Big Spring Creek (707B) Fisheries Restoration Plan Summary

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Historically, Big Spring Creek was renowned for supporting an excellent wild brook trout fishery. A number of events have occurred over time that have severely degraded the habitat in this stream to a point where much of the stream does not presently support a viable wild trout fishery. Based on recent inventory information the 150 meter headwater portion of Big Spring Creek, also known as the Ditch, continues to support an extremely dense trout fishery. Although natural reproduction of brook trout is still evident in this area, much of the extremely dense trout population (6,076/ha and 3,693.62 kg/ha) can be attributed to hatchery trout escaping from the Big Spring Fish Culture Station. In addition, a short 200 meter segment of stream (located directly downstream of the Ditch) continues to support a high biomass of trout (ranging from 92-135 kg/ha). However, this segment of stream is also influenced by trout that have escaped from the hatchery. The remaining sections of stream support only low to moderate densities of trout primarily composed of recently stocked hatchery trout.

With the closure of the hatchery, the Ditch should not be expected to maintain these unnaturally high densities of trout in the future, simply due to the elimination of large numbers of trout escaping from the hatchery. The closure of the hatchery should benefit the wild trout population by reducing the amount of competition between wild and hatchery trout and the amount of predation on small wild trout. This should allow the wild trout fishery to stabilize at a density similar to wild trout populations on other southcentral Pennsylvania limestone streams.

The objective of the restoration plan is to restore a self-sustaining wild trout population in suitable reaches of Big Spring through the use of habitat enhancement technology. To accomplish the elements of the restoration plan it is imperative to implement the best current technology available to restore suitable trout habitat in Big Spring Creek. Therefore, habitat restoration should become an agency priority on this water. Stream enhancement efforts should begin at the source and continue in a downstream progression to at least Thomas Dam. These efforts should include the elimination of the impounding effects from the remnants of the McCracken Dam and the stop logs located at the downstream end of the Ditch. Big Spring Creek is a productive limestone stream that aside from habitat limitations provides the potential to support an exceptional wild trout fishery. Clearly, if the habitat issues are not addressed on this stream the wild trout population will not be expected to improve in the future.

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PENNSYLVANIA FISH & BOAT COMMISSION
BUREAU OF FISHERIES
FISHERIES MANAGEMENT DIVISION

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Introduction

Big Spring Creek originates from a large limestone spring one mile north of Stoughstown, Cumberland County, and flows northeast to its confluence with Conodoguient Creek near the borough of Newville, PA. The stream is 8.2 km (5.1 mi.) in length and has a drainage area of 33.5 sq km (12.9 sq mi). A variety of land uses have occurred throughout the drainage basin including, agriculture, aquaculture, and residential development, as well. This water can be characterized as a fertile, low gradient, limestone stream with the potential to support an excellent coldwater fishery.

In 1983 the Pennsylvania Fish Commission (now the Pennsylvania Fish & Boat Commission) recommended a water quality standards upgrade for a 0.6 mile section of Big Spring Creek extending from the source downstream to Thomas Dam, from Cold Water Fishes (CWF) to the special protected use designation of High Quality Cold Water Fishes (HQ-CWF) based on the presence of a Class A wild brook trout fishery (Snyder 1983). Upon further evaluation by the Pennsylvania Department of Environmental Resources (now the Pennsylvania Department of Environmental Protection), the Department recommended that a 0.13 mile section of Big Spring Creek extending from the source downstream to SR 3007 (T-333) should be upgraded to Exceptional Value (EV) status (PA DER 1990). Subsequently, since 1992 a 0.13 mile section of Big Spring Creek extending from the source downstream to SR 3007 (T-333) has been classified as an Exceptional Value (EV) water by the Pennsylvania Department of Environmental Protection's Chapter 93: Water Quality Standards. The Cold Water Fishes (CWF) designation continues to apply to the remainder of Big Spring Creek from SR 3007 (T-333) downstream to the mouth (PA DEP 2000).

For Fisheries Management purposes, Big Spring Creek has been partitioned into five management sections listed as follows:

Section 01: From the source downstream for a distance of 0.6 miles to Thomas (Piper Mill) Dam.

Section 02: From Thomas (Piper Mill) Dam downstream for a distance of 1.0 mile to Strohm (Irwin Mill/Keck Mill) Dam.

Section 03: From the Strohm (Irwin Mill/Keck Mill) Dam downstream for a distance of 1.0 mile to the Stone Arch Bridge.

Section 04: From the Stone Arch Bridge downstream for a distance of 1.3 miles to the SR 0641 Bridge.

Section 05: From the SR 0641 Bridge downstream for a distance of 1.2 miles to the mouth.

The Commonwealth of Pennsylvania via the Pennsylvania Fish & Boat Commission (PFBC) is the riparian landowner along Sections 01-03, whereas, Section 04 and 05 are under private ownership. Currently the PFBC manages Sections 01 & 02 for wild trout under special regulations as part of the Heritage Trout Angling Program. Sections 03 & 04 are managed with the planting of PFBC catchable trout to provide recreational angling opportunities under statewide regulations. Due to access limitations, Section 05 is managed as a biomass Class D fishery under the Natural Yield option with no stocking.

In addition to Fisheries Management activities, the Pennsylvania Fish & Boat Commission owns and operated the Big Spring Fish Culture Station from 1972 through 2001. Located on the headwaters of Big Spring Creek, the purpose of the station was to produce catchable size and fingerling trout for stocking to provide recreational angling opportunities in waters where wild trout populations were inadequate to sustain the fishery at desired levels. Following construction, the first full year of trout production occurred in 1972 (Farner 2000). Due to water quality concerns and more stringent guidelines placed on hatchery effluent discharge, hatchery operations were discontinued on November 14, 2001. While in operation, the station produced some 728,300 catchable size and 56,700 fingerling trout on an annual basis for distribution into Commonwealth waters that were open to the general angling public.

The following report outlines a variety of problems that have been associated with the Big Spring Creek watershed over time and includes information on the current status of the resource. This report also includes recommendations to address these problems. The objective of the Big Spring Creek Restoration Plan is as follows:

To improve instream habitat through the use of habitat enhancement technology to restore a self-sustaining wild trout population in suitable reaches of the stream. At the completion of habitat enhancement work, this should be accomplished over at least the upper 0.6 miles of stream from the source downstream to Thomas Dam (the former Fish Barrier). Minimum biomass density of the trout population should be typical of other southcentral Pennsylvania coldwater streams, ranging from 50 to 100 kilograms per hectare.

Background Information

Historically, the Big Spring watershed has been influenced by agriculture, not only from farming but also from the operation of a series of Mill Dams on the stream. These dams were used to supply the power to operate grist mills, primarily for the purpose of grinding wheat into flour (Kressler 1962). At one time, there were a total of six Mill Dams in operation along Big Spring Creek. These were constructed during the late 1700s and many remained in operation until the 1930s (Porter 2000). There have been several name changes to the Mill Dams that have coincided with the numerous changes in ownership over time. In progression from the headwaters downstream, the names and locations of these dams are as follows: the McCracken Mill Dam (at the lower end of what is now known as the Ditch), the Piper Mill Dam (at the site of the former Fish Barrier also known as Thomas Dam), the Irwin Mill Dam (at the downstream limit of the current special regulations area also known as Strohm Dam or Keck Mill Dam), the McFarland Mill Dam (near the Presbyterian Home below the existing Stone Arch Bridge), Laughlin Mill Dam (located just upstream of SR 0641 in Newville) and the Ginter Mill Dam (located between SR 0641 and the mouth). At present only the Laughlin Mill Dam remains, as it has been preserved for historical significance.

