Aquatic Biological Investigation in Response to the June 30, 2006 Norfolk Southern Train Derailment and Sodium Hydroxide Release

Sinnemahoning Portage Creek, Driftwood Branch of Sinnemahoning Creek, and Sinnemahoning Creek, McKean and Cameron Counties

November 15, 2006

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Section 1. Executive Summary

On June 30, 2006, a Norfolk Southern freight train derailed near the village of Gardeau, McKean County. Three tank cars carrying 50% sodium hydroxide ruptured, spilling approximately 42,000 gallons of this caustic chemical onto the ground, into Big Fill Run and then into Sinnemahoning Portage Creek. The spill traveled 11.02 miles downstream in Sinnemahoning Portage Creek to its mouth, where it flowed into the Driftwood Branch of Sinnemahoning Creek. The spilled sodium hydroxide traveled an additional 19.7 miles down the Driftwood Branch to its confluence with the Bennetts Branch and then down Sinnemahoning Creek toward the West Branch of the Susquehanna River.

Sodium hydroxide causes acute injury through caustic chemical burns. The chemical release resulted in a fish kill that was immediate and extensive. Thousands of dead fish were observed by Pennsylvania Fish and Boat Commission (PFBC) Law Enforcement Officers and local residents. Although Sinnemahoning Portage Creek was observed to be severely impacted, the downstream extent of aquatic impacts has been unknown prior to this report due to the timing of caustic travel downstream and additional dilution and assimilation factors. PFBC Law Enforcement personnel received reports at the end of the first day of the incident near the village of Driftwood 30 miles downstream from the sodium hydroxide release and fish in distress 34 miles downstream at the village of Sinnemahoning. As a direct result of the train derailment release, a contamination warning and an advisory against recreational water use was issued by PFBC, Department of Environmental Protection (DEP) and local emergency management agencies for a 10-day period for the 34-mile area described above from the village of Gardeau to the village of Sinnemahoning.

PFBC Bureau of Fisheries staff conducted assessments from July 10 through July 24, 2006 at the request of the Bureau of Law Enforcement to provide a technical evaluation of impacts from release of sodium hydroxide from the train derailment. PFBC and DEP sampled fish, amphibians and aquatic organisms as part of the post-release assessment.

Sinnemahoning Portage Creek is designated in 25 Pa. Code Chapter 93 as an Exceptional Value water upstream of Cowley Run. The PFBC has divided Sinnemahoning Portage Creek in three fisheries management sections. Section 1 extends from the headwaters to Parker Run. Section 2 is found between Parker Run and Cowley Run. The PFBC has managed Sinnemahoning Portage Creek Sections 1 and 2 as a wild trout fishery and a Class A (> 40 kg/ha) wild brook and brown trout biomass existed upstream of Cowley Run before the train derailment. Section 3, which extends 6.4 miles from Cowley Run to the mouth, contains a wild trout fishery and has been supplemented by 3,700 stocked trout per year. Aquatic resources in Portage Creek sustained 63 to 98% loss of aquatic invertebrates (Dudzic 2006) and a total kill of fish in the 11.02 miles downstream of the derailment site. Invertebrate recovery is projected to return to baseline in two years. Recovery of wild trout is expected to take an estimated six years and nongame fish are expected to recover to pre-spill numbers in three years.

The Driftwood Branch of Sinnemahoning is a regionally important stocked trout water. The stream had a growing reputation as a warmwater fishery that featured smallmouth bass and rock bass. The Department of Environmental Protection (DEP) post-spill aquatic macroinvertebrate

analysis (Friday 2006) could not discern any change in diversity and abundance of invertebrates in the Driftwood Branch or downstream as a result of the sodium hydroxide release. An estimated 96.8% loss of smaller nongame fish occurred in riffle and run habitat in the Driftwood Branch. Recovery of smaller nongame fish in the fish community is expected to take 3 years in riffle and run habitats. Larger fish other than smallmouth bass in pools and runs experienced a kill estimated at 80%. Smallmouth bass numbers in Driftwood Branch runs and pools were 86.7% lower than estimated pre-spill numbers. Some movement of smallmouth bass into upper Sinnemahoning Creek was noted and this factor was accommodated in the injury analysis. Recovery of smallmouth bass and other game fish is expected to take 6 years. Repopulation of nongame fish is expected to take 3 years in the Driftwood Branch. Dead hellbenders were observed in field assessment work. A total of 36 hellbenders was estimated to be killed in 2006 and 429 were estimated to be missing in the projected 25-year recovery period.

Sinnemahoning Creek is also an important warmwater fishery resource. The origin of this stream is affected by acid mine drainage impacts from the Bennetts Branch as it meets the Driftwood Branch to form Sinnemahoning Creek. No negative impact to fish attributable to the sodium hydroxide release in Sinnemahoning Creek downstream of the confluence with the Bennetts Branch was identified.

Impacts to fish, aquatic macroinvertebrate, amphibians, and recreational fishing and boating are summarized as follows:

- Aquatic macroinvertebrates
  - Sinnemahoning Portage Creek
    Section 1 sustained a 98% invertebrate kill
    Section 2 sustained a 91% invertebrate kill
    Section 3 sustained a 63% invertebrate kill.
- Fish
  - Sinnemahoning Portage Creek - coldwater fish, projecting injury until 2012
    367,707 fish were estimated to be killed in 2006 in Sinnemahoning Portage Creek
    374,277 fish are estimated to be lost in the future due to lack of breeding adults
  - Driftwood Branch of Sinnemahoning Creek - Warmwater fish, projecting future injury until 2012
    149,334 fish were estimated to be killed in 2006 in the Driftwood Branch
    164,846 fish are estimated as future injury due to severe loss of forage and adults
- Amphibians
  - Driftwood Branch of Sinnemahoning Creek – Hellbenders killed, projecting future injury until 2030
    An estimated 36 hellbenders were killed over 19.64 mi. of the Driftwood Branch
    429 hellbenders will be lost from the population in 25 years of projected recovery
- Lost recreational use
  - Fishing, projecting future injury until 2012
    Trout fishing – a total of 2,953 trips for wild trout have been estimated to be lost
    160 lost trips in 2006
    2,793 trips from 2007 until 2012, when the wild trout are projected to return to baseline

Warmwater species fishing - 40,375 fishing trips total are estimated to be lost
4,224 lost trips for all kinds of fishing in 2006
36,152 future lost bass and panfish trips until 2012, when recovery is expected

Table 21 at the end of this report is a tabular summary of information presented above.

Section 2. Introduction

2.1 Background

The McKean and Cameron County areas (Figure 1) of Pennsylvania are dependent on abundant natural resources for their economy. Cameron County (2006) bills itself as the "Land of Endless Mountains" and McKean County is touted as the "Black Cherry Capital of the World". Land use is primarily forest, with pasture and agriculture limited to areas of lesser slope and better soil. Second growth forest supports timbering in the area. Scattered residences and hunting camps result in low area population density. Emporium is the largest town in the study area with a population of 2,526 in 2000 (U. S. Census Bureau 2007).

