician) to review each completed data form for completeness and accuracy prior to leaving the site. To assure that this step has been taken, the supervisor present should initial each data form in the upper right corner as “reviewed by” (initials) and “date”. Prior to leaving the site, all completed forms representing that site should be organized with the **site form** at the top followed by the **habitat, gamefish and nongame fish forms** in that specific order. These should be paper-clipped together and temporarily stored in the protective chamber of the large aluminum clipboard. Upon arrival back at the office at the end of the day, all groups of forms from completed sites should be filed in the folder corresponding to the current year located in the drawer labeled “Current Electrofishing Data”.

Specific instructions for using the park’s Aquatic Database System to perform data entry, edits, validations and summaries follow in the Appendices. Data entry should be performed at opportunity during the field season to avoid large backlogs of accumulated data. Short field days or periods of inclement weather should be used advantageously to this end. Data entry can be accomplished efficiently by a crew of two, one serving as a caller and one operating the keyboard. Crew should routinely rotate between these two tasks every 30 to 45 minutes in an effort to reduce fatigue. As available staff allows, a crew of three is better in the sense that an individual can routinely be rotated out for a break of 30 to 45 minutes. Although, the database and associated queries are not case sensitive, all data should be entered in “large case” by selecting “Caps Lock” on the keyboard. This provides for consistency with data entry procedures from previous years.

Briefly, The Shenandoah National Park fish data entry program consists of three main components, the data entry application, the temporary storage databases, and the master database. Data is entered into the first temporary database using the data entry application. Then to help provide accurate data the data is entered a second time into a second temporary database. The two temporary databases are compared and any discrepancies can be reviewed and fixed. Then at the end of the field season the data in the temporary databases are reviewed by the program staff and then added to the master database.

Upon the completion of data entry for specific section of the data the date entry crew should initial and date the original form. A pen with green ink works well for this function as red ink should be reserved for any editorial changes made to records on the field sheets.

Upon the completion of all data entry and validation procedures, the program manager will follow the instructions for exporting fish data to MICROFISH. All of the quantitative fish data will be formatted for and loaded into the MICROFISH (VanDeventer and Platts, 1989) program for basic analysis. MICROFISH provides population estimates, population estimate standard errors, capture probabilities, condition factors, mean lengths, mean weights and other useful information by site for each stream. From the population estimates and mean weights generated, density (# fish/100m²) and biomass (kg/ha) estimates will be generated in EXCEL for each species at each site. These results will be used to generate data summaries, charts and reports on an annual basis or as needed for park management.

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APPENDICIES

Appendix A: SHEN Field Equipment List and Description

FISHERIES MONITORING

FIELD EQUIPMENT CHECKLIST

Fish Sampling

- _____ Backpack Electrofishing Units
- _____ Anode/Cathode Probes
- _____ Cooler with Gas Mix
- _____ Tool Kit with Spark Plugs
- _____ Long Handled Dip Nets
- _____ Short Handled Dip Nets
- _____ Holding Cage(s)
- _____ Block Nets (large sites)
- _____ Plastic Buckets
- _____ Blue Plastic Tubs
- _____ Bucket Pack(s)
- _____ Back Packs
- _____ Clove Oil (brown Nalgene bottle)
- _____ Measuring Boards
- _____ Electronic Balances
- _____ Extra AA batteries for Balances
- _____ Rubber Gloves
- _____ Polarized Glasses
- _____ Fish Key (Jenkins and Burkhead)

General Equipment

- _____ GPS Unit
- _____ " Polycorder (Yellow case)
- _____ " Receiver (Yellow)
- _____ " Antenna
- _____ " Antenna Staff
- _____ " Batteries (2)
- _____ Hand Held Radios w/Batteries
- _____ First Aid Kit
- _____ Site Directions
- _____ Field Data Forms (1 set per site)
- _____ Site Form/H2O/Discharge
- _____ Gamefish Data Form
- _____ Nongame Fish Data Form
- _____ Habitat Data Form
- _____ Metal Clipboards
- _____ Pencils
- _____ Hip Boots
- _____ Drinking Water
- _____ Lunches

Flow & Physical Site Measurements

- _____ 100 m tape
- _____ 30 m tape
- _____ MMB flow meter
- _____ Extra batteries for MMB (size D)
- _____ Top setting metric wading rod
- _____ Depth stick (graduated in .01m)
- _____ Compass
- _____ Clinometer

Stream Chemical Measurements

- _____ Hydrolab Multi-Sensor Unit
- _____ " data Display System
- _____ " cable
- _____ " weighted sensor guard
- _____ " extra AA batteries

Backpack Electrofishing Units:

The principal unit in use at Shenandoah is the Smith-Root, Model 15-D backpack electrofisher that was designed for use in low to medium conductivity waters. Each unit consists of a Honda model EX350 generator and a transformer box mounted on a reinforced nylon backpack frame.

Anode/Cathode Probes:

Probes for the backpack units consist of two 1" x 60" fiberglass poles each activated by pressing the rubber flapper forward against the pole. A magnet within the flapper will close the reed switch within the pole handle and activate the output. Each probe is also fitted with a ½" diameter aluminum frame. The anode net frame is equipped with a 3/16" mesh nylon net that is 6" deep and the cathode consists of the aluminum frame only.

Cooler with Gas Mix:

The recommended fuel mixture for the generators is 100:1 unleaded gas/small engine oil. The fuel mix should be thoroughly mixed in the metal 2 ½ gallon gas can labeled "Shocker". For daily use, the fuel mix is transported in aluminum fuel bottles of 1 liter capacity. Individual fuel bottles should be packed into the Rubbermaid® cooler labeled "Fuel" for transport in any vehicle. At the parking site, individual fuel bottles are stowed in the side pocket of an available backpack for transport to the monitoring site(s).

Tool Kit with Spark Plugs:

The tool kit is contained in an old white plastic "first aid" box. In addition to spark plugs, the tool kit contains a screwdriver, a roll of electrical tape, a tube of waterproof cement, washers, bolts, nuts and other spare parts for the shockers, packs and waders.

Long Handled Dip Nets:

Long handled dip nets consist of ½" aluminum frames with 3/16" x 18" mesh mounted on 60" fiberglass poles. Adjustments can be made to mesh depths by knotting the bottom of the net to the desired level. These are used primarily for capturing stunned fish in the stream and for transferring fish between buckets.

Short Handled Dip Nets:

These nets consist of 3/16" x 4" mesh minnow nets with aluminum frames mounted on 24" aluminum handles. Short handled nets should only be used at the processing site for sorting and transferring fish between buckets and the electronic balances.

Holding Cages:

Holding cages consist of frames constructed from ¾" PVC pipe and cemented copper fittings equipped with special ordered net boxes or cages. Each 12" x 16" x 20" x 3/16" mesh net box is equipped with a zippered top for loading, unloading and preventing the escape of captured fish. Holding cages are erected on site and submerged in shaded pool habitats such that the bottom 2/3 of the cage is submerged in the stream. These are typically located adjacent to the processing site either upstream or downstream of the monitoring site.

Block Nets:

These 4' x 25' nets are typically needed at the largest sites (lower Rapidan and lower Moorman's River) to adequately block the downstream end of these sections to impede fish movements in or out of the site. Associated gear includes a 100' x 3/8" length of steel cable, 3/8" cable clamps, 45 double-ended snap connectors and a 3/8" socket set with spare 9/16" sockets. These items are typically stored together in a single five-gallon bucket. The top of each net is suspended from the steel cable and the bottoms are anchored to the streambed with large rocks.