The presence of the dams and their operating practices has influenced the physical characteristics of Big Spring Creek. When the mills were in operation, routine procedures were followed to ensure that the dams continued to operate in an efficient manner. Due to extensive agricultural activities in the watershed, large amounts of silt would collect in the dams and cleaning was necessary to maintain efficient operations. Therefore, the dams were flushed at time intervals ranging from a weekly to monthly

basis. This procedure was conducted on Saturday afternoons and continued in one hour intervals until the gates were raised to drain and clean all of the dams. The time interval between the opening of the gates on each dam allowed for the removal of silt and debris before flooding occurred from draining the next dam upstream. The gates on each of the dams were left open until they were closed on Sunday afternoon (Kressler 1962). Cleaning of the dams often involved the use of teams of horses and equipment to literally dredge the dams. The regular practice of flushing the dams continued as long as the mills were in operation and most of the mills operated until sometime in the 1930s (Porter 2000). With the exception of Laughlin Mill Dam, all of the dams were either removed or breached sometime during the 1950s or 1960s.

Big Spring Creek has long been renowned for supporting a fine trout fishery and in particular an excellent brook trout (*Salvelinus fontinalis*) fishery. Historically, the stream was reported to support a dense population of wild brook trout throughout most of its entire length. This population density was reported to have been maintained during most of the 1930s (Moore 2000). However, a number of events occurred that contributed to a change in the Big Spring Creek fishery. When the mills were in use, instream habitat was largely influenced by the operation of the dams. The regular cleaning of the dams benefited the trout population by flushing silt and debris out of the system, which resulted in clean gravel beds for the trout to use for spawning purposes. The dams also provided holding areas and cover for the trout. These conditions existed until sometime in the 1930s. At that time the mills ceased operations and the dams were no longer flushed on a regular basis. Therefore, siltation became more prevalent in the drainage. Since the dam owners were no longer continually removing debris and obstructions from in and around the dams, riparian and aquatic vegetation began to flourish and became an important source of cover for the trout residing in Big Spring Creek. Overhanging trees and shrubs fell into the stream and also provided cover for the trout. Due to the low gradient nature of this stream, these formed several blockages in the stream channel. During the 1940s and 1950s, the trout population was reported to be more localized into isolated areas and was no longer widespread throughout the entire length of stream (Moore 2000). Concomitant with these changes in the physical habitat, the practice of widespread stocking of catchable size and fingerling trout began during the 1930s. According to PFBC distribution records, the stocking of catchable size brook trout (6 to 9 inches in length) in Big Spring Creek began in May of 1932 and the stocking of catchable size rainbow trout (*Oncorhynchus mykiss*) soon followed in March of 1935. The earliest PFBC records of the planting of brown trout (*Salmo trutta*) in this stream date back to March of 1957 for catchable size trout and to April of 1955 for fingerlings. However, anglers were catching brown trout in this stream before the 1950s, so it was likely that some brown trout were mixed in with earlier shipments of brook and rainbow trout.

The Green Springs commercial trout hatchery began operations at the location of the Piper/Thomas Dam in the early 1950s (Porter 2000). Various controversies erupted surrounding this facility regarding its affects on the stream and the trout population. As a result, some sportsmen were in opposition to the operation of the trout hatchery and wanted to have the hatchery removed. They voiced concerns about the potential for increased siltation and sedimentation from the hatchery effluent and questioned what effect hatchery operations would have on the trout fishery. They were also disturbed by the fact that the hatchery owner had raised the dam to a level approximately one and one half feet above the permitted height of the dam. Eventually, the level of the dam was restored to the permitted height. Nonetheless, these controversial issues prompted many of these same individuals to join the local Big Spring Fish & Game Association. The influence of the new members led to a meeting to determine how conditions could be improved on Big Spring Creek. Finally, the local Big Spring Fish & Game Association organized a large group of anglers to conduct a massive clean up of Big Spring Creek during the spring of 1957 (Porter 2000). This project involved removing debris from the stream and large amounts of aquatic and riparian vegetation. Despite the well meaning efforts of this group, in reality, the project had a negative long-term impact on Big Spring Creek. The results of this effort led to the removal of large amounts of cover from the stream and the stream banks as well. Around the same time period, a number

of the dams were removed from the stream. The sum total of these efforts lowered the water level of the stream and decimated the instream and riparian habitat along Big Spring Creek. Basically, most of the cover that existed to support the trout population had been removed. Overall, the general lack of instream habitat and cover is similar to many of the problems that continue to persist on this water at present day.

Trout Population Studies

Since the late 1950s, a number of stream examinations have been conducted to document the trout fishery on Big Spring Creek. By the 1930s, the wild brook trout fishery in this water had undoubtedly been influenced by the intensive stocking of hatchery trout. The stocking of hatchery trout led to an intermixing of hatchery stocks with the original stock. It also attracted unusually large groups of anglers, particularly during the early season (Porter 2000).

The results of a stream examination conducted in 1958 recorded the presence of a dense brook trout fishery, estimated at 641 trout/acre, within a 1000 foot (303 meter) sample site located just downstream of the Ditch. Surveys were also conducted at three downstream sites located in the proximity of Strohm Dam, the Stone Arch Bridge and Ginter Mill Dam. However, sampling resulted in low density trout populations at each of these sample locations (Simes 1958).

A stream examination conducted by Cooper and Scherer (1967) during the fall of 1962 also recorded the presence of a dense brook trout fishery, estimated at 305 kg/ha, near the headwaters of Big Spring Creek. However, sampling was limited to one 700 foot (212 m) site in proximity to the Ditch (Scherer 1998). During this examination no downstream sites were examined for comparison of the trout population in Big Spring Creek.

In an April 1972 memorandum from Rickalon Hoopes to Robert Hesser, Hoopes stated that recent investigations had shown that natural reproduction of brook trout was limited to the headwater areas from the spring downstream approximately one quarter mile or to about 500 meters of stream (Hoopes 1972a). A subsequent electrofishing inventory during June of 1972 confirmed this observation as a dense brook trout fishery, estimated at 125.96 kg/ha was recorded in a 500 foot (152 m) site ending 200 feet downstream of the hatchery effluent. However, electrofishing efforts at two 152 m sites located 0.5 mile upstream of Strohm Dam (or approximately halfway between Strohm and Thomas Dams) and near the Presbyterian Home captured only six and three trout, respectively (Hoopes 1972b). This sampling coincided with the first year of full production at the Big Spring Fish Culture Station.

Snyder (1977a) noted concerns with brown and rainbow trout encroaching on the reproducing brook trout population near the headwaters of the stream. Problems were compounded by fish escaping from the hatchery, as large numbers of rainbow trout fingerlings were reported to have escaped during the initial year of production. At this time, the Big Spring brook trout population was recognized as a mixture of the original strain, introduced commercial fish and those stocked by the Commission. Nonetheless, this fishery represented one of the last limestone streams in Pennsylvania that supported a reproducing brook trout population where individuals exceeded 15 inches in length and brook trout over 17 inches were not uncommon (Snyder 1978). Therefore, it was determined that the brook trout fishery merited further protection. As part of a management plan to enhance the brook trout fishery, regulations were modified (effective January 1, 1976) to encourage the harvest of some brown and rainbow trout and to protect the majority of the brook trout population. The revised regulations changed the daily creel and length limits from one 20 inch trout per day to a creel limit of two trout per day under a 15 inch minimum length limit. These revisions also permitted angling to occur on a short segment of stream near the headwaters that had been closed for study purposes since 1972 (PFC 1975). Subsequently, the revised regulations did not produce the desired level of protection for the brook trout fishery. Therefore, an alternative management action was recommended that included the construction of a fish barrier at the location of the Thomas

Dam (Snyder 1977a). The purpose of this device was to protect the brook trout population from competition with other salmonids. This would be accomplished by removing brown and rainbow trout by electrofishing and using the Barrier to deter any upstream migration into the 0.6 mile headwaters section of stream. During August 1977 a fish barrier was constructed at the location of the Thomas Dam. Following the installation of the Barrier, annual electrofishing efforts were used to examine the status of the brook trout fishery and to remove brown and rainbow trout from the section of stream upstream of the Barrier. All of the brown and rainbow trout that were captured in this section were released in Big Spring Creek at points located downstream of the Barrier. These efforts continued through the fall of 1993. By that time, the original Fish Barrier had deteriorated to a point where it was no longer effective in preventing the upstream migration of trout.