The area and its streams are located in the Deep Valleys Section of the Appalachian Plateaus Physiographic Province (Pennsylvania DCNR 2000). Rock types are sedimentary in origin and include sandstone, siltstone shale and conglomerate. Geologic folds control valley frequency and orientation. The area's waters and forests provide important recreational opportunities for local residents, many camp owners, and for visitors from other in- and out-of-state locations. A total of 5% of the land in McKean County and 61% of the land in Cameron County is publicly owned (Amy Gimbel, The Center for Rural Pennsylvania, September 27, 2006, personal communication). The study area is in the northcentral part of the state featured in the heavily promoted Pennsylvania Wilds (Pennsylvania Department of Community and Economic Development 2007) tourist campaign. The campaign features fishing and other forms of active and passive outdoor recreation. Historically, the area's relatively pristine setting has produced high quality recreational experiences.

2.2 Train derailment

On June 30, 2006 on or about 9:30 a.m., a Norfolk Southern freight train derailed near the village of Gardeau in McKean County. Three tank cars breached, which allowed 42,000 gallons of 50% sodium hydroxide (Civil & Environmental Consultants 2006) to flow onto the derailment site soil and into Big Fill Hollow Run and Sinnemahoning Portage Creek. The Pennsylvania Department of Environmental Protection (DEP) emergency response program and county emergency management programs were notified of the derailment and were involved in early response. A large quantity of sodium hydroxide contaminated water, observed by Pennsylvania Fish and Boat Commission (PFBC) Waterways Conservation Officers Robert Mader and William Crisp to be characterized by a brownish tea color, flowed downstream as a pollution slug. At its leading edge, the contaminated water produced foam and caused fish to leap out of the water and move toward the banks in an attempt to escape (R. Mader and W. Crisp, personal communication). An extensive fish kill totaling thousands of fish was observed by PFBC Officers as the spilled sodium hydroxide traveled down Sinnemahoning Portage Creek and continued downstream in the Driftwood Branch of Sinnemahoning Creek. When darkness fell on the day of the derailment, Officers Mader and Crisp received reports that fish were dying at the village of Driftwood, 30 miles downstream from the derailment site, and a report of fish in distress was received from the village of Sinnemahoning, an additional 4 miles downstream. The PFBC received many reports of extensive numbers of dead fish over the next few days. Media coverage of the derailment and resulting environmental injury was extensive. The PFBC, DEP, and county emergency management agencies issued a contamination warning and advisory to

avoid water contact immediately after the spill. A blinking highway sign alerted local travelers of the spill and advisory. The fish kill of an undetermined magnitude affected angler use in impacted streams, and PFBC received inquiries regarding impacts downstream to Keating, which is at the junction of Sinnemahoning Creek and the West Branch of the Susquehanna River 46 miles downstream of the train derailment site.

2.3 Nature of product released

Sodium hydroxide (NaOH) is a chemical that is destructive to fish and aquatic life at elevated concentrations. This strong base is highly caustic and causes chemical burns associated with dissolution of proteins (Seiler and Sigel 1988). Injury is caused by physical destruction of tissue; so typical dose related toxicology information associated with ingestion and alteration of biological processes is not employed with this chemical. Gill tissue of fish, with its fine filaments and large surface area, is particularly sensitive to damage by strong acids or bases. Sodium hydroxide is the most common example of a strong base and is commonly used in products ranging from drain cleaner to glass processing. Warnings to human users related to chemical burns are well known for products containing high concentrations of sodium hydroxide, such as drain opening products and oven cleaners. Sodium hydroxide readily dissociates in water to Na^+ and OH^- ions. The pH of a 50% NaOH solution is 14. Measurement of pH was employed to determine if a significant increase in hydroxyl ions associated with the train derailment, and corresponding decrease in hydrogen ions, could be measured. Due to its chemical properties, sodium hydroxide that was released dissociates quickly in water and should not cause chronic impacts to the Commonwealth waters. However, soils saturated at the derailment site store residual chemical, and lingering impacts are being addressed by remedial action.

Title 25, Pa. Code, Chapter 93 Water Quality Standards lists a pH range of 6.0 to 9.0 in §93.7 as an acceptable water quality criterion to protect all designated protected uses for aquatic life. Measurement of pH occurs on a logarithmic scale ranging from 0 to 14. The value of 7 is neutral (neither acidic nor basic), so a pH of 9 is 100 times more basic (also accurately described as less acidic) than a pH of 7 and 10 times more basic than a pH of 8. A pH greater than 9.0 or less than 6.0 is not protective of existing uses of Commonwealth waters under Chapter 93 regulations.

2.4 Report purpose

The purpose of this report is to provide a technical evaluation of impacts from release of sodium hydroxide from the train derailment site to the PFBC Bureau of Law Enforcement. Evaluation of impacts to aquatic macroinvertebrates, fish, selected amphibians and recreational fishing was undertaken to estimate the nature and extent of injury to resources managed by the PFBC.

2.5 Description of resources affected by the sodium hydroxide release

Sinnemahoning Portage Creek originates in McKean County and is located in the West Branch Susquehanna River Basin. It is adjacent to, and separated by a short portage from Allegheny Portage Creek, which drains into the Allegheny River to the north. Sinnemahoning Portage Creek has been divided into three sections by the PFBC) and is managed as a trout fishery. Section 1 extends from the headwaters to the confluence with Parker Run and contains a robust population of wild trout. The train derailment occurred near the mouth of Big Fill Hollow Run

in Section 1, 1.85 miles upstream of Parker Run. The affected Big Fill Hollow tributary had been upgraded to Exceptional Value protected use status (25 Pa. Code §93.9l) following a 1996 survey (PA DEP 1999) at the same time that Sinnemahoning Portage Creek and Cowley Run were upgraded from Cold Water Fishery designation to Exceptional Value. Parker Run and Section 2 of Sinnemahoning Portage Creek are listed by PFBC as Class A, the highest wild trout classification. A Class A combined wild brook and brown trout fishery must have a biomass in excess of 40 kg/ha. Section 3 of Sinnemahoning Portage Creek extends the final 6.42 miles from Cowley Run to the mouth. This downstream section does contain wild trout and is supplemented by 3,700 stocked trout per year. The wild trout biomass before the train derailment ranged from 8.1 kg/ha (Class D) to 31.2 kg/ha (Class B) within Section 3. A total of 11.02 miles of Sinnemahoning Portage Creek was affected by sodium hydroxide spilled at the Norfolk Southern train derailment site.