Plastic Buckets:

Plastic five-gallon buckets are used for temporarily storing, transporting and processing captured fish. The number needed is determined by the expected number of species at each site, expected fish volumes and the number of participating crew as based on previous experience at individual sites.

Blue Plastic Tubs:

The large blue tubs are used for sorting large volumes of fish and for processing trout or other species captured in very large numbers, primarily to prevent overcrowding. The specific number needed is determined by anticipated volumes of trout and/or other fish based on results from previous years.

Bucket Pack(s):

These pack frames are typically needed to transport large numbers of buckets to and from monitoring sites.

Back Packs:

The specific number of packs needed on any particular day is largely dictated by the number of participating crew. In most cases, every person on the crew will be required to transport either a shocker, bucket pack, or regular backpack loaded with sampling and/or personal gear. Generally, the larger the crew, the more packs are required to accommodate the additional personal gear. Several pack sizes and styles are available to accommodate individual needs.

Clove Oil/Ethanol Mix:

Clove oil mixed with ethanol in a 1:10 ratio (clove oil/ethanol) serves as a good fish anesthetic which lowers the circulatory rate and subsequent oxygen demand of fishes thus reducing handling stress. This compound is stored and transported in small (250 mL) **brown** nalgene bottles and is used primarily for gamefish and eels.

Measuring Boards:

All measuring boards consist of steel rulers ranging in size from 0-300mm to 0-450mm, attached to a wood trough with a wood stop at the “0” end. It is helpful to have the three existing measuring boards present at all of the quantitative sites.

Electronic Balances:

The two 600g O-Haus balances will be required at all of the quantitative sites for processing trout and/or other gamefish. The 1.2 and 6 kg balances will be needed in addition to the 600s at high volume sites, brown trout sites, eel sites and/or sites with other large game or nongame fish species. Each scale will need to be calibrated on site with the calibration weights provided. **Make sure that a full range of weights is present in the Pelican® cases for the calibration of each balance taken to the field.**

Extra AA Batteries:

These should be stored in a waterproof container and will serve both the electronic balances and the Hydrolab. There should always be at least two dozen batteries of this size on hand while in the field.

Rubber Gloves:

These gloves are a critical safety element by guarding against electric shock. Several sizes and lengths are available but each person on or assisting the stream crew is required to wear them at all times when the electrofishing units are in operation.

Polarized Glasses:

Polarized glasses should be worn by the entire stream crew. These glasses dramatically reduce surface glare and thus enabling the crew to spot fish more readily.

Fish Key:

Condensed from Jenkins and Burkhead, 1994, this key represents all of the species known to inhabit park streams. Several copies are available, all on waterproof paper.

100m Tape:

The 100m/300' open reel fiberglass measuring tape is used to measure the total lengths and to delineate the 10m cross sections of all monitoring sites. Each 10m interval on the tape has been marked with red electrical tape.

30m Tape:

This shorter (30m/100') measuring tape is used for measuring stream widths at each of the 10m cross sections and for delineating width intervals when measuring stream flow.

MMB Flow Meter:

The primary unit for measuring stream velocity is the Marsh-McBirney model 2000 "Flo-Mate". The MMB model 201D serves as a backup unit when the Flo-Mate is out of service.

Extra "D" Cell Batteries:

These should be stored in a waterproof container and will serve both of the flow meter units. The Flo-Mate requires two D-cell batteries and the 401D requires six. Pack spare batteries accordingly.

Top Setting Metric Wading Rod:

This device serves to position the flow meter probe at the appropriate depth in the water column for measuring stream velocity.

Depth Stick (graduated in .01m):

Unlike the wading rod, the depth stick is a 1.5m x 1" section of treated wood dowel that has been marked at .01m intervals for measuring channel depths at each of the 10m cross sections.

Compass:

While not a critical component of the fish or stream sampling effort, a hand-held compass should be included with the sampling gear for all of the interior sampling sites.

Clinometer:

This is a small hand-held instrument used for measuring the percent (%) gradient of stream sites. In using the clinometer, hold the instrument such that the round side-window faces to the left. The instrument is aimed by tilting it up or down until the hairline in the middle of the sight is at the top edge of the point to be measured. **Make sure to read and record the percent (%) scale.**

GPS Unit:

Each functional GPS unit consists of several components including a polycorder, receiver, antenna, antenna staff and two camcorder batteries. Many of the current and historic monitoring sites have been GPS'd. Coordinate all GPS activities with the lead biological technician.

Hand-Held Radios w/Batteries:

The portable radios used by park staff are Bendix-King model EPH5102As. These are equipped with rechargeable batteries that should be checked prior to leaving for the field. Due to the location of monitoring sites in steep watersheds, the whip antenna should be installed on one of the units for better transmission/reception. The crew should pack at least two of these portable radios with batteries in the field at all times.

First Aid Kit:

Items in the first aid kit include bandages of various sizes, an eye dressing unit, gauze, adhesive tape, iodine, ophthalmic solution, aspirin tablets, forceps, scissors, instructions and other useful items.

Site Directions:

Site directions are stored in the central file drawer labeled "Historic Electrofishing Data" within the I&M building. Each day, the appropriate field copy should be made on waterproof paper on which individual sites should be highlighted. The appropriate page or pages of the *Fisheries Management and Data Report* of 1994 should be checked for the number and type of expected species such that electronic balance and bucket needs can be planned accordingly.

Field Data Forms:

The full suite of data forms required for each site includes the "Site/Water Chem/Velocity" or cover form, "Gamefish Data Form", "Nongame Fish Data Form" and "Habitat Data Form". These should all be copied onto waterproof paper as needed each day from originals located in the central files. Multiple copies of all forms should be taken into the field each day. This is especially true for the gamefish forms since multiples are needed at almost every monitoring site in the park.

Metal Clipboards:

At least two of the aluminum clipboards will be required at each site. Three may be required at large or high fish volume sites. Clipboards contain copies of empty and completed data forms, the fish key, site directions, a fish species code list and pencils.

Pencils:

All data is recorded in pencil using mechanical pencils. Always ensure that a supply of these is present or on person before leaving for the field.

Drinking Water:

Each person on the crew is responsible for packing an adequate supply of drinking water for the anticipated conditions of the day. It is particularly important to plan ahead for the longer hikes and to anticipate personal water needs accordingly.

Lunches:

Likewise for food. Each person on the crew has different metabolic rates and other physiological factors and must plan accordingly.

Hydrolab Multi-Parameter Units:

Complete Hydrolab units consist of a number of components including the multi-sensor unit, data display system, cable, weighted sensor guard and extra AA batteries should be included for emergency backup.

Appendix B: Standardized Sampling Guidelines for Wadable Trout Streams

**AMERICAN FISHERIES SOCIETY
SOUTHERN DIVISION
TROUT COMMITTEE**

**Standardized Sampling Guidelines
For Wadeable Trout Streams**

August 1992

The following guidelines for standardized sampling methods in wadeable trout streams are based on the recommendations of the Standardized Trout Stream Sampling sub-committee of the American Fisheries Society, Southern Division Trout Committee.

Wadeable trout streams, exclusive of tailwaters, are defined as those that can be waded and sampled with backpack electrofishing gear. Southeastern trout streams are the primary focus of these guidelines, although they may be used (with or without modification) in other geographical regions. The objectives of these guidelines are:

1. Establishment of standardized sampling procedures that will provide a mechanism by which data can be more readily compared among various streams
2. Provision of standardized trend data on population changes (e.g., density, standing crop, species composition, size and age structure, etc.) through time as they relate to various abiotic effects (e.g., droughts, floods, regulation differences or changes, etc.)