Stream inventories from 1977 through 1993 found similar results, with a dense brook trout population ranging from 483.88 kg/ha to 1,465.80 kg/ha estimated in the headwaters portion of the stream (the Ditch) and a low density brook trout population over the remainder of the special regulations area (Weber and Greene 1993; Greene and Marcinko 1989). The results of these examinations were similar to those found during previous inventories. During this time period, the brook trout population in the Ditch was composed of a mix of wild and hatchery trout and problems with the presence of brown and rainbow trout in the section upstream of the Barrier continued to be compounded by trout escaping from the hatchery. Therefore, since the Barrier was no longer functioning properly and in fact hindering habitat improvement efforts by impounding stream flow, the decision was made to remove this device. The Barrier was finally dismantled during May of 1994 and efforts to remove brown and rainbow trout from the upper 0.6 miles of stream were discontinued. Since that time the special regulations area has been managed for its resident brook, brown and rainbow trout fishery.

Beginning with the 1995 season, the regulations were changed to manage Big Spring Creek (Sections 01 & 02) under the Heritage Trout Angling program. The major changes in the regulations were that no trout may be killed or had in the angler's possession and that gear was restricted to the use of barbless artificial flies and streamers only. Similar to the previous regulations angling continued to be permitted on a year-round basis.

Recent stream examinations were conducted by the PFBC Fisheries Management staff during January and September of 1999, August 2000 and September 2001. Sampling was conducted at four sample sites as follows: downstream of the Ditch, downstream of the former Thomas Dam, upstream of the Stone Arch Bridge and downstream of Laughlin Mill Dam.

Sampling at the site located downstream of the Ditch consisted of a single pass electrofishing effort (C.U.E.) during January 1999. Due to the presence of a dense trout fishery, the Petersen Mark-Recapture method was used to estimate the standing stock of the trout population at this site during subsequent inventories in September 1999, August 2000 and September 2001. The September 1999 examination resulted in the capture of modest brook (14.17 kg/ha) and brown trout (12.77 kg/ha) populations and a dense rainbow trout fishery (109.03 kg/ha) with some evidence of rainbow trout reproduction in the 300 meter (990 foot) sample site located downstream of the Ditch (Tables 1, 2 and 3). Similar results were obtained from the August 2000 and September 2001 examinations, as the estimated biomass of brook (5.52 kg/ha and 4.86 kg/ha) and brown trout (3.47 kg/ha and 6.25 kg/ha) was low in comparison with the biomass estimates for rainbow trout at 106.77 kg/ha and 81.35 kg/ha, respectively (Tables 1,2 and 3). As with previous examinations, the trout fishery was composed of a mix of wild trout and numerous hatchery trout. It should be pointed out that prior to the September 1999 examination intensive stream improvement had been completed in the upstream 200 meters of this sample site. Interestingly, most of the trout captured at this site were within the area where stream improvement had taken place.

During January 1999, September 1999 and August 2000 stream examinations were also conducted at sites located downstream of Thomas Dam, upstream of the Stone Arch Bridge and downstream of Laughlin Mill Dam. As with the upstream sample site, each of these sites was approximately 300 meters in length. However, due to the lower numbers of trout captured at these sites sampling consisted of single pass electrofishing efforts. The examinations at each of these sites in 1999 and 2000 resulted in the capture of only low to moderate densities of trout and most of the trout captured were of recent hatchery origin (Tables 4-6). Therefore, sampling at these sites during September 2001 was limited to collecting relative abundance information on all fish species at a 100 meter Index of Biotic Integrity (IBI) monitoring site.

Additional monitoring in September 2000 included a Petersen Mark-Recapture estimate of the trout population within the 150 meter segment of stream known as the Ditch (from the base of the former McCracken Mill Dam upstream to the source). As with previous inventories, this site continued to support an extremely dense trout fishery composed of a mix of wild trout and numerous hatchery trout. By species, the brook trout population was estimated at 1,971/ha and 468.80 kg/ha, the brown trout population was estimated at 2,278/ha and 1,783.40 kg/ha and the rainbow trout population was estimated at 1,827/ha and 1,441.42 kg/ha (Table 7). Overall, the estimated standing stock of the trout fishery (species combined) in the Ditch was 6,072/ha and 3,693.62 kg/ha. Interestingly, large trout (greater than or equal to 14 inches) composed nearly half of the abundance (3,012/ha) and over eighty percent of the biomass (3,076.78 kg/ha).

The exceptionally high density of trout and presence of numerous large individuals in the Ditch was undoubtedly a result of trout escaping from the hatchery. With the closure of the hatchery the standing stock of the trout fishery should not be expected to remain at these levels. As stated, the objective of the Big Spring Creek Fisheries Restoration Plan is to restore a self-sustaining wild trout fishery to all suitable reaches of this stream beginning with the 0.6 miles of stream extending from the source downstream to Thomas Dam. The maintenance of a high density trout fishery that is largely supported by hatchery trout would be counter to this objective. The elimination of the artificial element of trout escaping from the hatchery should benefit the wild trout fishery by reducing competition between wild and hatchery fish and by reducing the amount of predation on small wild trout by excessive numbers of larger fish. Furthermore, without the influence of numerous hatchery trout, the wild trout fishery should stabilize over time and provide a fishery similar in density to other fine southcentral Pennsylvania limestone streams.

At the present time most of the spawning activity and the majority of the trout population in Big Spring Creek is limited to the 350 meters of stream located in the headwaters. These results are strikingly similar to the observations made in 1972.

Additional Biological Surveys

In addition to examinations of the trout population, surveys have been conducted to examine the benthic macroinvertebrate community over time. Sheaffer (1972) reported on macroinvertebrate sampling that was conducted in June 1971 at six sites along Big Spring Creek. These samples were collected prior to the onset of hatchery production at the Big Spring Fish Culture Station. The benthic macroinvertebrate community was also sampled at three sites during May of 1998 (Botts 1999). For comparison, two of the sites that were sampled in 1998 were located in the same area as two of the 1971 sample sites. The upstream site was located downstream of the Ditch and the lower site was below the Nealy Road bridge (Strohm Dam). During 1971 a total of four macroinvertebrate taxa were collected downstream of the Ditch and five taxa were

collected at the site located downstream of the Nealy Road Bridge (Table 8). These collections were dominated by pollution tolerant taxa. However, one mayfly family (Baetidae) that is considered to be moderately tolerant of pollution was collected at both sites. Sampling during 1998 collected a total of five macroinvetebrate taxa at the site located downstream of the Ditch and only three taxa were collected downstream of the Nealy Road Bridge (Table 8). Again, these collections were dominated by pollution tolerant taxa. Interestingly, one caddisfly (Genus Glossosoma) that is considered to be very intolerant of pollution was collected at the site located downstream of the Ditch. Overall, the macroinvertebrate community was very similar in comparison between the 1971 and 1998 collections at these sites.

As part of the PFBC monitoring plan for Big Spring Creek the overall fish community was also examined as part of an Index of Biotic Integrity (IBI) assessment. This sampling effort involved capturing and enumerating fish from all fish species that were collected within a 100 meter sample site (330 foot) located within each of the four 300 meter sample sites. Stream examinations for the IBI assessment have been conducted on an annual basis during late summer or early autumn since September 1999.

Sampling at the site located downstream of the Ditch (RM 4.96) was conducted on September 21, 1999, August 30, 2000 and September 25, 2001. Collectively, a total of seven fish species were captured during these examinations (Table 9). Fish species captured at this site included, slimy sculpin (*Cottus cognatus*), brook trout, brown trout, rainbow trout, pearl dace (*Margariscus margarita*), blacknose dace (*Rhinichthys atratulus*) and white sucker (*Catostomus commersoni*). Two of the fish species captured at this site, slimy sculpin and brook trout, were fish species considered to be intolerant of general organic pollution and sedimentation (Spear 2000, Lyons et al. 1996). Overall, slimy sculpin were the most abundant species and the only species that was captured during each of the samples at this site.