The Driftwood Branch of Sinnemahoning Creek (hereinafter referenced simply as Driftwood Branch) flows from northeastern Elk County southeast to Emporium, where Sinnemahoning Portage Creek enters. It changes in character from a wild trout stream to a stocked trout fishery to a mixed warmwater/stocked trout fishery over this length. Warmwater fishes dominate the naturally reproducing fish community downstream from Emporium. PFBC Sections 4, 5 and 6 were affected by the train derailment chemical spill. Section 4 begins upstream of the mouth near the State Route 120 bridge in Emporium and ends at Hunts Run. Section 5 extends from Hunts Run to Sterling Run and Section 6 reaches from Sterling Run to the confluence with the Bennetts Branch. Sections 4, 5 and 6 of the Driftwood Branch have been included in the stocked trout management program since at least 1932 (PFBC – unpublished data). In 2006, a total of 15,700 trout were stocked in the Driftwood Branch Sections 4, 5 and 6. Additionally and equally noteworthy is the warmwater fishery provided by smallmouth and rock bass that has improved in recent years (Bruce Hollender, Area 3 Fisheries Manager, personal communication) and is utilized particularly in late spring and summer in Sections 4, 5 and 6. A total of 19.7 miles of the Driftwood Branch received sodium hydroxide released from the train derailment site.

Sinnemahoning Creek is formed by the confluence of the Driftwood and Bennetts Branches at the village of Driftwood. The water quality of this stream is compromised by acid mine drainage from the Bennetts Branch and the limited buffering capacity of the Driftwood Branch. Angelo (1999) reported that metals concentrations associated with abandoned mine drainage limited aquatic invertebrate community in most of the Bennetts Branch. Smallmouth bass and rock bass were present in fishable populations in Sinnemahoning Creek near the Bennetts Branch, but most angling use of Sinnemahoning Creek was reported to occur downstream of the village of Sinnemahoning and the confluence with the First Fork of Sinnemahoning Creek. Sinnemahoning Creek flows 15.75 miles from the Bennetts Branch to its mouth at Keating.

Section 3. Methods

3.1 Habitat evaluation

3.1.a. Habitat definitions

StreamNet (2007) provided simple definitions for three basic stream habitat types: riffles, runs and pools. The definitions shown below were used in this study. Definitions are qualified by language in italics to describe relative depths and practical application of fish sampling techniques in each habitat type for this study.

Riffle -- A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders. *"Whitewater" was helpful in characterizing riffles. Riffles in the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek ranged from 0.25 to 0.75 meters deep and shallower riffles could be sampled with backpack electrofishing gear.*

Run (in stream or river) -- A reach of stream characterized by fast flowing low turbulence water. *Whitewater was absent in run sections. In the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, runs varied from 0.5 to 2 meters deep. Runs in the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek were sampled with boat electrofishing gear.*

Pool -- A reach of stream that is characterized by deep low velocity water and a smooth surface. *In the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, pools varied from 1 to approximately 4 meters deep and required boat electrofishing gear to sample.*

3.1.b. Habitat assessment methods

The EPA Rapid Bioassessment Protocol for high gradient streams (Barbour et. al 1999) was used as a standard methodology to compare habitat at all five stations. This rating assists in determining if the aquatic community's biological potential is limited by physical habitat. Overall habitat scores can be compared among stations, and individual parameters can be examined to identify station-to-station habitat differences. Ten individual parameters were rated on a standardized scale from 0 (lowest) to 20 (highest). The highest possible habitat score, therefore, is 200. Parameters reflect microhabitat qualities, usually substrate characteristics, channel morphology, and riparian corridor characteristics. Individual habitat parameter scores fall into one of four categories:

Category	Score
Poor	0 - 5
Marginal	6 - 10
Suboptimal	11 - 15
Optimal	16 - 20

Habitat mapping of larger streams was conducted by on-site analysis by two PFBC Bureau of Fisheries staff during a two-day canoe float from the confluence of the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Portage Creek in Emporium downstream to the mouth of the First Fork of Sinnemahoning Creek. The PFBC biologist in the bow of the canoe

pinpointed latitude and longitude of breakpoints between riffle, run and pool features using a handheld Lowrance ifinder GPS Unit. A Bushnell Yardage Pro rangefinder was used to measure the width of each habitat feature. Data was entered into ArcView GIS software, which plotted riffle, run and run locations, lengths and widths and produced a feature-by-feature habitat map. Individual areas of each habitat feature and categorical totals by riffle, run and pool were calculated for selected stream reaches. Fish community analyses were partitioned into the three habitat categories for the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek.

3.2 Aquatic macroinvertebrates

Pennsylvania DEP biologists (Dudzic 2006 and Friday 2006) sampled and processed aquatic macroinvertebrates. Macroinvertebrate evaluations focused on riffles, which are widely recognized as the most productive invertebrate habitat type and targeted in most assessment protocols. Two invertebrate evaluations were conducted as part of the response to the Norfolk Southern derailment.

A preliminary field evaluation was conducted at most sites to determine if the short time lag of less than one week caused dead, but undecomposed aquatic macroinvertebrates to be inaccurately considered in the sample. Usually, a ten-day to two-week time lag is allowed to occur before assessment so decomposition of dead macroinvertebrates occurs and invertebrates subjected to a chronically lethal dose of pollutant have succumbed to exposure effects. Due to the extensive impacts noted with the pollution event associated with the derailment, assessment response was accelerated. The first evaluation consisted of collection and field processing of a 1-meter square kick net sample at most sites. Invertebrates collected by this method using the standard PA DEP unassessed waters protocol were identified to family level and invertebrates were examined to determine if they were alive at the time of sampling or dead and potentially impacted by the chemical spill.

Aquatic macroinvertebrates were collected, preserved and processed according to the methods described in the Pennsylvania DEP Summer Protocol (2006). Six samples were collected at each site with a 500-micron mesh D-frame net. The sample was divided into two composite samples: one two-kick composite and one four-kick composite. The two-kick composite was subsampled by randomly selecting squares in a pan divided into a grid of 28 squares until a subsample of 100 organisms (+/- 20%) was obtained. Organisms in the subsample were identified to genus or the lowest practical taxonomic level. To date, the four-kick composite sample remains preserved, but has not been processed. PFBC has used these DEP macroinvertebrate results as an accurate representation of organisms that were living at the time of collection. DEP preliminary analysis showed that live organisms with some difficulty could be discerned from dead organisms in Sinnemahoning Portage Creek (Dudzic 2006) and an inconsequential number of dead organisms were collected in preliminary samples from the Driftwood Branch of Sinnemahoning Creek (Friday 2006) described above.

3.2.a. Injury determination

Sodium hydroxide's caustic action is likely nonselective across invertebrate taxa. The primary parameter used to evaluate impact of sodium hydroxide to the invertebrate community was the

number of invertebrates per sample location. DEP used the following relationship to estimate number of invertebrates per sample:

$$\text{Total number of invertebrates} = \text{No. of organisms subsampled} \times \frac{\text{28 grids per sample}}{\text{No. of grids subsampled}}$$

Invertebrate injury was defined as reduction in invertebrate numbers after exposure to sodium hydroxide as compared to reference conditions (Dudzic 2006 and Friday 2006).