Recommended Sampling Protocol Station Selection

1. Since complete electrofishing surveys of even the smallest streams are usually impractical, fish stock assessments must be based on a sample of stream reaches (Bohlin et al. 1982). The recommended procedure for selecting these sampling sections (also referred to as stations or sites) for monitoring purposes is to use 'representative' stream reaches that contain the major habitat types or units present, such as pools, riffles, runs, etc. If possible, streams should be traversed prior to station selection to ensure that major habitat types are included in proportion to their occurrence. Representative reaches can be chosen randomly or sited using specific criteria as project needs dictate. Bovee (1982) and Hamilton and Bergersen (1984) provide additional information regarding habitat-based site selection. Non-contiguous habitat units may also be sampled if 'representative' reaches are unavailable or lack the desired level of precision for specific studies. Representative reaches are, however, recommended for long-term monitoring stations.

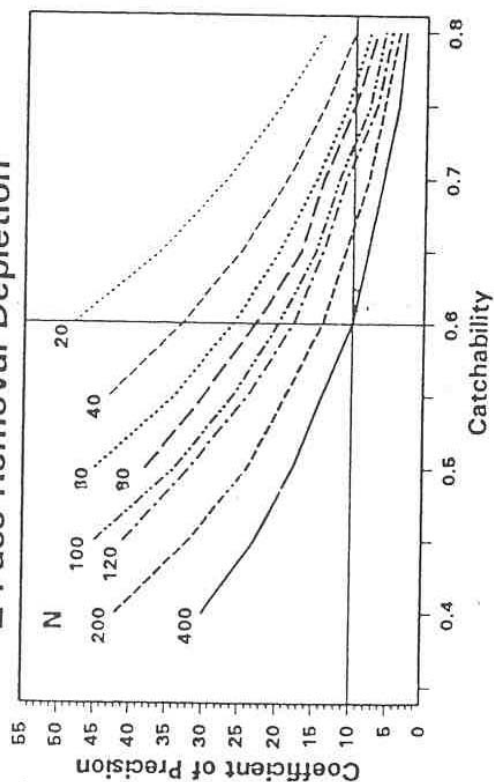
2. Minimum recommended station length is 100 m in streams ≤ 10 m in mean width as this length typically provides for the inclusion of at least one cycle of the basic stream habitat units present. The recommended station length in streams with mean widths exceeding 10 m is 200 m since it is difficult to include all major habitat types in 100-m stations in these larger streams. In practice, these station length recommendations should be used as points of reference since actual station lengths will often require adjustment to avoid habitat unit fragmentation and to make use of any fish passage obstructions present.

Sampling Techniques

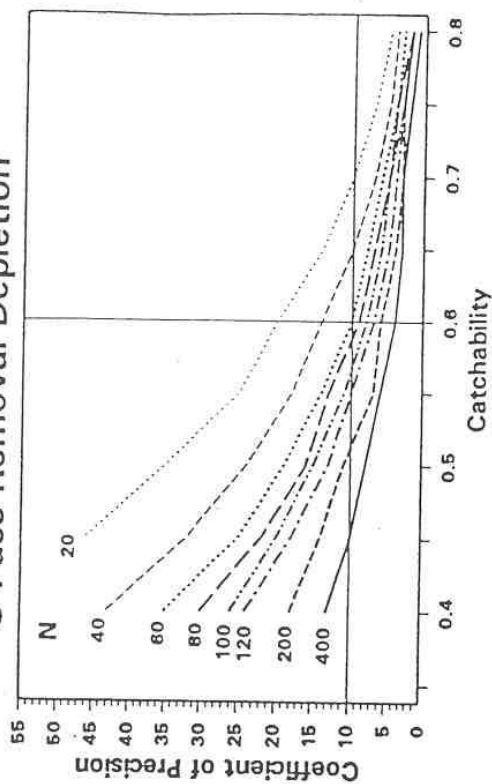
1. Backpack electrofishing is the most commonly used, non-lethal means for sampling trout population in relatively small streams (Armour et al. 1983) and is recommended here. Other sampling techniques, such as ichthyocides and explosives, may be necessary under specific circumstances and are described in Armour et al. (1983) and Platts et al. (1983). Removal-depletion and mark-recapture population estimation techniques are typically employed with backpack electrofishing gear. The removal-depletion method, however, is strongly recommended because of its overall efficiency (Armour et al. 1983) and because its associated assumptions (see Section 2 below) are more easily met. For example, behavioral responses of trout released after capture by electrofishing and marking may be such that the assumption of equal catchability (among marked and unmarked fish) is violated (Mesa and Schreck 1989). Little change in the behavior of trout remaining in stream sections following successive removal-depletion electrofishing passes has been noted (Mesa and Schreck 1989).

Two to four removal passes, made in the upstream direction only, may be used in removal-depletion sampling (Armour et al. 1983), although three passes are ideal in nearly all situations (Figure 1). Bohlin (1982) and Bohlin et al. (1982) recommend three removal passes where capture probabilities (catchabilities) are ≥ 0.50 , although they note that two passes may be sufficient where large populations are present (Figure 1). Catchability refers to a fish's estimated probability of capture on a given pass of a removal-depletion sample and characterizes the sample's reliability (Armour et al. 1983). Electrofishing catchabilities ranging from 0.50 to 0.70 are considered typical for stream salmonids (Bohlin 1982). In samples from Southeastern streams, catchabilities have averaged near 0.60 for adult trout (Figures 2 and 3). Catchabilities ≥ 0.50 will provide reliable population estimates.