Sampling at the site located downstream of the former Thomas Dam (RM 4.35) was conducted on September 15, 1999, August 30, 2000 and September 25, 2001. Collectively, a total of five fish species were captured during these examinations (Table 10). Fish species captured at this site included slimy sculpin, brook trout, brown trout, rainbow trout and pearl dace. As with sampling at site RM 4.96, two of the species captured, slimy sculpin and brook trout, were fish species considered to be intolerant of general organic pollution and sedimentation (Spear 2000, and Lyons et al. 1996). Again, slimy sculpin were captured during each of the samples and were the most abundant fish species captured at this site.

Sampling at the site located upstream of the Stone Arch Bridge (RM 2.53) was conducted on September 21, 1999, August 30, 2000 and September 25, 2001. Collectively, a total of eight fish species were captured during these examinations (Table 11). Fish species captured at this site included, slimy sculpin, brown trout, rainbow trout, pearl dace, blacknose dace, white sucker, tessellated darter (*Etheostoma olmstedi*) and fourspine stickleback (*Apeltes quadracus*). Slimy sculpin was the only fish species captured at this site considered to be intolerant of general organic pollution and sedimentation (Spear 2000, and Lyons et al. 1996). Based on these examinations, the presence of slimy sculpin was uncommon at this site, as only three individuals were captured during the September 1999 examination and no slimy sculpin were captured during the 2000 and 2001 examinations. Overall, white suckers were the most abundant fish species captured during each of the examinations at this site. This species is considered to be tolerant of pollution (Spear 2000, and Lyons et al. 1996).

Sampling at the site located downstream of Laughlin Mill Dam was conducted on September 15, 1999, August 30, 2000 and September 25, 2001. Collectively a total of 15 fish species were captured during these examinations (Table 12). Fish species captured at this site included, brown trout, rainbow trout, pearl dace, blacknose dace, white sucker, tessellated darter, fourspine stickleback, longnose dace (*Rhinichthys cataractae*), banded killifish (*Fundulus diaphanus*), cutlips minnow (*Exoglossum maxillingua*), common shiner (*Luxilus cornutus*), green sunfish (*Lepomis cyanellus*), river chub (*Nocomis micropogon*), rock bass (*Ambloplites rupestris*) and spottail shiner (*Notropis hudsonius*). According to

Lyons et al. (1996), rock bass and spottail shiner were the only fish species captured at this site considered to be intolerant of pollution. Based on these examinations, the presence of rock bass and spottail shiner was uncommon at this site, as they were not captured during the 1999 examination. Furthermore, only sparse numbers of rock bass were captured during 2000 and 2001 and only two spottail shiners were captured during the 2000 examination. Overall, blacknose dace were the most abundant fish species captured during each of the examinations at this site. Again, this species is considered to be tolerant of pollution (Spear 2000, and Lyons et al. 1996).

Interestingly, the abundance of fish considered intolerant of general organic pollution and sedimentation was more prevalent in the upstream sections of this stream as compared with the downstream sections (Tables 9-12). This is counter to some claims that conditions are better for aquatic life in the downstream sections of Big Spring Creek as compared with upstream sections.

Habitat Improvement

Aside from the Ditch and the 200 meters of stream located immediately downstream of the Ditch (where intensive stream enhancement work has already been completed), habitat is severely lacking in the remaining 1.4 miles of the special regulations area on Big Spring Creek. At present, this segment of stream can be characterized as a wide and shallow stream channel with a very limited amount of cover available to support a trout fishery.

Over time recommendations from numerous evaluations have recognized the need for habitat improvement work on Big Spring Creek. Following an examination in February of 1977, Snyder (1977b) noted the need for habitat improvement work, as much of the stream downstream of the Ditch was wide and shallow with little cover. Subsequently, a work request for stream improvement and bank stabilization was submitted to address the need for stream improvement in the special regulations area (Snyder 1977c). After a field review in June of 1979 Snyder (1979) also stated the need for the placement of fill to narrow the stream channel and to stabilize some of the existing stream deflectors in Big Spring Creek. Following the completion of inventory work during the 1980 season, Frazier (1980) concluded that habitat improvement was needed in most of Section 01 and that this work should benefit the fishery. During the 1988 inventory the loss of watercress was noted as a serious habitat related problem that contributed to the widening of the stream channel below the Ditch. Habitat degradation was also noted in the Ditch at this time, as the stream channel was widening due to the recession of willows along the east bank (Greene and Marcinko 1989). Jackson (1989) noted a limited amount of natural cover between Strohm Dam and the Barrier and pointed out that based on the results of annual electrofishing operations, this area very often fails to hold trout. He further suggested that the long-term approach to remedy this situation was through habitat improvement. Lutz (1990) inspected the stretch of Big Spring Creek between the Barrier and the Ditch and recommended that improvements to this area should occur in two phases. The first phase would involve work to narrow the stream using a series of deflectors. The most cost effective method would be to construct these devices with brush bundles that would act to trap silt and gravel and build the stream bank. The second phase would be to add instream cover using devices to be determined at a later time. Subsequently, work involving the first phase commenced during the 1991 season. Snyder (1993) pointed out that the stream banks were significantly eroded in the Ditch and the bank along the roadside was in dire need of stabilization. Following a field evaluation Houser (1993) concluded that the stream bank was eroding in the Ditch and suggested that stabilization and cover could be provided by the construction and placement of “lunker” structures and/or “skyhook” covers. At that time, an inspection of a completed project upstream of the Barrier indicated that the project was showing some positive results, as brush deflectors were collecting sediments and depositing fines below the structures and the stream reach was building new stream banks and creating a narrow meandering channel. Following the completion of annual inventory work in 1993 it was recommended that habitat improvement work should be initiated to enhance holding areas for trout in the Ditch. It was also pointed

out that habitat degradation continued to be a major limiting factor to the wild trout fishery in the section of stream between the Barrier and the Ditch (Weber and Greene 1993). Staff held a meeting in April 1994 to discuss proposed habitat improvement initiatives on Big Spring Creek (Weber 1994). Since that time intensive habitat improvement work has been conducted in the Ditch and along an adjacent segment of stream extending approximately 200 meters downstream of the Ditch. This work has vastly improved the amount of cover available to hold trout in this segment of the stream. However, this is only a small portion of Big Spring Creek.

Interestingly, the field observations from several staff members have stated the need for habitat improvement work on Big Spring Creek over the past two decades. Collectively, these recommendations provide an overwhelming indication that habitat problems have been and continue to present a major limiting factor to the improvement of the Big Spring Creek trout fishery. Therefore, it is strongly recommended that habitat improvement activities become an agency priority on this water with work continuing in a downstream progression to at least Strohm Dam.

Water Levels and Siltation Concerns

It should be pointed out that when the Big Spring Fish Culture Station was in operation, the station consistently met the National Pollutant Discharge Elimination System (NPDES) standards for effluent water quality (PFBC 1999). While in operation the hatchery used an average of 5,000 gallons of water per minute for trout production purposes. The spring typically provided an average flow of between 15,000 and 20,000 gallons of water per minute. However, more recent observations indicated that the water levels in the spring tended to fluctuate more than they had in the past. For example, during the morning hours (6-10 am), hatchery personnel consistently noticed a one to two inch drop in the level of the spring (Farner 2000). These fluctuations were attributed to additional development in the area, as daily changes in the level of the spring coincided with a time period of peak demand by those drawing on the aquifer for their water supply.

In addition, siltation continued to occur in the watershed and was more evident during periods of restricted flow, as hatchery personnel observed an increase in the amount of silt in the water supply during the fall of 1990. This was a concern for hatchery production and the maintenance of the wild trout fishery in Big Spring Creek as well, as excessive amounts of silt can literally smother developing trout eggs during the incubation stage. To account for this problem in the hatchery, a sand filter system was installed on the inflow to the hatch house during 1991 to remove the excessive amount of silt (Farner 2000). Siltation continues to be a concern, as based on visual examination from a field review of the Ditch on 1/15/02, a heavy deposition of silt had accumulated along the west bank of the stream between the intake weir located below the spring and the hatchery effluent discharge pipes. This accumulation of silt extended from the west bank of the stream well into the middle of the stream channel.