Additionally, taxa diversity and the percentage of Ephermeroptera, Trichoptera and Plecoptera (EPT) organisms in the total number of organisms were compared among sites to determine if some invertebrate taxa could have been selectively injured due to varying sensitivity to sodium hydroxide exposure. Missing sensitive taxa that are not rare in reference locations were evaluated to assess the potential for sodium hydroxide injury.

3.3 Fish

3.3.a. Wadable habitat

Electrofishing was conducted on July 10, 11 and 12, 2006 at wadable riffle locations using Coffelt BP1C alternating current backpack units with two hand held probes. In Sinnemahoning Portage Creek, which was less than 10 meters wide, a single AC backpack was used on each electrofishing run. All available habitats in this stream were sampled with the described gear. Two runs were made per station on Sinnemahoning Portage Creek. Station lengths were measured with a 100-meter surveyor's tape and at least 5 width measurements were taken per 100 meters of stream with the surveyor's tape.

On the larger Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, two or three electrofishing units were used simultaneously. Only riffle habitat was sampled on these larger streams with the AC backpack electrofishing units. Riffles were defined in *Section 3.1.a, Habitat definitions*. Where width was less than 20 meters, effort for one electrofishing run that sampled the entire width of stream consisted two electrofishing units being used side-by-side simultaneously for the length of the sample station. The electrofishing path was sinuous to cover the entire stream width. Where width exceeded 20 meters, six sinuous passes over the entire width of stream constituted an electrofishing run. This effort was carried out on a third of the stream width at a time using two electrofishing units or three electrofishing units on each half of the stream width. Table 2 summarizes electrofishing methodology for various wadable study locations. Station lengths and widths on larger streams were measured with a 100 m surveyor's tape or a Bushnell Yardage Pro rangefinder.

Sample stations are identified in Figure 1 and Table 1 with an explanation of electrofishing methodology employed at each site. Nets and holding cages used 0.25 inch mesh netting. All fish were collected, identified to species, and counted in each electrofishing run. Game fish and suckers were also weighed and measured. Representative lengths for nongame fish species were determined by measuring all fish in selected runs. Results from two electrofishing runs per station for Sinnemahoning Portage Creek were used to calculate an estimate of fish abundance based on two run depletion sampling (Van Deventer and Platts 1989). Fish population estimates

for the Driftwood Branch and Sinnemahoning Creek were based on the first electrofishing run catch. Abundance of each species of fish was expressed as number per hectare. The electrofishing run catch total for each species was divided by the area sampled. An assumption that effort was conducted with the same degree of thoroughness at each station was made with this method.

3.3.b. Unwadable habitat

Unwadable habitat, identified as runs and pools, was sampled with a boat on the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek. Runs and pools were previously defined in *Section 3.1.a, Habitat definitions*. Run and pool habitat was sampled during daylight hours with a 16' motor and oar-powered aluminum flat-bottomed jon boat outfitted with a generator and Smith Root 2.5GPP electrofishing unit that produced pulsed DC current through one 3-foot diameter electrode array. An electrofishing run consisted of one timed pass through the habitat units in the stream reach. A counter that summed the time when the electrofishing switch was turned on determined time for each run. Pools were sampled using a motor-powered boat with sinuous pass. Runs were sampled with an oar-powered drift pass from upstream to downstream. Sampling stations are identified in Figure 1 and Table 1 with differentiation between wadable and boat sampling sites. All fish were collected, identified to species, and counted in each electrofishing run. Game fish and suckers were also weighed and measured. Catch per unit effort (CPUE) was calculated for each station. Typically, CPUE is the metric used by the PFBC to compare boat electrofishing locations within a given water and among different waters.

The population of fish at each station sampled with boat electrofishing gear was estimated with the following methodology. Catch per unit effort (catch per hour) was transformed to catch per hectare by determining a study area specific catch per hour to catch per hectare conversion. The assumption is made that at each station, the same amount of electrofishing time is expended to sample equal habitat areas. For this study, a very discrete habitat area, the Driftwood Branch of Sinnemahoning Creek pool upstream of the Sterling Run Bridge identified in Table 1 as Station DB04 was sampled in two electrofishing runs in 1998 and one run in 2006. Flows varied between years so widths specific to the given year were used to develop the catch per hour – catch per hectare conversion. The conversion was determined as follows:

Date	Time	Area	
7/15/98 Run 1	0.336 hr.	0.488 ha	1.45 ha/hr
7/15/98 Run 2	0.354 hr.	0.488 ha.	1.38 ha/hr
7/12/06	0.359 hr.	0.618ha.	1.72 ha/hr
Conversion factor	= mean	=	**1.52 ha/hr**

CPUE was converted to catch per unit area simply by dividing the station catch per hour results by the above conversion factor of 1.52 hectares per hour to obtain catch per hectare. Sample station fish populations per hectare could be expanded to represent run and pool habitat total areas by multiplying catch per hectare by habitat area determined from GIS analysis.

3.3.c. Injury determination

Sinnemahoning Portage Creek fish injury was calculated by determining the difference between reference or historical abundance and July 2006 station sample results for each of the three PFBC management sections. Missing fish were attributed to mortality associated with the June 30 train derailment and sodium hydroxide release. In Section 1 (upstream of Parker Run) reference abundance upstream of the derailment site was compared to abundance downstream of the derailment site for both trout and nongame fish. In Section 2 (Parker Run to Cowley Run), missing trout were determined by comparing most recent historical abundance to trout present in 2006. Nongame fish reference abundance from Section 1 was also used for Section 2. The most recent historical trout abundance for Section 3 (Cowley Run to mouth) was used as the reference condition and compared to July 2006 results to estimate "missing" fish. Since the nongame fish community was judged to be intermediate between Sinnemahoning Portage Creek headwater conditions (SPC01) and upstream Driftwood Branch conditions (DB00), the mean nongame fish abundance of SPC01 and DB00 stations was used to represent reference conditions. Again, reference minus July 2006 results yielded an estimate of fish killed by the sodium hydroxide spill.