2-Pass Removal Depletion



3-Pass Removal Depletion



4-Pass Removal Depletion

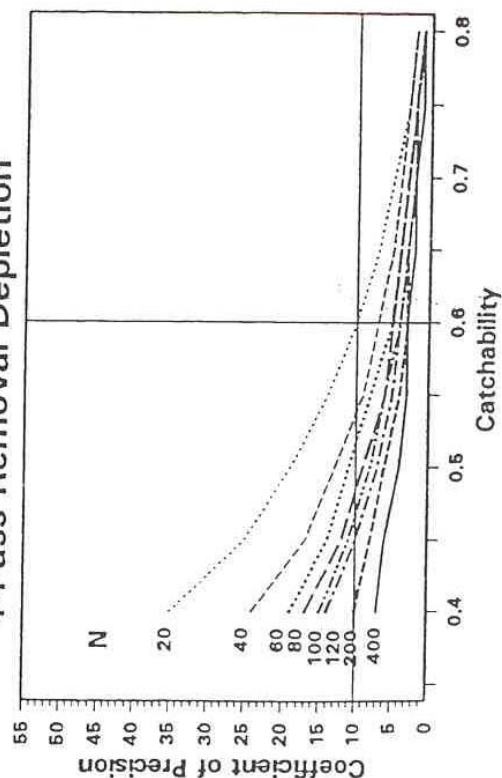


Figure 1. Coefficient of precision (Van Deventer and Platts 1989) vs. catchability curves for population sizes (N) ranging from 20 to 400 with two-, three-, and four-pass removal depletions. The coefficient of precision, $CP(N)$, is a measure of the difference between N (actual population size) and the corresponding population estimate ($\hat{N}$). For example, a $CP(N)$ of 10% means that $\hat{N}$ will be within 10% of N at the 95% confidence level. The graphs indicate that to maintain a given level of precision (e.g., 10%), catchability must increase as N decreases since the effect of capturing (or not capturing) a given fish on a given pass becomes increasingly important when N is relatively small and each fish represents a larger percentage of N . Using a reference catchability of 0.60, which the literature (Bohlin 1982) and data (unpublished) from GSMNP indicate is average, it is apparent that a 10% level of precision is possible only when sampling the largest populations ($N \geq 400$) with a two-pass removal depletion. Catchabilities of >0.75 must be achieved when sampling small populations ($N < 50$) using two removal passes if a 10% level of precision is to be obtained. Conversely, catchability need not exceed 0.60 for population sizes as low as 20 to achieve a 10% level of precision using four removal passes, although the additional effort required for four removal passes usually will not justify any added precision. Three-pass removals with catchabilities near 0.60 enable high levels of precision ($\leq 10\%$) for populations where $N \geq 60$. Where $N < 60$, somewhat higher catchabilities are necessary (0.65–0.70) but not unrealistic. Graphs are adaptations of those presented in Van Deventer and Platts (1989).

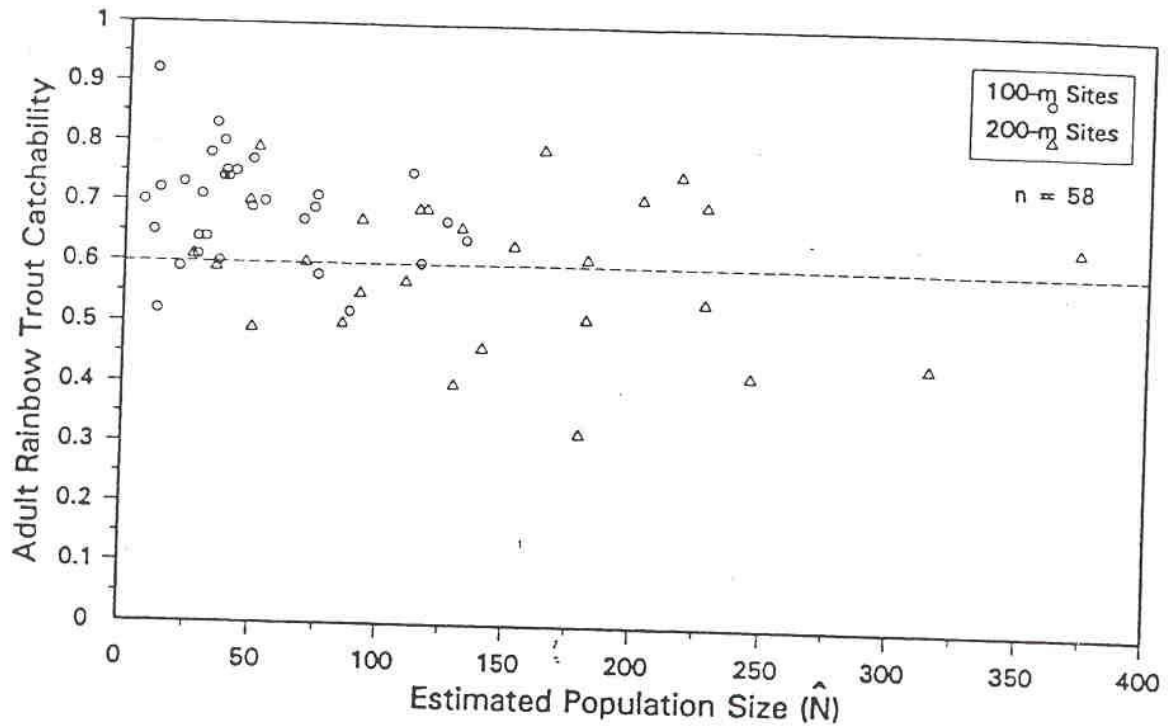


Figure 2. Adult rainbow trout catchabilities corresponding to 3-pass depletion samples of 58 Tennessee and North Carolina populations from 100- and 200-m sites. Catchabilities averaging near 0.60 were achieved over a range of population sizes.

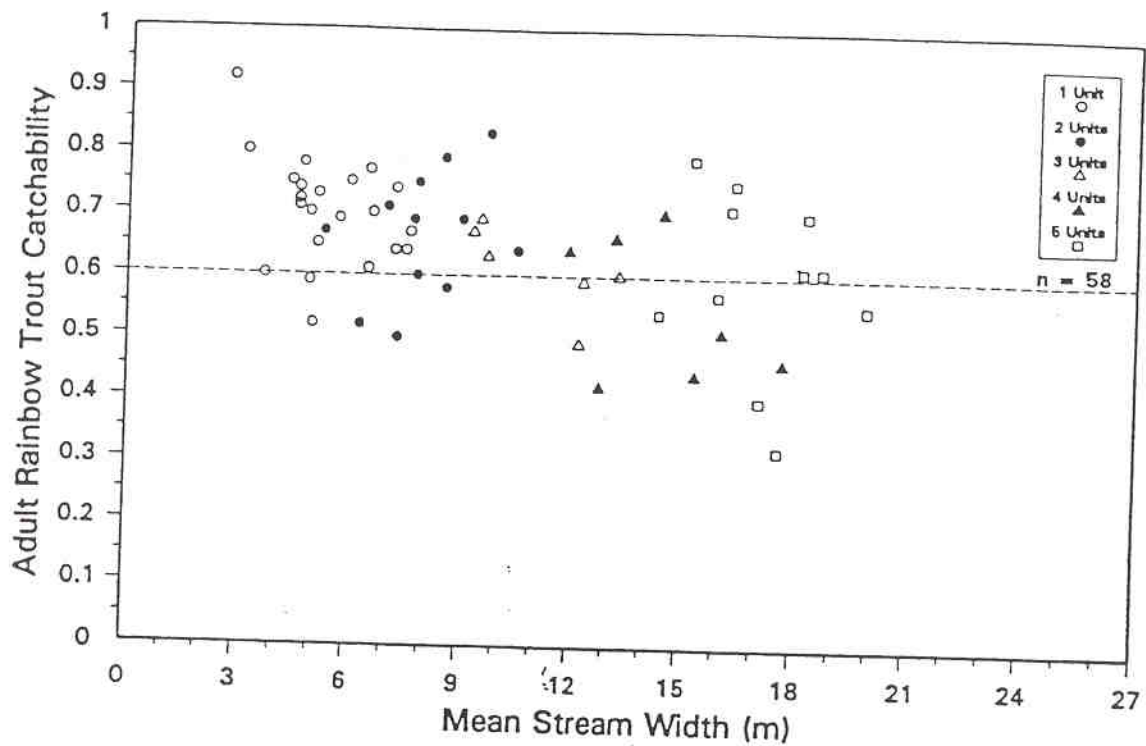


Figure 3. Adult rainbow trout catchabilities corresponding to 3-pass depletion samples of 58 Tennessee and North Carolina populations from a range of stream sizes. Catchabilities averaging near 0.60 were achieved in wider streams by employing additional electrofishing units, typically at the rate of one unit per 3 to 4 m of mean stream width.

The small size of young-of-the-year (YOY) trout tends to lower the catchability of this group. Field observations indicate that part of this lowered catchability may be due, in part, to the tendency of netters to first capture the larger individuals (adults) in a group of stunned fish. When relatively large numbers of YOY are present, the overall catchability estimate for the sample may be lowered into the 0.40 to 0.50 range if YOY data are not treated separately.