Summary

Big Spring Creek has long been renowned for supporting an excellent brook trout fishery. The stream was reported to support a dense population of wild brook trout over most of its entire length until sometime in the 1930s. During the 1940s and 1950s the trout population was reported to be more localized and no longer widespread throughout the drainage. Since the late 1950s, the trout population has primarily been limited to a short section of stream near the headwaters. Although this short section of stream continues to support an extremely dense trout population, it should be noted that the fishery is composed of a mix of wild trout and a large number of trout that escaped from the hatchery. With the closure of the hatchery, the density of the trout fishery should not be expected to remain at this extremely high density simply due to the elimination of trout escaping into this stream from the hatchery. However, the closure of the hatchery should benefit the wild trout fishery by reducing the amount of competition

between wild and hatchery trout and the amount of predation on small wild trout. This should allow the wild trout fishery to stabilize and support a wild trout population more typical of the densities observed in other southcentral Pennsylvania limestone streams.

Over time a number of events have occurred that led to the demise of the Big Spring brook trout fishery. Historically, this water was heavily influenced by agricultural activity and the operations of a series of six Mill Dams. Siltation, stemming from agricultural runoff, was recognized as one of the early problems on Big Spring Creek. When the Mill Dams were in operation, this problem was addressed by the continual flushing of silt out of the watershed. This procedure removed silt and debris from the system and provided areas of clean gravel for the trout to use for spawning purposes. However, during the 1930s mill operations were terminated and the dams were no longer being flushed. With the demise of dam operations, siltation became more prevalent in the drainage. Since debris and obstructions were no longer being removed, the amount of riparian and aquatic vegetation increased, and subsequently, several blockages were formed in the stream. As these changes in physical habitat were occurring, the practice of the widespread stocking of hatchery trout in Big Spring Creek also began. Therefore, by the 1940s and 1950s the trout population had become more localized to isolated areas of the stream. Controversies surrounding the operation of a commercial trout hatchery on Big Spring Creek during the 1950s led to a heightened state of concern for the resource by sportsmen. These concerns resulted in the organization of a massive clean-up effort along Big Spring Creek during the spring of 1957. Around the same time frame a number of the dams were removed from the stream. Despite the well meaning intentions of these efforts, the results served only to lower the water level of the stream and literally decimate instream and riparian habitat. These problems are similar to the present habitat related problems that exist on Big Spring Creek.

Since the demise of the dams conditions have not improved on this water, and in fact, have continued to decline. Numerous evaluations have been conducted to examine the status of the trout population on the stream since the late 1950s. All of these have documented the presence of a dense trout fishery in the short segment of stream near the headwaters. However, these same evaluations have failed to record the presence of a dense trout fishery in downstream areas. Much has been stated alluding to the negative impact that the Big Spring Fish Culture Station had on this water. Interestingly, benthic macroinvertebrate studies have reported similar results from sampling both prior to and after this facility went into operation. In addition, recent fish monitoring surveys have recorded abundant populations of slimy sculpin (a pollution intolerant fish species) at sites located in upstream areas that were closer to the hatchery effluent, as opposed to downstream sample sites.

The recommendations from several examinations by Pennsylvania Fish & Boat Commission personnel have recognized the need for habitat improvement on Big Spring Creek. Currently aside from a short segment of stream in the headwaters, where habitat enhancement has been completed, the general lack of habitat and instream cover continues to provide the major limiting factor to the trout fishery on the remaining 1.4 miles of stream managed under special regulations. The lower 3.5 miles of stream continues to be heavily influenced by impounded areas and siltation. Overall, Big Spring Creek is a productive limestone stream that aside from habitat limitations has the potential to support an excellent wild trout fishery. Clearly, if the habitat issues are not addressed on this stream the trout population will not be expected to improve in the future.

Recommendations

1. Intensive habitat enhancement efforts should become an agency priority on Big Spring Creek. These efforts should begin at the source and continue in a downstream progression to Thomas Dam (the site of the former Fish Barrier). This should include the removal of the concrete base of the former McCracken Dam and any required renovations to the existing structures within the Ditch. After the work in the this section is completed, efforts should continue in a downstream progression to Strohm Dam and from this point downstream to the Stone Arch Bridge.

2. Annual monitoring should continue on Big Spring Creek to assess the trout population density at site RM 4.96 (downstream of the Ditch) and fish community using IBI sampling methodology at four sample sites (RM 4.96, RM 4.35, RM 2.53 and RM 1.10). To maintain consistent timing with previous examinations, annual fish sampling efforts should be conducted during late summer or early autumn and continue through the 2005 season. It is also advised that sampling efforts to examine water quality and the benthic macroinvertebrate community should also continue. Based on previous discussions, there was an understanding that the Division of Research would periodically examine water quality at selected sites along Big Spring Creek and Environmental Services staff would examine the benthic macroinvertebrate community. Collectively, these efforts should provide a baseline comparison to assess the progress of the fishery in conjunction with habitat enhancement efforts and measure the progress of water quality improvements

3. Big Spring Creek (707B), Section 01, (0.6 miles, from the headwaters downstream to Thomas Dam, including the Ditch) should continue to be managed for a naturally reproducing trout fishery. Heritage Trout Angling regulations should apply with no stocking.

4. Big Spring Creek (707B), Section 02, (1.0 mile, from Thomas Dam downstream to Strohm Dam) should continue to be managed for a naturally reproducing trout fishery. Heritage Trout Angling regulations should apply with no stocking.

5. Big Spring Creek (707B), Sections 03 and 04, (2.3 miles, from Strohm Dam downstream to the SR 0641 Bridge in Newville) should continue to be managed with the planting of PFBC catchable trout. Stocking rate and frequency should be determined by classification according to program guidelines. All stocking in these sections of stream should be restricted to the use of brook and or rainbow trout and all trout stocked in these sections should be fin clipped prior to stocking for future identification purposes. Brown trout should not be stocked in these sections.

6. Big Spring Creek (707B), Section 05, (1.2 miles, from the SR 0641 Bridge in Newville downstream to the mouth) should be managed as a biomass Class D fishery under the Natural Yield option. Statewide regulations should apply with no stocking.

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Table 1: Big Spring Creek (707B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Brook Trout at site River Mile 4.96 (downstream of the Ditch) during September 1999, August 2000 and September 2001.

Length Group (mm)	1999		2000		2001	
	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha
50			2	0.01		
75	7	0.05	7	0.08	2	0.01
100	5	0.07	24	0.32	36	0.50
125			9	0.23	34	0.82
150	2	0.13	2	0.08	4	0.18
175			4	0.36		
200	14	1.61	4	0.49		
225	37	5.39	2	0.36	7	0.87
250	14	2.73			11	1.99
275	7	1.86	2	0.61	2	0.49
300			4	1.70		
325			2	1.28		
350						
375						
400	2	2.33				
Totals	88	14.17	62	5.52	96	4.86

Table 2: Big Spring Creek (707B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Brown Trout at site River Mile 4.96 (downstream of the Ditch) during September 1999, August 2000 and September 2001.

Length Group (mm)	1999		2000		2001	
	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha
100	2	0.03				
125	2	0.05	2	0.06	2	0.05
150	2	0.09				
250			2	0.43		
275	2	0.70	2	0.68		
300	2	0.67				
325	2	1.12				
350			4	2.30		
425	2	2.78				
500	2	2.73			4	6.20
550	2	4.60				
Totals	18	12.77	10	3.47	6	6.25

Table 3: Big Spring Creek (707B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Rainbow Trout at site River Mile 4.96 (downstream of the Ditch) during September 1999, August 2000 and September 2001.