Injury to fish in the Driftwood Branch of Sinnemahoning Creek was determined by habitat type and not by stream section. Riffle habitat fish injury was estimated much like Sinnemahoning Portage Creek. Reference fish abundance for riffles was determined from the mean of reference stations DB00 and FF01 (First Fork of Sinnemahoning Creek). Injury was estimated by the number of missing fish in July 2006 when compared to the mean reference abundance. The run habitat fish community was addressed in two components. The smaller nongame fish present in riffles are also present in runs, but were not able to be sampled by wadable or boat electrofishing methods. PFBC biologists have made the assumption that 50% of the fish in the riffle community are present in runs, based on similarity of habitat, requirements of the fish and inability to sample effectively with backpack or boat electrofishing gear. Dr. Richard Horwitz, Academy of Natural Sciences of Philadelphia, (personal communication) agreed that the assumption was reasonable. An estimate of the second component of fish present in runs, the larger game and nongame fish, was determined by boat electrofishing and expressed as catch per hectare. Missing gamefish were determined by comparing historical 1998 and 2003 sample results to July 2006 sample results. Missing nongame fish were determined by comparing 1998 DB04 complete community sample results to 2006 DB04 sample results. Other historical sample locations had presence/absence data and no nongame abundance estimates. Pool fish injury was determined by using the boat electrofishing methodology as described above for runs.

3.4 Amphibians

3.4.a. Injury determination

Injury to amphibians was recorded through counts of dead amphibians observed at sampling stations. Total injury was calculated by expanding the linear distance the sampling areas represented to the entire distance of the stream or stream portions in over which injury was observed.

3.5 Recreational use loss

3.5.a. Fishing

Recreational fishing effort for wild trout in Sinnemahoning Portage Creek was estimated from the Greene et al. (2006) study of angler use of wild trout streams. Since the geographic extent of spill impacts covered 11 stream miles, a major impact on the wild trout population resulted. The major impact has lasting effects due to impairment of reproductive capacity and reduced ability of the population to recover. Future lost angling opportunity is expected with such and a major fish population impact. Hersh (1993) and Hartle (2000) assumed that angling effort for wild trout was directly correlated with abundance of wild trout of catchable size. The methodology for this study correlates angling use to estimated wild trout population. Future injury was estimated by correlating angling to fish population recovery to baseline and the time at which legal-sized fish will be in the population. Once legal size is reached, percent reduction of the population of catchable wild trout will be directly transferred to the same percent reduction in angling use from the baseline identified by Greene et al. (2006). This methodology assumes no avoidance of affected waters following recovery from the fish kill.

Some stocked trout were observed by Waterways Conservation Officers Crisp and Mader (personal communication) to have been killed by the sodium hydroxide release. Bald Eagle Creek (PFBC – unpublished data) survey information was used to estimate lost fishing for stocked trout in the Driftwood Branch of Sinnemahoning Creek in 2006. Absent unforeseen events, there is no plan to cancel future stocking by the PFBC in Sinnemahoning Portage Creek and the Driftwood Branch of Sinnemahoning Creek. However, it is possible that public and angler avoidance of these waters will occur due to negative publicity associated with the train derailment and resulting fish kill. The only injury estimate for stocked trout is where transferable information exists for 2006 injury determination on the Driftwood Branch.

Available warmwater fishing creel information was evaluated and Bald Eagle Creek (PFBC unpublished data) was selected as the surveyed stream that was most similar to the Driftwood Branch and Sinnemahoning Creek. These streams share attributes of size, a rural setting, similar fish communities, a stocked trout fishery, and smallmouth bass – panfish populations. Similarities are striking enough that use data for Bald Eagle Creek were applied without change to both the Driftwood Branch and Sinnemahoning Creek. As with wild trout, angling use was correlated to the projected warmwater gamefish population as it relates to baseline and obtaining legal size. Baseline is defined as warmwater gamefish populations surveyed in the Driftwood Branch and Sinnemahoning Creek in 1998 and 2003. Percent reduction of the population of catchable warmwater gamefish was directly transferred to the same percent reduction in angling use from the baseline identified by PFBC Bald Eagle Creek angler use data (PFBC unpublished data), with one change. A more conservative assumption was made for this study that bass and panfish angling was restricted to run and pool habitat, which is where angling for these species is focused.

Section 4. Results

4.1 Habitat evaluation

Habitat assessment scores for sample station reaches can be categorized by expanding the four ranges used for scoring individual habitat parameters. Categories with associated scores are:

0 – 59	60 – 109	110 – 159	160 - 200
Poor	Marginal	Suboptimal	Optimal

Table 2 and Figure 2 summarize station habitat scores and show that good habitat was present throughout the study area with one exception. Habitat scores in Sinnemahoning Portage Creek were uniformly in the high suboptimal range. Scores in the Driftwood Branch and First Fork of Sinnemahoning Creek were optimal. Sinnemahoning Creek habitat was optimal at SC01, but in the low suboptimal range at SC02R. SC02R was the wadable site farthest downstream, and the site represented the shallower of two split channels.

Habitat estimates from spatial analysis of GIS coverages of the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek showed that riffle, runs and pool habitats were well represented throughout both streams. Table 3 summarizes the riffle area, run area and pool area for the Driftwood Branch of Sinnemahoning Creek between the mouth of Sinnemahoning Portage Creek and the Bennetts Branch, and the riffle area, run area and pool area for Sinnemahoning Creek between the Bennetts Branch and First Fork of Sinnemahoning Creek. Field data collected in each habitat unit was considered more accurate than using available aerial photography, where habitat types and breakpoints between habitat units were more uncertain.

4.2 Aquatic macroinvertebrates

4.2.a. Sinnemahoning Portage Creek

The Pennsylvania DEP Northwest Region (Dudzic 2006) assessed injury of the sodium hydroxide release to aquatic macroinvertebrates in Sinnemahoning Portage Creek. Sample site locations are described in Table 4. Some difficulty was experienced in discerning invertebrates that were already dead from those that were living at the time of sampling. Sample results from Dudzic (2006) are reported in Table 5. Two samples in Sinnemahoning Portage Creek Section 1 showed a 98% reduction from sample results upstream from the derailment site. The sample from Section 2 (Parker to Cowley Run) sample showed a 91% reduction from reference invertebrate abundance. Three samples from Section 3 (downstream from Cowley Run) showed a mean reduction of 63 % from mean abundance. Results show a significant but diminishing difference from reference abundance as distance from the train derailment site increased.

4.2.b. Driftwood Branch Sinnemahoning Creek, Sinnemahoning Creek and First Fork of Sinnemahoning Creek

The Pennsylvania DEP Northcentral Region (M. Friday 2006) completed invertebrate sampling at 11 stations in the Driftwood Branch of Sinnemahoning Creek sampling extended from upstream of the Emporium sewage treatment plant and mouth of Sinnemahoning Portage Creek to the mouth of Sinnemahoning Creek at Keating. Stations are shown in Table 6. DEP Northcentral Region field biologists (M. Friday 2006) indicated that macroinvertebrates were alive and appeared normal when sampled. Results presented in the DEP report (M. Friday 2006)

are shown as Table 7. Other than a change in the aquatic community at the Emporium sewage treatment plant aquatic community where organic pollution tolerant oligochaete worms and dipterans in the family Chironomidae thrived, the only notable excursion from a diverse aquatic macroinvertebrate community was at Wayside Memorial, where the total taxa and EPT index were lower than other stations. Other than the Wayside Memorial Station, diversity at downstream stations was similar to reference and total invertebrate abundance was slightly higher than at the reference station.