2. Three important assumptions apply if reliable electrofishing data are to be obtained using the removal-depletion method: (1) no fish may enter or leave the study site during sampling; (2) each fish has an equal chance of being captured; and (3) catchability remains constant with each removal (Armour et al. 1983; Van Deventer and Platts 1983). The use of block nets is necessary to meet the first assumption, particularly at the downstream end of sampling sites. The upstream boundary of sampling sites can often be located where fish passage is obstructed (e.g., by small waterfalls or cascades), thus making a block net unnecessary. The other two assumptions can be reasonably met by maintaining uniform sampling effort and equipment settings (e.g., current and voltage) among the removal passes. One netter per electrofishing unit (in addition to the operator) per pass is recommended and the availability of a back-up electrofishing unit will permit equal effort among passes should a unit fail during the sample.

3. Alternating current (AC) is recommended for sampling the softwater streams typically encountered in the Southeast since it has proven to be more effective than direct current (DC). The most suitable voltages appear to be 300-700 VAC in streams with conductivities of < 50, μ S (umhos). Battery-powered (DC) electrofishing units can be used if desired where conductivity is higher (> 50 μ S) and may be necessary in wilderness areas where internal-combustion engines are prohibited. Information regarding the current and voltage used should always be recorded on the appropriate field data sheets.

4. Unpublished data from Great Smoky Mountains National Park and Cherokee National Forest (Tennessee) indicate that one electrofishing unit will provide reliable quantitative data from streams up to 4 m in mean width (Figure 3). Additionally, Habera et al. (1992) and Russell (1992) found that many streams with a mean width of 4.5-6 m can also be adequately sampled with one electrofishing unit. The results of Habera et al. (1992) and Russell (1992) also indicate, however, that site-specific decisions should be made where mean stream width are in the 4.5- to 6-m range. Higher-gradient streams with distinct habitat units can often be sampled more easily with one unit than lower-gradient streams without distinct habitat units.

Electrofishing effort (in terms of electrofishing units) must be increased in wider streams if assumptions associated with the removal-depletion method are to be met. As a general rule, one electrofishing unit per 3 m of mean stream width has provided reliable data in streams over 4 m wide (Figure 3) and is, therefore, recommended. The number of electrofishing units required may also be affected by other stream features such as channel morphology and habitat types present. Therefore, decisions regarding the use of an additional electrofishing unit in situations where mean width suggests this may be necessary (i.e., >4 m) should be based on these factors as well.

Sample Timing

1. The recommended stream sampling period is summer and early fall (June October), primarily because this time frame coincides with the period of lowest stream flows in the Southeast. Stream flow rates have a marked effect on electrofishing efficiency; therefore, avoid sampling during high flow conditions (e.g., those typically occurring in the winter and early spring or after storm events). Sampling during summer and early fall also permits collection of YOY trout and subsequent assessment of year-class strength. Disadvantages associated with winter and early spring sampling, notwithstanding high stream flows, may include safety hazards (e.g., anchor ice) and lowered fish catchability related to extremely cold water and the tendency for trout to enter the substrate and not float well when stunned (Armour 1983). Sampling during the period of peak leaf fall may present problems with keeping block nets in place and with seeing and retrieving stunned fish.
2. Temporal differences in trout life-history parameters at higher elevations (e.g., spawning dates) may necessitate delaying sampling to late summer if YOY assessments are to be made.
3. Individual streams should be sampled at approximately the same time each year, particularly if the stream is part of a long-term monitoring program.

Data Collection and Analysis

1. Mean stream width based on multiple measurements (a minimum of 10 per sample site) should be determined as this is necessary for calculating the surface area of the site. Other physicochemical features such as gradient, elevation, substrate composition, discharge, basic water quality parameters, etc. can be measured or characterized as needed. These data may greatly enhance comparisons between streams by helping to explain part of the observed variability.
2. Minimum data to be collected from individual adult and YOY trout (and other game fish) include total length (mm) and weight (g). Total number and total weight by species may be recorded for non-game species if desired. Electronic scales expedite the handling of large numbers of specimens. Hand-held spring scales are highly accurate if maintained and are easily carried to remote sampling locations (Jennings 1989).
3. The recommended computer software for processing electrofishing data acquired using the removal-depletion method is MicroFish 3.0 (Van Deventer and Platts 1989). This software uses the maximum-likelihood method (Carle and Strub 1978; Van Deventer and Platts 1983) to calculate population estimates and provides various other population statistics such as mean length, weight, and condition factors. MicroFish 3.0 output can be used, along with surface area measurements for each sampling station, to calculate fish densities and standing crops. Densities and standing crops serve as basic means for comparing trout populations among sites, streams, or years. It is recommended that adult and YOY trout population estimates (and other statistics) be calculated separately since YOY catchabilities tend to be lower than those for adults.

Summary

These guidelines constitute an attempt to standardize trout stream sampling procedures and promote data exchange among the various natural resource management agencies represented by members of the American Fisheries Society, Southern Division Trout Committee. Compliance with these guidelines is strictly voluntary, although it is anticipated that widespread acceptance of the concept of standardized trout stream sampling procedures will provide the basis for a sound regional coldwater fisheries database. Such a database would enable more accurate assessments of trout population responses to various environmental and management changes within and across the Southeast region and might eventually decrease the amount of sampling necessary in the future.

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Appendix C: SHEN Annual Quantitative and Qualitative Streams and Sites

ANNUAL QUANTITATIVE SITES (3-Pass)			
Stream	District	# Sites	Site #(s)
Jeremy's Run	North	3	1F007, 1FVA1, 1F118
Piney River	North	3	1F003, 1F145, 1F138
North Fork Thornton River	North	3	1F030, 1FVA2, 1FVA3
Overall Run	North	1	1F132
Pass Run	Central	1	2F095
North Fork Dry Run	Central	1	2F131
Hughes River	Central	3	2F038, 2F039, 2F040
Rose River	Central	3	2F015, 2F016, 2F017
Rapidan River	Central	3	2F093, 2F135, 2FVA4
Staunton River	Central	3	2F072, 2F074, 2F075
Two Mile Run	South	2	3F103, 3F102
One Mile Run	South	2	3F126, 3F128
Paine Run	South	3	3F123, 3F124, 3F125
Meadow Run	South	2	3F107, 3F109
North Fork Moorman's River	South	3	3F084, 3F045, 3F044
ANNUAL QUALITATIVE SITES (1-Pass)			
Hannah Run	Central	1	2F050
Hogcamp Branch	Central	1	2F055
Rapidan River	Central	1	2FVA5
Staunton River	Central	1	2F076
Big Branch	South	1	3F079

Appendix D: SHEN Other Qualitative Streams and Sites

OTHER QUALITATIVE SITES (1-Pass)			
Stream	District	# Sites	Site #(s)
Land's Run	North	1	1F133
Bolton Branch	North	2	1F056, 1F058
South Fork Thornton River	Central	1	2F036
South Fork Dry Run	Central	1	2F140
Hazel River	Central	3	2F071, 2F053, 2F090
Broad Hollow Run	Central	1	2F067
Brokenback Run	Central	1	2F033
Ragged Run	Central	1	2F060
Berry Hollow Run	Central	1	2F063
White Oak Canyon Run	Central	1	2F010
Cedar Run	Central	1	2F062
East Hawksbill Creek	Central	1	2F119
Little Hawksbill Creek	Central	1	2F110
West Branch Naked Creek	Central	1	2F113
East Branch Naked Creek	Central	1	2F029
Fultz Run	Central	1	2F122
Pocosin Hollow Run	Central	1	2F048
South River	Central	1	2F069
Swift Run	South	2	3F041, 3F043
Ivy Creek	South	2	3F019, 3F020
Big Run	South	3	3F021, 3F023, 3F101

Appendix E: SHEN Fish Data entry guide

Summary:

The Shenandoah National Park fish data entry program consists of three main components, the data entry application, the temporary storage databases, and the master database. Data is entered into the first temporary database using the data entry application. Then to help provide accurate data the data is entered a second time into a second temporary database. The two temporary databases are compared and any discrepancies can be reviewed and fixed. Then at the end of the field season the data in the temporary databases are reviewed by the program staff and then added to the master database.