Length Group (mm)	1999		2000		2001	
	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha
100			18	0.28		
125	7	0.20	2	0.08		
150	14	0.76	4	0.24	16	0.67
175	9	0.72	7	0.42	11	0.78
200	11	1.50	18	2.03	4	0.46
225	19	3.21	2	0.32	20	2.80
250	11	2.26			4	0.81
275	5	1.16			2	0.55
300	2	0.86	2	0.91	2	0.69
325	2	1.02	4	3.33		
350	23	13.21	11	6.81	11	5.00
375	9	6.28	11	8.07	9	5.28
400	9	8.11	7	6.93	2	1.53
425	11	13.00	11	10.44	2	1.83
450	7	7.50	11	13.27	9	8.22
475	7	8.61	4	5.67	4	5.56
500	14	20.11	7	9.22	4	5.72
525	5	5.97	11	14.08	4	7.31
550			4	7.84	7	12.33
575	5	9.09	4	8.72	9	17.78
600	2	5.46	4	8.11	2	4.03
Totals	172	109.03	142	106.77	122	81.35

Table 4. Big Spring Creek (707B) Length Frequency Distribution of Brown and Rainbow Trout captured during single pass electrofishing efforts at site River Mile 4.35 (downstream of Thomas Dam/Barrier) on January 27 1999, September 21, 1999 and August 30, 2000.

Length Group (mm)	1/27/1999		9/15/1999		8/30/2000	
	BT	RT	BT	RT	BT	RT
50		5				
75		2				
100						
125						
150				2		4
175				3		2
200		1		3		
225				2		
250		2		1	1	
275		1				
300		1	2			1
325			1	1		1
350			1	2	1	
375						1
400						
425	1					
450						
475	1	1	1		1	
500		2		1		
525					1	
575					1	
Totals	2	15	5	15	5	9

Table 5. Big Spring Creek (707B) Length Frequency Distribution of Brown and Rainbow Trout captured during single pass electrofishing efforts at site River Mile 2.53 (upstream of Stone Arch Bridge) on January 27 1999, September 21, 1999 and August 30,
2000.

Length Group (mm)	1/27/1999		9/21/1999		8/30/2000	
	BT	RT	BT	RT	BT	RT
150					1	
225			1		5	1
250			10	3	10	
275	1		5		22	
300	1				11	
325	1		3		3	
350					1	
500					1	
Totals	3	0	19	3	54	1

Table 6: Big Spring Creek (707B) Length Frequency Distribution of Brown and Rainbow Trout captured during single pass electrofishing efforts at site River Mile 1.10
(downstream of Laughlin Mill Dam) on January 27 1999, September 15, 1999 and August 30,
2000.

Length Group (mm)	1/27/1999		9/15/1999		8/30/2000	
	BT	RT	BT	RT	BT	RT
125					3	
150					5	
175	2			1		
200	4			2	1	1
225	4			1	4	
250			1	1	5	
275	1		7	1	11	1
300	2		8		5	
325	2				1	1
350			2			
375			1		1	
400			1			1
450	1				1	
475			1			
Totals	16	0	21	6	37	4

Table 7. Big Spring Creek (707B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Brook, Brown and Rainbow Trout at site River Mile 5.05 (The Ditch) during September 2000.

Length Group (mm)	ST		BT		RT	
	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha
50	33	0.07				
75	147	0.88	33	0.20	7	0.04
100	200	2.80	67	0.93	47	0.65
125	98	2.35	13	0.35	40	1.04
150	40	1.64	7	0.29	53	2.29
175	33	2.10			40	2.80
200	145	13.17	13	1.29	67	6.87
225	175	22.61			53	7.47
250	77	13.81	48	8.74	20	3.64
275	223	49.47	170	40.46	27	6.53
300	360	112.32	177	54.11	96	29.85
325	230	99.34	176	68.40	149	60.33
350	122	60.83	170	82.11	205	92.40
375	67	66.40	270	162.71	178	105.79
400	7	5.67	189	136.42	87	61.71
425	7	5.67	183	156.75	139	116.48
450	7	9.67	246	271.26	135	128.66
475			215	267.72	80	94.56
500			116	161.55	108	168.75
525			73	130.68	120	197.28
550			85	161.02	107	201.28
575			13	32.67	42	91.67
600			7	15.74	27	61.33
650			7	30.00		
Totals	1971	468.80	2278	1783.40	1827	1441.42

Table 8. Occurrence of benthic macroinvertebrate organisms during sampling in June 1971 and May 1998.

TAXA	Downstream of the Ditch 6/71	Downstream of the Ditch 5/98	Downstream of Nealy Road Bridge 6/71	Downstream of Nealy Road Bridge 5/98	Mod HBI
Turbellaria			**X**		7
Annelida					
Oligochaeta		**X**			10
Isopoda					
Asellidae	**X**		**X**		8
Lirceus		**X**		**X**	8
Amphipoda					
Gammarus	**X**	**X**	**X**	**X**	6
Ephemeroptera					
Baetidae	**X**		**X**		6
Trichoptera					
Glossosoma		**X**			0
Diptera					
Chironomidae spp		**X**		**X**	6
Simuliidae			**X**		6
Gastropoda					
Physidae	**X**				8
Total Taxa	4	5	5	3	

Modified HBI vales were derived from the Pennsylvania Department of Environmental Protection listing for Invertebrate Pollution Tolerance.

Table 9. Big Spring Creek (707B) Fish Species Occurence, Numbers Captured per Species and Pollution Tolerance Level of Fish Captured from a 100 Meter IBI Sample Site at River Mile 4.96 in September 1999, August 2000 and September 2001.

Common Name	Scientific Name	September 1999	August 2000	September 2001	Tolerance Level
Brook Trout	*Salvelinus fontinalis*		2	2	I
Brown Trout	*Salmo trutta*	1			M
Rainbow Trout	*Oncorhynchus mykiss*		1		M
Blacknose Dace	*Rhinichthys atratulus*	1			T
Pearl Dace	*Margariscus margarita*		1	12	M
White Sucker	*Catostomus commersoni*		1	4	T
Slimy Sculpin	*Cottus cognatus*	133	226	88	I

T - Tolerant
I - Intolerant
M - Moderately Tolerant

Table 10. Big Spring Creek (707B) Fish Species Occurence, Numbers Captured per Species and Pollution Tolerance Level of Fish Captured from a 100 Meter IBI Sample Site at River Mile 4.35 in September 1999, August 2000 and September 2001.

Common Name	Scientific Name	September 1999	August 2000	September 2001	Tolerance Level
Brook Trout	*Salvelinus fontinalis*			1	I
Brown Trout	*Salmo trutta*	3	4	4	M
Rainbow Trout	*Oncorhynchus mykiss*	1	2	1	M
Pearl Dace	*Margariscus margarita*	1			M
Slimy Sculpin	*Cottus cognatus*	201	394	245	I

T - Tolerant
I - Intolerant
M - Moderately Tolerant

Table 11. Big Spring Creek (707B) Fish Species Occurence, Numbers Captured per Species and Pollution Tolerance Level of Fish Captured from a 100 Meter IBI Sample Site at River Mile 2.53 in September 1999, August 2000 and September 2001.

Common Name	Scientific Name	September 1999	August 2000	September 2001	Tolerance Level
Brown Trout	*Salmo trutta*	1	16	5	M
Rainbow Trout	*Oncorhynchus mykiss*	2		1	M
Blacknose Dace	*Rhinichthys atratulus*	17	4	13	T
Pearl Dace	*Margariscus margarita*	73	25	76	M
White Sucker	*Catostomus commersoni*	292	134	189	T
Fourspine Stickleback	*Apeltes quadracus*	9	6	78	M
Tessellated Darter	*Etheostoma olmstedi*	1	2	4	T
Slimy Sculpin	*Cottus cognatus*	3			I

T - Tolerant
I - Intolerant
M - Moderately Tolerant

Appendix A. Big Spring Creek (707B) Length Frequency Distribution of Brook, Brown and Rainbow Trout captured during single pass electrofishing efforts at site River Mile 4.96 (downstream of the Ditch) on January 27, 1999.