4.3 Fish

4.3.a. Sinnemahoning Portage Creek

Catch results from three electrofishing stations on Sinnemahoning Portage Creek are shown in Table 8. Population estimates standardized by hectare are reported in Table 9, which allows direct comparison of abundance among stations. Survey results showed a healthy coldwater community immediately upstream of the train derailment site with nine species and an estimated 31,855 fish per hectare present. This density is 3.2 fish/m^2. A total of 1,339 brook and brown trout per hectare were estimated to occur in the reference area.

No fish were captured in one electrofishing pass each at Stations SPC03 and SPC05 downstream of the train derailment site. The population at these stations was concluded to be zero. SPC03 is in PFBC Fisheries Management Section 1 and SPC05 is in Section 3.

4.3.b. Driftwood Branch Sinnemahoning Creek, Sinnemahoning Creek and First Fork of Sinnemahoning Creek

4.3.b.1. Wadable habitat

Catch results from wadable (riffle) habitat electrofishing is reported in Table 10. Abundance of each species was taken as a total count from one electrofishing run, which was the total effort of multiple unit passes across the stream width as described in the Methods section. Table 11 reports abundance of each fish species per hectare determined from catch and area from Table 10. Stations identified as reference were noted to have more than fifteen times the number of fish (2,162 fish/ha at FF01 and 3,226 fish/ha at DB00) than downstream Driftwood Branch stations through which the sodium hydroxide from the spill passed (122 fish/ha at DB05 and 53 fish/ha at DB07). The riffle area impacted by the sodium hydroxide release showed a mean reduction of 2608 fish per hectare or 96.8% reduction in the riffle fish community of the Driftwood Branch as compared to reference.

Catch from Sinnemahoning Creek wadable habitat stations, located downstream of Driftwood Branch Station DB07 (Figure 1) is shown in Table 10 and the estimated abundance of each species per hectare is shown in Table 11. Abundance at these stations, 678 fish/ha for SC01 and 714 fish/ha at SC02R, was much higher than Driftwood Branch stations, but lower than abundance at the two reference stations. Wadable riffles were less frequent as sampling crews progressed down the drainage. PFBC biologists did not identify wadable habitat able to be sampled with backpack electrofishing gear downstream of the mouth of the First Fork.

4.3.b.2. Unwadable habitat

Deeper run and pool habitats are more difficult to sample thoroughly than shallower riffle habitat. Even though boat-sampling methods were employed, greater depth in runs and pools provides a larger escape area for larger more mobile fish in these habitats. Fish near the bottom are frequently not effectively captured by the boat electrofishing gear employed. PFBC Area 3 Fisheries Management biologists had sampled station DB04 for all fish species in 1998 and DB06 for warmwater gamefish in 2003. Area 3 personnel repeated these same locations in July 2006 to obtain a comparison between historical and post-spill results. Raw catch totals and sampling effort from July 2006 data are presented in Table 12. Table 13 presents 2006 and historical data from 1998 and 2003 (PFBC unpublished data) as catch per hour for each species encountered. A very notable drop in smallmouth bass (55 to 86 less per hour) and rock bass catch (23 less per hour at DB06) was evident between 2006 and historical data in the Driftwood Branch Stations. Suckers and nongame species were not specifically targeted in 2003, but were in 2006, so direct comparison of results could not be made from Table 11 for Driftwood Branch station results.

Sinnemahoning Creek deeper habitat (run-pool) Stations SC02P and SC04 were sampled by boat electrofishing in 2003 by Area 3 personnel and again in July 2006 as part of spill assessment. Table 12 shows Sinnemahoning Creek as well as Driftwood Branch raw catch numbers and Table 13 provides the catch per hour comparison between 2003 and 2006. Catch per hour at SC02P (Figure 1) showed approximately the same number of rock bass between 2003 (22/hr) and 2006 (19/hr), but surprisingly, the smallmouth bass catch increased greatly from 18/hr to 100/hr. SC04, located approximately 40 miles downstream of the derailment site, yielded a higher catch in 2006 than 2003 for smallmouth bass (112/hr compared to 68/hr) and lower catch for rock bass in 2006 compared to 2003 (12/hr compared to 30/hr). Increased smallmouth bass catch in 2006 was contradictory to the similar or lower rock bass catch. The data therefore received additional scrutiny to consider the historical and 2006 fish communities in proper context before a pre- and post-spill analysis was conducted. This contextual data evaluation follows.

The 2006 sampling effort occurred in optimal conditions of slightly elevated flows and turbidity, and the catch is believed to accurately correlate to the population. Experience of the PFBC Area 3 Fisheries Management survey crew in other West Branch of the Susquehanna River basin surveys (PFBC 2006) showed that the area farthest from the spill, SC04, and other stations (PFBC 2006) had a much higher catch rate in 2006 than in previous years. The increase in smallmouth bass catch at SC04 of 164.7% between 2003 and 2006 (Table 13) is consistent with catch increases seen at other West Branch Susquehanna River basin stations between 1996 and 2006 (166% increase), and lower than the increase between 2005 and 2006 (435% increase). Therefore, all historical smallmouth bass catch per hour data for this study was increased by 164.7% demonstrated at SC04 to reflect a more representative pre-spill smallmouth bass population. This adjustment was applied in Table 14.

In response to the observed fish kill, an effort was made to quantify the number of fish per unit area to expand sample estimates to the habitat areas measured by GIS analysis. The conversion

of 1.52 hectares sampled per hour of electrofishing described in the methods section was applied to data in Table 14 to produce historical and 2006 catch results per hectare for all Driftwood Branch and Sinnemahoning Creek stations. Catch per hectare results for these stations are shown in Table 15. The 2006 smallmouth bass catch per hectare in Driftwood Branch Stations DB04 and DB06 was 86.7% lower in 2006 than in previous years, which equals 85 missing smallmouth bass per hectare. Other species suffered a similar 79.7% or 63 fish per hectare decrease as measured at DB04 where historical data was available for nongame species.

The increased catch of smallmouth bass at Station SC02P was attributed to smallmouth bass movement from the Driftwood Branch into upper Sinnemahoning Creek. Movement of smallmouth bass in times of disease, stress or seasonal migration has been noted in the Susquehanna River basin and elsewhere. Between 2003 and 2006, a net gain of 46 smallmouth bass per hectare of boat electrofishing habitat was observed at SC02P, which represents the 3.8 mile portion of Sinnemahoning Creek between the mouths of the Bennetts Branch and the First Fork of Sinnemahoning Creek. Rock bass numbers were similar between 2003 and 2006 and even though historical numbers of other species are not available, they were noted to be very similar in their presence between 2003 and 2006. Other than an increase in the number of smallmouth bass at SC02P in 2006, no other differences in the fish community of Sinnemahoning could be discerned between historical and 2006 results.