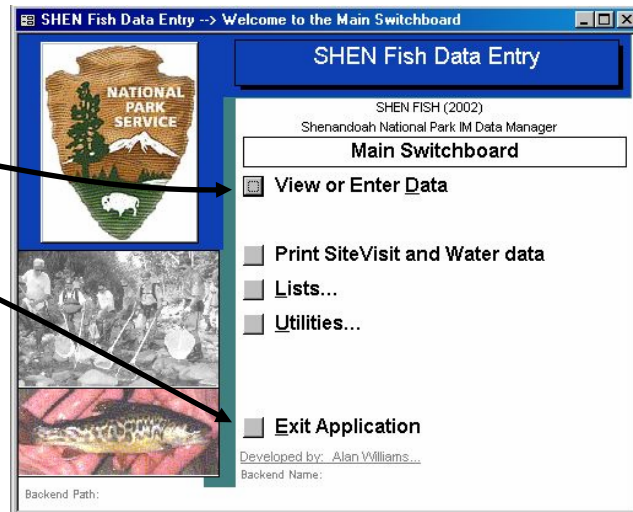
Data entry –

1) Overview:

To start data entry press
<View or Enter Data>

To quit press
<Exit Application>

The other buttons are used by the
data or program managers



2) The main data entry screen has
basic date and location information at
the top, followed by a series of tabs
with different types of data on each
tab.

To enter data for a new date and site
press the <Add New> button.

To search for data that has already
been entered use the pull down list.

You can also use the navigation
buttons at the bottom of the form to
move between records.

Data is automatically saved as you
go, row by row, so there is no need
to save manually.

FISH DATA ENTRY GUIDE

3) **Water Chemistry:** fill in the information for each of the fields from the data sheet.

4) **Crew:** Select the members of the crew that were present from the right side (A) then press the “move” button(B). If you need to add someone to the list use the “Edit” button (C).

SHEN Fish Data Entry

Project: FISH Jump to (order by): ☐ date ☒ site Select a Site Visit Add New DONE

DATE (mmddyy): 06/27/01 SITEID: 1F138 Edit Stream: Piney River SiteVisit_ID: 2001-06-27-1F138

Water Chemistry and Crew Discharge Habitat GameFish Non-GameFish Site Info and Notes

Sampler	Time	Temp	DO	Cond	pH	TDS	Level	Color	Notes
HYD1	9:00	14.63	9.73	26.00	6.73	0.0166			

Crew Working at that Site Visit

Crew: Carswell_Ben, Cyphert_Mike, Daley_Michelle, Degel_Kristin, Demarest_David, McBride_Ryan, Reidler_Trevor, Rowles_Matt, Sager_Scott

Select >> then click below to Move to Current list

Potential Crew List: Jim, Mike, David, Mike, Sara, Ryan, Trevor, Matt, Scott, Hanson, Cyphert, Demarest, Backles, Hall, McBride, Reidler, Rowles, Sager, SHEN, SHEN, SHEN, USGS, Volunteer, SHEN, SHEN, SHEN

Edit Potential Crew list

Use these buttons to move between SiteVisits Record: 19 of 55 Data Entry User: abw

5) **Discharge:** Enter the stream width and the interval that was selected.

Then press the <Add Stream...> button and the CX and Dist data should be filled in by the computer.

After that data is confirmed enter in the depth and velocity for each distance.

SHEN Fish Data Entry

Project: FISH Jump to (order by): ☐ date ☒ site Select a Site Visit Add New DONE

DATE (mmddyy): 07/09/01 SITEID: 2FVA5 Edit Stream: Rapidan River SiteVisit_ID: 2001-07-09-2FVA5

Water Chemistry and Crew Discharge Habitat GameFish Non-GameFish Site Info and Notes

Interval Width_m: 0.3 Stream Width_m: 3.6 Method: Flowmeter Flag: Add Stream CXs

CX	Dist	Depth	Vel	Notes	Flag
1-00	0.00	0.00	0.00		
1-01	0.30	0.06	0.02		
1-02	0.60	0.16	0.00		
1-03	0.90	0.57	0.02		
1-04	1.20	0.55	0.02		
1-05	1.50	0.50	0.01		
1-06	1.80	0.39	0.04		
1-07	2.10	0.39	0.04		
1-08	2.40	0.33	0.15		
1-09	2.70	0.33	0.16		
1-10	3.00	0.22	0.13		
1-11	3.30	0.19	0.12		
1-12	3.60	0.00	0.00		

Use these buttons to move between SiteVisits Record: 26 of 55 Data Entry User: abw

6) **Habitat:** Enter the total length of the transect.

Then press the <Add Stream...> button and the CX data should be filled in by the computer.

After that data is confirmed enter the rest of data for each of the CX row of data.

SHEN Fish Data Entry

Project: FISH Jump to (order by): ☐ date ☒ site Select a Site Visit Add New DONE

DATE (mmddyy): 01/01/02 SITEID: 1F003 Edit Stream: Piney River (Current site 1996-present) SiteVisit_ID: 2002-01-01-1F003

Water Chemistry and Crew Discharge Habitat GameFish Non-GameFish Site Info and Notes

Stream Distance: Add Stream Distances [Use Auto DropList]

CX	Width	Grad %	Rip	Cover	D1Q	D2Q	D3Q	S1Q	S2Q	S3Q	P	R	Notes
0	4.0		T	1	1.00	2.00	1.20	B	BR	C			
10	6.0	5	T	1	2.00	0.20	0.36	B	C	C	5	5	
20	4.0	30	T	3	1.20	1.20	0.20	B	BR	O	6	4	(Fake Data)
30			T										
40			T										
50			T										
60			T										
70			T										
80			T										
90			T										
100			T										
101			T										
109			T										

Use these buttons to move between SiteVisits Record: 54 of 55 Data Entry User: abw

FISH DATA ENTRY GUIDE

7) Game Fish:

Enter the total length of the transect.

Then press the <Add number...>

button and the EntryOrder data

should be filled in by the computer. This should be a number where the last two digits match the line number of the data sheet and the first 1 or 2 digit(s) is the page number.

The last Run and Species entered will be carried down so be sure to confirm they are correct.

The screenshot shows the 'SHEN Fish Data Entry' window with the 'GameFish' tab selected. The 'EntryOrder' column is being populated with values like 101, 102, etc. The 'Run' and 'Species' columns are also visible. The 'Total Number of Game Fish' is set to 100. The 'Add number of fish' button is highlighted.

6) Non-Game Fish:

Enter the data for each run from the data sheet. The last Run entered will be carried down so be sure to confirm it is correct for each line.

If there are generic notes about the that day at that site including, data collection, equipment problems, water level, fishing signage etc, enter it in the space provided on the last tab.