Length Group (mm)	ST	BT	RT
50			7
75			4
100	1		
125	13		1
150	11		
175	1		2
200			1
225	4		1
250	1	1	5
275	1		4
300	2	1	1
325			
350			1
375			2
400			5
425			1
450			3
475			4
500			3
525			2
550			
575			1
Totals	34	2	48

Appendix B. Big Spring Creek (7B) Estimated Abundance (N/ha) and Biomass (kg/ha) of Brook Trout in the Ditch from 1977 to 1980 and 1983 through 1993.

Length	1977		1978		1979		1980		1983		1984		1985		1986	
Gr. (mm)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)
50	54	0.11			47	0.05	68	0.07	149	0.30	20	0.04	7	0.02	68	0.27
75	115	0.46	27	0.16	88	0.18	338	2.37	392	2.35	155	0.78	61	0.30	669	4.68
100	47	0.24	115	1.26	68	1.09	311	3.73	135	1.48	196	2.35	108	1.08	541	7.03
125	61	2.20	108	2.59	27	1.89	115	4.72	81	1.94	223	4.68	149	2.98	385	10.01
150	115	3.91	68	2.92	20	1.04	189	8.69	108	4.75	196	8.62	95	3.32	243	11.68
175	61	3.54	54	4.43	88	7.04	155	10.54	68	4.35	142	9.51	34	1.87	142	9.22
200	108	10.04	128	14.34	115	16.33	189	21.17	74	8.29	135	13.90	68	6.60	41	4.42
225	196	24.30	81	13.61	264	39.86	115	25.99	223	33.23	209	32.81	176	25.52	162	24.49
250	459	109.70	101	19.29	318	74.41	290	65.83	250	52.25	399	82.59	466	84.81	284	58.46
275	547	136.20	189	59.72	277	79.78	250	75.25	176	48.75	358	92.72	541	132.00	311	87.96
300	358	161.82	122	61.24	128	62.59	209	77.96	290	109.04	318	103.03	378	111.89	345	119.23
325	203	110.03	115	75.32	149	84.93	209	109.31	365	198.56	297	123.85	297	113.16	372	169.09
350	74	51.21	149	121.14	169	110.19	236	169.68	324	228.10	162	84.24	291	130.37	324	195.57
375	20	18.28	74	69.56	34	31.25	108	94.28	135	110.43	135	94.50	189	118.12	149	109.41
400			34	30.60	47	48.18	54	55.08	61	58.99	108	95.36	68	49.10	54	42.81
425			7	7.70			34	41.99	7	7.00	20	22.50	20	20.00	14	14.86
450					7	9.32			7	9.80	14	17.68	14	18.55		
Totals	2418	631.93	1372	483.88	1846	568.13	2870	766.66	2845	879.61	3087	789.16	2962	819.69	4104	869.19

Appendix B. Continued

Length Gr. (mm)	1987 (N/ha)	(kg/ha)	1988 (N/ha)	(kg/ha)	1989 (N/ha)	(kg/ha)	1990 (N/ha)	(kg/ha)	1991 (N/ha)	(kg/ha)	1992 (N/ha)	(kg/ha)	1993 (N/ha)	(kg/ha)
50	40	0.12	40	0.08	53	0.16	180	0.54	280	0.56	60	0.18	127	0.25
75	1127	6.76	73	0.22	327	1.96	607	3.64	1573	6.29	580	3.48	1140	7.98
100	2007	22.07	220	5.28	233	3.27	907	13.60	1293	15.52	667	10.00	1953	29.30
125	1353	28.42	213	5.12	100	2.60	253	7.85	607	15.77	427	12.37	807	22.59
150	320	11.52	100	3.90	213	9.60	207	10.13	207	7.44	593	29.07	193	10.25
175	220	14.96	153	12.88	147	10.85	160	11.52	167	13.50	340	27.20	40	3.08
200	113	10.54	580	67.86	207	23.56	147	17.16	407	45.95	307	35.27	127	14.95
225	493	71.04	1233	197.33	480	74.88	207	32.86	787	122.72	653	105.19	453	81.15
250	740	148.00	1473	310.87	647	138.39	480	102.24	880	183.04	793	172.95	753	176.28
275	793	215.79	953	259.31	893	242.09	560	162.40	600	172.80	740	210.90	673	205.37
300	480	172.32	573	193.21	1093	380.48	640	234.24	547	194.07	513	186.85	587	221.76
325	280	121.80	373	154.56	707	301.04	513	222.79	333	152.00	287	133.59	420	196.56
350	220	130.02	307	160.39	233	116.20	233	126.00	160	84.00	173	100.36	213	128.64
375	127	98.93	80	64.08	67	44.13	40	29.48	100	76.00	40	30.12	113	78.43
400	13	11.00	13	11.71	7	2.93			7	5.00	33	29.83	67	55.53
425	7	8.67	13	13.00			7	3.83					13	11.33
450	7	10.67							7	9.67				
475			7	6.00										
Totals	8340	1082.63	6404	1465.80	5407	1352.14	5141	978.28	7955	1104.33	6206	1087.36	7679	1243.45

Appendix C. Big Spring Creek (7B) Estimated Abundance (N/ha) and Biomass (kg/ha) of Brook Trout from the Barrier to the Ditch from 1977 to 1980 and 1983 through 1993.

Length	1977		1978		1979		1980		1983		1984		1985		1986	
Gr. (mm)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)
50	1	0.01									1	0.01	1	0.01		
75	1	0.01	24	0.14	1	0.01	11	0.07	4	0.03	12	0.07	1	0.01	1	0.01
100	1	0.01	51	0.56			7	0.08	24	0.29	26	0.31	4	0.06	19	0.13
125			10	0.24	1	0.02			43	0.95	23	0.55	4	0.09	37	0.48
150	1	0.04	1	0.14	1	0.04	1	0.05	9	0.32	1	0.04	1	0.04	22	0.48
175	3	0.17	1	0.08	4	0.29	3	0.20			2	0.11	1	0.07	2	0.09
200	6	0.47	1	0.10	6	0.63	1	0.10			1	0.10	1	0.11	1	0.04
225	7	0.84	1	0.15	5	0.80	1	0.15	1	0.15	2	0.30	4	0.58		
250	4	0.70	2	0.42	3	0.67	2	0.43	1	0.19	5	1.00	3	0.62	1	0.07
275	7	1.61	1	0.19	1	0.30			1	0.30	8	1.89	4	1.08	1	0.10
300	1	0.42					1	0.35	1	0.32	6	1.84	1	0.31	4	1.17
325	1	0.49			1	0.55					1	0.44	1	0.49	2	0.67
350	1	0.57	1	0.60									1	0.50	1	0.21
375	1	0.61											1	0.88	1	0.30
400															1	0.33
425																
Totals	35	5.95	93	2.62	23	3.31	27	1.43	84	2.55	88	6.66	28	4.85	93	4.08

Appendix C. Continued

Length Gr. (mm)	1987 (N/ha)	(kg/ha)	1988 (N/ha)	(kg/ha)	1989 (N/ha)	(kg/ha)	1990 (N/ha)	(kg/ha)	1991 (N/ha)	(kg/ha)	1992 (N/ha)	(kg/ha)	1993 (N/ha)	(kg/ha)
50			1	0.01									3	0.01
75	5	0.04	7	0.05	6	0.03	25	0.20	7	0.06	8	0.05	33	0.27
100	22	0.28	86	1.20	5	0.06	43	0.61	49	0.63	14	0.14	43	0.65
125	31	0.70	19	0.39	2	0.07	15	0.40	21	0.47	13	0.29	21	0.55
150	7	0.28	7	0.32	1	0.02	1	0.05	1	0.06	4	0.17		
175	1	0.04	1	0.06			1	0.07	1	0.04	1	0.03		
200	2	0.19	1	0.05	5	0.66	1	0.06	4	0.48	4	0.39	1	0.06
225	2	0.33	3	0.48	9	1.49	3	0.50	16	2.39	5	0.71	2	0.28
250	3	0.59	5	1.13	22	4.86	5	1.17	13	2.45	7	1.29	5	0.85
275	6	1.49	9	2.39	10	2.81	1	0.25	1	0.39	1	0.22	3	0.97
300	1	0.39	3	1.39	3	1.23	3	1.02	1	0.31	1	0.16	1	0.21
325	3	1.30	1	0.68			1	0.78	1	0.44	1	0.57		
350	1	0.89	1	0.89	3	1.72	1	0.52			1	0.30		
375	1	0.38	1	0.42			1	0.33						
400	1	0.47					1	0.39						
425			1	0.58										
Totals	86	7.37	146	10.04	66	12.95	102	6.35	115	7.72	60	4.32	112	3.85

Appendix D. Big Spring Creek (7B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Brook Trout at Section 02 from 1978 to 1979 and 1983 through 1986 and 1988.