4.4 Amphibians

Four dead adult hellbenders were found along the Driftwood Branch in the 3540 meters of stream that was sampled. Two were found at boat site DB06 and two at wadable site DB07. A photograph of one specimen from DB07 is shown in Figure 3. All dead hellbenders were in a state of similar decomposition consistent with larger dead fish found nearby. Hellbenders are strictly aquatic and death was attributed to the sodium hydroxide release.

The four dead hellbenders found in the 3.54 kilometers sampled were estimated to represent 36 hellbenders killed along the 19.64 miles (31.61 km) of the Driftwood Branch of Sinnemahoning Creek affected by sodium hydroxide from the train derailment. These results for 2006 amphibian injury are shown in Table 16. No hellbenders or other dead amphibians were found downstream of the village of Driftwood in Sinnemahoning Creek.

4.5 Recreational fishing use loss

No recreational fishing was observed to occur during the June 30-July 9 contamination warning and water contact advisory period in Sinnemahoning Portage Creek, the Driftwood Branch and Sinnemahoning Creek upstream of the S.R. 2001 bridge at Sinnemahoning (Station SC02R). Waterways Conservation Officer Crisp observed no angling effort on Sinnemahoning Portage Creek and the Driftwood Branch between Emporium and the village of Driftwood in the month after the June 30 sodium hydroxide spill. Two trout anglers, however, were encountered by the survey crew at the Driftwood Branch reference station DB00 on July 11 when it was surveyed. Anglers reported fishing effort and successful catches of rock bass and smallmouth bass to Officer Crisp on Sinnemahoning Creek downstream from the confluence with the First Fork in mid- to late July three to four weeks after spill.

PFBC staff observations following the sodium hydroxide release indicated that no fishing effort was occurring or expected to occur in 2006 for Sinnemahoning Portage Creek, and greatly reduced angling effort is expected in the Driftwood Branch. Correlation of trout and warm water fishing effort with fish populations present in 2006 and projected for the future occurs in Section 5, Discussion.

Section 5. Discussion

5.1 Habitat evaluation

Analysis of wadable habitat (riffles) using the EPA Rapid Bioassessment Protocol methods indicated that habitat is similar enough in the streams evaluated that major differences in fish populations due to habitat would not be expected among stations. Habitat in all cases was rated as optimal or suboptimal.

GIS analysis of riffle, run and pool habitat in the Driftwood Branch and Sinnemahoning showed that all three habitats were well represented in each stream (Table 3). The 19.7 miles (31,778 meters) of the Driftwood Branch between Sinnemahoning Portage Creek and the Bennetts Branch contained 37.26 hectares of riffles, 32.07 hectares of runs and 45.78 hectares of pool habitat. The Driftwood Branch contained 159 habitat units in 19.7 miles. The 3.6 miles (5,829 meters) of Sinnemahoning Creek to its confluence with the First Fork contained similar proportions of the three habitats. Riffle habitat totaled 11.38 hectares, run habitat totaled 10.9 hectares and four large pools totaled 14.76 hectares. A total of 29 habitat units were delineated on Sinnemahoning Creek. The number of habitat units remained constant at 8.1 per stream mile, even though the stream width increased downstream.

5.2 Aquatic macroinvertebrates

5.2.a. Sinnemahoning Portage Creek

DEP (Dudzic 2006) conducted a straightforward evaluation of impacts of the sodium hydroxide release associated with the June 30, 2006 Norfolk Southern train derailment. Based on results reported by Dudzic (2006), aquatic invertebrates in Sinnemahoning Portage Creek sustained injury in 2006 quantified as a 98% reduction in numbers in 1.85 miles of Fisheries Management Section 1 as a result of the sodium hydroxide release (Table 5). Injury in 2.75 miles of Section 2 was 91% reduction of individuals and injury in the 6.42 miles of Section 3 was a 63% decrease in invertebrate numbers (Table 5).

A 2-year recovery to baseline and future injury through 2007 is projected for aquatic invertebrates. Future injury is expected since some species have multiple year life cycles, and progeny of many single-brooded invertebrate species produced prior to the spill would have suffered exposure and likely severe mortality. Using linear recovery, 2007 injury is expected to be 50% of 2006 injury. Section 1 is projected to have a 49% reduction from reference baseline in 2007, Section 2 injury is estimated at 46% injury and Section 3 injury projected as 32% below baseline. Aquatic invertebrate recovery to baseline is projected for 2008.

5.2.b. Driftwood Branch Sinnemahoning Creek and Sinnemahoning Creek

DEP's conclusion (Friday 2006) that no difference can be discerned between the reference condition and downstream areas exposed to sodium hydroxide from the train derailment is supported by the benthic data. The exposure of invertebrates at the water/substrate interface or within interstitial spaces within the substrate was apparently not toxic enough to produce invertebrate injury and death in the Driftwood Branch and Sinnemahoning Creek. No aquatic macroinvertebrate injury in the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning

Creek was revealed in 2006 by DEP's study. No macroinvertebrate injury is projected for future years as well.

5.3 Fish

5.3.a. Sinnemahoning Portage Creek

5.3.a.1 2006 injury

PFBC manages Sinnemahoning Portage Creek in three sections. Section 1 extends 4.85 miles from the headwaters to the mouth of Parker Run. Big Fill Hollow and the train derailment site are located within this section at River Mile 11.02. The sodium hydroxide release affected 1.85 miles of Section 1, causing a total fish kill. Reference station SPC01 (Tables 9 and 17) provides the basis for the pre-existing fish population in Section 1 that was eliminated by the chemical spill. Sampling associated with this assessment confirmed the presence of a Class A wild trout population (>40 kg/ha), which places it in the highest biomass classification managed by the PFBC. In the 0.98 hectare area of Section 1 affected by the derailment, an estimated 31,218 fish perished in 2006, including 1,312 trout and 29,906 nongame fish (Table 17).

Sinnemahoning Portage Creek Section 2 extends 2.75 miles from Parker Run downstream to Cowley Run. Absence of fish both upstream (SPC03) and downstream (SPC05) of this section leads to the conclusion that the fish kill in Sinnemahoning Portage Creek was total. The fish kill was estimated by using the most recent historical trout population estimates from 1989 for Section 2 (PFBC Fisheries Management database – unpublished data). Abundance of nongame fish is typically not determined in fisheries management surveys and the abundance of nongame fish was extrapolated from SPC01 to represent baseline nongame fish abundance before the sodium hydroxide release. The historical trout population from a 1989 PFBC survey (Table 17) in Section 2 was 102 brook trout and 288 brown trout per hectare, and this section was designated as Class A. A total of 30,516 nongame fish per hectare were estimated to have been present before the kill. The estimate of fish killed in 2006 in the 2.81 hectares of Section 2 is 93,645, including 1,182 trout and 92,463 nongame fish (Table 17).