The screenshot shows the 'SHEN Fish Data Entry' window with the 'Non-GameFish' tab selected. The 'Run', 'Species', 'Num', 'Min Len', 'Max Len', 'Weight', 'Mort', and 'Notes' columns are visible. The 'Order' column is also present. The 'Add New' button is highlighted.

7) Second pass data entry:

Follow the same basic procedures for entering data during both data entry passes.

The main differences on the 2nd pass are:

a) The form will be yellow indicating a 2nd pass.

b) You will not be entering the Date or site data again, rather you will be choosing from the list of already entered dates and sites.

c) Once you have completed entering all of the data for a site press the <Check> button to compare it to the first pass.

The screenshot shows the 'SHEN Fish Data Entry - Second pass Data Entry' window. The 'Check' button is highlighted. The 'Crew' and 'Potential Crew List' sections are visible. The 'Add New' button is also present.

FISH DATA ENTRY GUIDE

8) **Checking** the 1st and 2nd data entry pass:

After pressing the <Check> button (see above) wait a moment and this form will appear.

At the top should show the date and site it is checking.

If there are any listings in the 2) or 3) areas then each of those tables will need to be fixed. To fix a table select the table name and press the button below or just double click the table name.

9) Un-Matched Records:

Each table will have a custom form. Check the records in question against the data sheets. Either keep or delete each one.

10) Resolve Errors:

Each table will have a custom form. Yellow fields will indicate the problem data. Check the records in question against the data sheets. Keep either the record from the 1st or 2nd pass.

When you have fixed all of the problems the form should close returning you to the "Checking" form. Fix all of the tables then press <Done>.

11) Exiting and Backing up:

When you are done entering data for that day you should return to the Switchboard by closing the data entry form using the <Done> button. Then press the <Exit Application> button. You will be asked if you want to make a back up of a file, press <Yes>. This saves a copy of the data from the network to your local computer.

For help contact the data manager:
Phone: 540-999-3431

Appendix F: SHEN Hydrolab Calibration Instructions

SHEN HYDROLAB CALIBRATION INSTRUCTIONS

This information has been condensed from the Hydrolab Note Books found in the I&M wet lab.

HYDROLAB D.O. CALIBRATION (found in sections 3.7, 2.5.4, 2.5.5, 5.1, 5.3 & Appendix 1) *Two methods for calibration are listed, either may be used.

- 1) Rinse sensors with distilled H₂O.
- 2) Invert unit, sensors up, screw on open-ended cup and fill to the O-ring for the D.O. sensor with distilled H₂O (DO NOT OVERFILL).
- 3) Dab the water off of the membrane and put the rubber top on.
- 4) Turn unit ON and go to SOM.
- 5) Wait for the D.O. to stabilize and go to the basic menu (CALIBRATE button).
- 6)* From Ch. 6 on the radio get the barometric pressure and plug into formula: Inches of Hg/0.039=mm of Hg (BP) to get mm of Hg. Then correct the BP for altitude (A) by using the following formula: $BP' = BP - 2.5(A/100)$. **For the I&M lab $BP' = BP - 31$**
- 7) Type % for the D.O. % saturation.
- 8) Enter the corrected BP into the unit in mm of Hg using the arrow keys and press ENTER.
- 9) Check to see that the % saturation is 100.0% in the SOM, if not, redo start w/#4.
- 10) Get the temperature while in SOM and then go to the basic menu and press "O".
- 11)* Look at chart for appendix 1. Use the temperature and go across the chart to find the corresponding value in the 1985 SM column. Enter this # and verify it.

SHEN HYDROLAB CALIBRATION INSTRUCTIONS

Appendix 1, using the 1985 edition of Standard Methods for the Examination of Water and Wastewater. All Values are in mg per liter.

°C	mg/l	°C	mg/l	°C	mg/l	°C	mg/l
0	14.621	12	10.777	24	8.418	36	6.837
1	14.216	13	10.537	25	8.263	37	6.727
2	13.829	14	10.306	26	8.113	38	6.620
3	13.460	15	10.084	27	7.968	39	6.515
4	13.107	16	9.870	28	7.827	40	6.412
5	12.770	17	9.665	29	7.691	41	6.312
6	12.447	18	9.467	30	7.559	42	6.213
7	12.139	19	9.276	31	7.430	43	6.116
8	11.843	20	9.092	32	7.305	44	6.021
9	11.559	21	8.915	33	7.183	45	5.927
10	11.288	22	8.743	34	7.065		
11	11.027	23	8.578	35	6.950		

HYDROLAB CONDUCTIVITY CALIBRATION (2.5.2, 2.6.3, 3.4)

1) Rinse the sensors twice thoroughly with distilled water by using the calibration cup and shaking the unit to clean all of the sensors.

2) Repeat step one with a small amount of the specific conductance standard.

HYDROLAB CONDUCTIVITY CALIBRATION (2.5.2, 2.6.3, 3.4) Continued...

3) Place the unit on the ring stand with the sensors pointed up.

4) Fill the calibration cup to within 1 cm of the top, making sure there are no bubbles around the sensors and cover with rubber top.

5) Turn the unit on and let it stabilize in the SOM. This may take 10 minutes or more.

6) Go to the Calibrate mode and choose "C".

7) Enter the number of the conductivity standard using the arrow keys and press ENTER.

8) Verify the calibration and the conductivity calibration is complete.

SHEN HYDROLAB CALIBRATION INSTRUCTIONS

HYDROLAB pH CALIBRATION (found in sections 2.5 & 2.5.1)

- 1) Rinse sensors with distilled H₂O; invert unit on stand.
- 2) Attach the calibration cup.
- 3) Fill cup with pH 7 buffer.
- 4) Turn unit on, make sure it is in the standard operating menu (SOM).
- 5) Wait for stable reading, about five minutes.
- 6) Once it is stabilized, go to basic menu (CALIBRATE button).
- 7) Use arrows to scroll over to "p" (for pH) and press ENTER: the next prompt is for the standard (Std:).
- 8) Use the arrows to change the #'s to 7.00 (the up and down arrows change the #'s and the right/left arrows change the position of the flashing digit).
- 9) Press ENTER. Answer "Y" to save.
- 10) Go back to the SOM.
- 11) Leave the unit ON, discard pH solution, and start the process over at step #1 for pH 4 and then go to #10.
- 12) Rinse the sensors and fill the cup with H₂O, screw on and go!

HYDROLAB NOTES (of interest)

pH

- 1) If the pH readings are slow, show a lot of drift, or never stabilize clean the electrode.
- 2) Clean pH sensor using rubbing alcohol on a Q-tip.
- 3) If that does not help the soak in 0.1 Molar HCl for 5 minutes. Rinse the sensor, then soak in pH 7 buffer for 10 minutes.
- 4) See section 3.5 for refilling the reference electrode.

SHEN HYDROLAB CALIBRATION INSTRUCTIONS

D.O.

- 1) The D.O. membrane should be changed every 3-4 weeks. Do this by the directions on 3.7.
- 2) The gold cathode may need to be cleaned (be CAREFUL) with an S.O.S. pad or fine steel wool.
- 3) Frequent electrode changes will maximize electrode life.

SPECIFIC CONDUCTANCE

Keep the six pins clean with emery cloth or 400 grit wet/dry. Polish the tips and sides then clean with alcohol swab.