Length	1978		1979		1983		1984		1985		1986		1988	
Gr. (mm)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)
75			1	0.01			1	0.01					1	0.01
100	1	0.01			1	0.01	1	0.01	1	0.01	3	0.04	2	0.03
125					1	0.02	1	0.01	1	0.02	1	0.02	1	0.02
150														
175	1	0.02	1	0.03										
200			1	0.04					1	0.07				
225	1	0.03	1	0.06									1	0.04
250	1	0.18	1	0.28	1	0.21	1	0.13	1	0.18			1	0.22
275	3	0.79	1	0.35			1	0.09	1	0.23	1	0.05		
300	1	0.31	1	0.10					1	0.23			1	0.11
325	1	0.13	1	0.22			1	0.19	1	0.35	1	0.13		
350			1	0.13					1	0.46	1	0.12	1	0.17
375	1	0.23	1	0.37										
Totals	10	1.70	10	1.59	3	0.24	6	0.44	8	1.55	7	0.36	8	0.60

Appendix E. Big Spring Creek (7B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Brown Trout at Section 02 from 1977 to 1981 and 1983 through 1986 and 1988.

Length	1977		1978		1979		1980		1981		1983	
Gr. (mm)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)	(N/ha)	(kg/ha)
75												
100					1	0.02	1	0.02	1	0.02		
125	1	0.02	2	0.05	1	0.02	3	0.08			1	0.02
150	1	0.04	2	0.11	1	0.05	3	0.12	1	0.05		
175			1	0.03	1	0.06			1	0.08		
200			1	0.01								
225					1	0.16	1	0.15	1	0.14		
250	1	0.18	1	0.12	3	0.58	3	0.62	3	0.86	1	0.24
275	2	0.49	2	0.57	6	1.72	6	1.61	2	0.58	2	0.53
300	2	0.63	6	2.34	8	3.01	2	0.65	3	1.12	1	0.34
325	3	1.18	5	2.26	4	2.04	5	2.06	2	0.90	2	0.93
350	3	1.68	4	2.69	6	3.58	4	2.39	3	1.65	1	0.58
375	1	0.72	10	9.07	7	5.22	4	2.91	1	0.87	1	0.75
400	1	0.94	4	4.02	7	6.30	5	4.01	3	2.19	1	0.88
425	2	2.12	4	4.77	6	6.54	3	2.72	2	1.73	1	1.25
450	1	1.13	5	6.17	2	2.47	3	3.48	3	3.28	2	2.50
475			1	1.23	2	3.12	2	2.67	1	1.30	1	1.50
500	1	1.51	1	0.89	2	3.28	1	1.66	2	2.88	1	1.60
525	1	1.98	1	0.39	1	2.10	1	2.07	1	1.85	1	2.18
550	1	2.20	1	0.75			1	1.98			1	1.90
575					1	2.80	1	2.93	1	2.70	1	2.80
600	1	2.20					1	2.70			1	2.48
625							1	3.02			1	3.00
650												
675									1	4.00		
700												
Totals	22	17.02	51	35.47	60	43.07	51	37.85	32	26.20	20	23.48

Appendix E. Continued

Length Gr. (mm)	1984 (N/ha)	(kg/ha)	1985 (N/ha)	(kg/ha)	1986 (N/ha)	(kg/ha)	1988 (N/ha)	(kg/ha)
75					1	0.01		
100			1	0.01	5	0.07		
125			1	0.01	35	0.92	1	0.01
150					37	1.51	1	0.01
175					7	0.49	1	0.02
200								
225							1	0.04
250	1	0.23			1	0.24	2	0.32
275	1	0.30			1	0.35	2	0.47
300	1	0.31			1	0.16	1	0.51
325			1	0.35	1	0.49	2	0.77
350	1	0.70	1	0.50			1	0.56
375	1	0.95	1	0.80			2	1.07
400	1	0.90	1	0.85	1	0.55	5	3.24
425	1	1.12	1	1.12			3	2.57
450	1	1.36	1	1.00	1	0.29	3	3.54
475	1	1.66	1	1.30	1	0.45	1	1.25
500	1	1.87	1	1.37	1	1.49	2	2.59
525					1	0.53		
550			1	2.27				
575	1	3.15	1	2.72				
600	1	2.92	1	2.20	1	0.85		
625	1	2.78	1	3.18	1	1.08		
650								
675	1	4.03						
700			1	4.14	1	1.19		
Totals	14	22.28	15	21.82	97	10.67	28	16.97

Appendix F. Big Spring Creek (7B) Estimated Abundance (N/ha) and Biomass (kg/ha) for Rainbow Trout at Section 02 from 1977

to 1981 and 1983 through 1986 and 1988.

Length Gr. (mm)	1977 (N/ha)	(kg/ha)	1978 (N/ha)	(kg/ha)	1979 (N/ha)	(kg/ha)	1980 (N/ha)	(kg/ha)	1981 (N/ha)	(kg/ha)	1983 (N/ha)	(kg/ha)
125												
150					1	0.10	1	0.05	1	0.05		
175			1	0.02	1	0.09	1	0.09			1	0.09
200			1	0.05	1	0.15	3	0.32			1	0.10
225	1	0.16	1	0.03	1	0.16	1	0.17	1	0.20	1	0.12
250					2	0.43	2	0.44			1	0.16
275			1	0.05	1	0.24	1	0.32	1	0.24	2	0.49
300	1	0.34	1	0.40	3	1.09	1	0.41	2	0.79	1	0.38
325	2	0.75	4	1.84	2	1.12	1	0.48	1	0.47	1	0.46
350	1	0.54	6	4.29	4	2.64	2	1.29	1	0.65	2	1.07
375	2	1.50	6	4.44	1	0.70	3	2.06	1	0.75	2	1.51
400	1	0.78	2	1.61	2	1.90	1	0.88	1	0.88	1	0.85
425	1	1.06	1	0.42	1	1.30	1	0.94	1	0.94	1	0.90
450			1	0.36			1	1.38	1	1.05		
475			1	0.40	1	1.48	1	1.64	1	1.35	1	1.78
500							1	1.66				
525												
550												
575												
Totals	9	5.13	26	13.91	21	11.40	21	12.13	12	7.37	15	7.91

Appendix F. Continued

Length Gr. (mm)	1984 (N/ha)	(kg/ha)	1985 (N/ha)	(kg/ha)	1986 (N/ha)	(kg/ha)	1988 (N/ha)	(kg/ha)
125	1	0.04						
150			1	0.03	1	0.01	1	0.01
175			1	0.09				
200			1	0.09	1	0.03	1	0.03
225	1	0.14			1	0.05		
250					1	0.05		
275					1	0.15	1	0.07
300	1	0.33	1	0.33	2	0.57		
325	2	0.94	1	0.35	3	1.32	1	0.23
350	1	0.72	1	0.38	1	0.85	1	0.15
375	1	0.88	1	0.70	1	0.25	1	0.34
400			1	0.78	1	0.49		
425	1	1.15	1	0.85			1	0.25
450	1	1.10			1	0.90		
475								
500								
525								
550								
575			1	1.90				
Totals	9	5.30	10	5.50	14	4.67	7	1.08