Replacing Batteries Hydrolab Units

– These units take 10 “AA” batteries each. The data display system box holds the batteries. Take the display box out of the blue rubber case and remove the four screws in the bottom. **USE EXTREME CARE FOR THE FOLLOWING STEPS AS THE WIRES ARE VERY SHORT AND FRAGILE!** Slowly remove the back cover and hold at a 90 degree angle to the box. Carefully replace old batteries with fresh ones paying attention to the +- diagrams. Make sure the wires are not in the way and replace the back cover. Tighten the screws and put the box back in its rubber case.

Appendix G: SHEN Fish Species List

SHENANDOAH NATIONAL PARK

FISH SPECIES LIST

COMMON NAME	ACRONYM	LATIN NAME	FAMILY
American Eel	AME	<i>Anguilla rostrata</i>	Anguillidae
Mountain Redbelly Dace	MRD	<i>Phoxinus oreas</i>	Cyprinidae
Rosyside Dace	RYD	<i>Clinostomus funduloides</i>	Cyprinidae
Longnose Dace	LGD	<i>Rhinichthys cataractae</i>	Cyprinidae
Blacknose Dace	BKD	<i>Rhinichthys atratulus</i>	Cyprinidae
Central Stoneroller	CES	<i>Campostoma anomalum</i>	Cyprinidae
Fallfish	FAF	<i>Semotilus corporalis</i>	Cyprinidae
Creek Chub	CRC	<i>Semotilus atromaculatus</i>	Cyprinidae
Cutlips Minnow	CUM	<i>Exoglossum maxillingua</i>	Cyprinidae
River Chub	RRC	<i>Nocomis micropogon</i>	Cyprinidae
Bluehead Chub	BHC	<i>Nocomis leptcephalus</i>	Cyprinidae
Common Shiner	COS	<i>Luxilus cornutus</i>	Cyprinidae
Satinfin Shiner ¹	SNS	<i>Cyprinella analostana</i>	Cyprinidae
Bluntnose Minnow	BLM	<i>Pimephales notatus</i>	Cyprinidae
Northern Hogsucker	NHS	<i>Hypentelium nigricans</i>	Catostomidae
Torrent Sucker	TOS	<i>Thoburnia rhotocoea</i>	Catostomidae
White Sucker	WHS	<i>Catostomus commersoni</i>	Catostomidae
Margined Madtom	MAM	<i>Noturus insignis</i>	Ictaluridae
Brook Trout	BKT	<i>Salvelinus fontinalis</i>	Salmonidae
Brown Trout	BRT	<i>Salmo trutta</i>	Salmonidae
Tiger Trout ²	TGT	<i>Salmo X Salvelinus</i>	Salmonidae
Rainbow Trout	RBT	<i>Oncorhynchus mykiss</i>	Salmonidae
Mottled Sculpin	MTS	<i>Cottus bairdi</i>	Cottidae
Potomac Sculpin	POS	<i>Cottus girardi</i>	Cottidae
Rock Bass	ROB	<i>Ambloplites rupestris</i>	Centrarchidae
Smallmouth Bass	SMB	<i>Micropterus dolomieu</i>	Centrarchidae
Largemouth Bass	LMB	<i>Micropterus salmoides</i>	Centrarchidae
Redbreast Sunfish	RDB	<i>Lepomis auritus</i>	Centrarchidae
Bluegill	BLG	<i>Lepomis macrochirus</i>	Centrarchidae
Pumpkinseed	PKS	<i>Lepomis gibbosus</i>	Centrarchidae
Johnny Darter ¹	JOD	<i>Etheostoma nigrum</i>	Percidae
Tessellated Darter	TED	<i>Etheostoma olmstedii</i>	Percidae
Fantail Darter	FAD	<i>Etheostoma flabellare</i>	Percidae
Greenside Darter ¹	GRD	<i>Etheostoma belinoides</i>	Percidae

¹ rare: Three satinfins found in the lower Rapidan in 1999. Three greenside darters found in Pass Run in 1998. Two johnny darters found in lower Moorman's, North Fork in 1995 prior to the flood.

² hybrid (progeny of female brown and male brook trout)

Appendix H: SHEN Fish Monitoring Data forms

SHEN FISH MONITORING COVER FORM

SITE, WATER CHEMISTRY AND VELOCITY

Date ____/____/2010

Site ID Code _____ Stream _____

Crew _____

Site Location Notes: _____

Data Entry

Entry 1: _____/____/2010

Entry 2: _____/____/2010

Other Notes (vegetation description & oddities, observation forms, etc.): _____

Recorders Initials _____

Water Condition and Chemistry

Level: Low ____ Med ____ High ____ Color: Clear ____ Stained ____ Muddy ____

Sampler is assumed to be HYD1 (Hydrolab Multiprobe) unless indicated otherwise.

Sampler	Time	Temp °C	DO mg/l	DO % Saturation	Cond. μ S	pH	TDS g/l	Comments

Notes:

DISCHARGE MEASUREMENTS

Method: Marsh-McBirney _____ Other _____ (show work)

Channel Width _____ m Interval Selected for Measurements _____ m

#	Dist (m)	Depth (m)	Veloc. (m/s)	#	Dist (m)	Depth (m)	Veloc. (m/s)
1	0	0	0	9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8				16			

SHEN FISH MONITORING DATA FORM

GAMEFISH

Date ___/___/2010

Site ID Code _____ Stream _____

Crew _____

Page ___ of ___

<i>Data Entry</i>
Entry 1: _____/___/2010
Entry 2: _____/___/2010

Run #	Species	TL (mm)	WT (g)	Notes	Run #	Species	TL (mm)	WT (g)	Notes
01					21				
02					22				
03					23				
04					24				
05					25				
06					26				
07					27				
08					28				
09					29				
10					30				
11					31				
12					32				
13					33				
14					34				
15					35				
16					36				
17					37				
18					38				
19					39				
20					40				

Notes Codes: 1 – Scale Sample, 2 – Discoloration (Burn), 3 – Bad Eye, 4 – Hook Wound, 5 – Fin Clipped, 6 – Broken Back, 7 – Mortality, 8 – Other Disfiguration, 9 – Tissue Sample

NONGAME FISH

Data Entry

Entry 1: _____ / _____ / 2010

Entry 2: _____ / _____ / 2010

Page _____ of _____

[illegible]

SHEN FISH MONITORING DATA FORM

HABITAT

Date ____/____/2010

Site ID Code _____ Stream _____

Crew _____

Data Entry	
Entry 1: _____	____/____/2010
Entry 2: _____	____/____/2010

Distance	Width (m)	% Grad	Rip. Cov.	Depth			Substrate			Habitat Types	
				1/4	1/2	3/4	1/4	1/2	3/4	Pool	Riffle
0											
10											
20											
30											
40											
50											
60											
70											
80											
90											
100											
110											
120											
130											

Substrate Classification		
Code	Type	Size
O	Organic	
L	Silt	<0.06mm
S	Sand	0.06-2mm
PG	Peb/Gravel	2.0mm – 10.0cm
C	Cobble	10.0 – 30.0cm
B	Boulder	>30 cm
BR	Bedrock	

Riparian Cover	
1	<33%
2	33-66%
3	>66%
T	Tree
S	Shrub
GF	Grass/Forb
0N	0 Cov. 0 Veg

ISLANDS
At each Distance Interval (Dist.) where Islands are present, measure each of the channels. Enter the Total Channel Width (A+B) as Width (m) in the Main Table.

Measurements Involving Islands				
Dist.	Chan. A	Chan. B	Total (A+B)	Isle. W.