Sinnemahoning Portage Creek Section 3 reaches 6.42 miles from Cowley Run to the mouth. The wild trout biomass ranged from Class B (20-30 kg/ha) to Class D (<10 kg/ha), and in 1990, 132 combined wild brook and brown trout were estimated to be present per hectare (PFBC Fisheries Management database – unpublished data). Section 3 is also stocked in the spring with 3,700 trout from PFBC hatcheries annually. Although some stocked trout were observed in July 2006 fish kill photographs, it was not possible to accurately reconstruct how many of these fish would have remained at the time of the chemical spill. Injury due to loss of stocked trout is not included in this report. The nongame species composition of lower Sinnemahoning Portage Creek is intermediate in nature between the headwater trout stream represented by SPC01 and the stocked trout stream at DB00, which has warmwater and coolwater species present (PFBC Fisheries Management database). The number of fish missing per hectare other than trout was 16,862, which is the mean of SPC01 and DB00 results that do not represent trout. Section 3 2006 fish injury estimates for the 14.29 hectares of Section 3 are a total of 242,844 fish, including 1,886 trout and 240,958 other species (Table 17).

5.3.a.2 Future injury

Future injury is projected because the fish kill in Sinnemahoning Portage Creek was total and the reproductive capacity of the stream is impaired. Migration of fish from other locations could not possibly fill such a large void in the fish community. Impairment of the entire aquatic ecosystem causes the aquatic community to start from a decimated condition in the area affected by the train derailment. It is estimated that it will take one entire generation of fish for the community to recover. Brook trout recovery is estimated at 4 years, based on its life history and longevity. Brown trout can live longer and a generation is estimated as 8 years. Cyprinids, darters, dace and other smaller fish are estimated to take three years to recover to baseline numbers. For the purposes of this report, trout recovery is generalized in an estimate of six years to reach baseline. Initial injury to trout and projected recovery are shown graphically in Figure 4. Nongame species, mostly represented by short-lived species, should take three years to recover to baseline condition. Figure 5 depicts a representation of initial injury and recovery of nongame fish to baseline. Since recovery of population numbers from zero will likely be exponential, the linear recovery adopted for this report may overestimate recovery and underestimate injury between 2006 and the point where the population has recovered to baseline.

Table 17 uses the described recovery times to predict that from 2007 through 2012, 10,950 trout will be lost to the population due to inadequate reproductive capacity. From 2007 through 2009, an additional 363,327 fish will be lost to the population because of the decimation caused by the spill and initial lack of reproductive capacity. Replacement stock for species affected exists in tributaries and in upstream areas in the general vicinity of the affected area. Restoration activities considered in the aftermath of this pollution event should not include stocking in an attempt to replace wild fish, since restoration of an entire fish community adapted to this stream by stocking is an initially attractive but biologically unsound solution. Species affected are frequently not available in the size classes lost and hatchery stock are not adapted to local conditions. The stocking option is biologically inferior to natural repopulation by fish in the Sinnemahoning Creek drainage that are present and adapted to local conditions. Enhancements that provide long-term benefit to the fish population are a more sound approach to any restoration efforts in Sinnemahoning Portage Creek.

5.3.b. Driftwood Branch Sinnemahoning Creek and Sinnemahoning Creek

5.3.b.1 2006 injury

Survey results indicated that injury to fish in the Driftwood Branch of Sinnemahoning Creek could be discussed most clearly by estimating impacts in different habitat types. Different survey methods and different fish community characteristics will be explained for riffles, runs and pools.

Riffle habitat abundance at reference Stations DB00 and FF01 averaged 2,608 fish per hectare more than mean abundance at spill-impacted locations DB05 and DB07. The estimate of injury shown in Table 18 was determined to be 97,174 fish missing for 2006 in the 37.26 hectares of Driftwood Branch riffles. This estimate represents a 96.8% reduction from reference riffle abundance.

The fish community in Driftwood Branch runs was projected with two components. Smaller fish sampled in riffles can also be oriented to substrate in run habitat, but are not available to wadable sampling techniques due to depth. Small shallow habitat fish were projected to be half as abundant in runs as compared to riffles and were assumed to be equally susceptible to spill impacts. Therefore small shallow habitat fish were estimated to be reduced 1,304 fish per hectare in 2006. The injury component estimate was 41,819 small shallow-water fish missing in 32.07 hectares of run habitat in 2006. Larger deep habitat fish sampled using boat electrofishing techniques showed that 63 fish other than smallmouth bass were missing per hectare. Smallmouth bass injury was determined by using the 85 bass per hectare missing from Driftwood Branch runs, which was partially offset by 46 smallmouth bass per hectare gain in Sinnemahoning Creek between the mouths of the Bennetts Branch and First Fork. The "mass balance" of larger deep habitat Driftwood Branch fish is a negative 2727 smallmouth bass and 2020 other species missing from 32.07 hectares adjusted by addition of 501 smallmouth bass estimated to have moved into 10.9 hectares of run in upper Sinnemahoning Creek. The large deep habitat component of 2006 fish injury in Driftwood Branch runs is therefore a loss of 4,245 fish. The total injury (net loss) of shallow- and deep-habitat fish from run habitat was 46,064 fish from 32.07 hectares of run habitat.

Pool habitat fish community injury was assumed to contain only a larger deep habitat fish component. As with run habitat, loss of smallmouth bass only was partially offset by fish assumed to have relocated to upper Sinnemahoning Creek. Other missing fish were assumed to be killed by the pollution event. A total of 3891 smallmouth bass and 2,884 fish of other species were missing from 45.78 acres of Driftwood branch pool habitat and an estimated 679 smallmouth bass relocated to 14.76 hectares of upper Sinnemahoning Creek pool habitat. Injury to fish in Driftwood Branch pools is estimated to be 6096 fish killed in 45.78 hectares of pool habitat.

In 2006, a total of 149,334 fish were estimated to have been killed in 115.11 hectares of combined riffle, run and pool habitats in 19.7 miles of the Driftwood Branch of Sinnemahoning Creek.

No evidence or historical information suggested fish were missing downstream in Sinnemahoning Creek due to the sodium hydroxide release. SC01 and SC02R were exposed to sodium hydroxide from the train derailment, but were farther downstream than DB07 and received additional dilution and assimilation from the Bennetts Branch before reaching these Sinnemahoning Creek Stations. Further downstream, flows from the First Fork of Sinnemahoning Creek, supplemented by a release requested from George B. Stevenson Dam, and other tributaries further diluted and assimilated spilled product and prevented observable fish mortality. The only conclusion reached in this analysis is that an estimated 1,180 smallmouth bass moved into upper Sinnemahoning Creek as a result of the sodium hydroxide release.

5.3.b.2 Future injury

The impact of the sodium hydroxide spill in the Driftwood Branch was severe in 2006 when the fish community suffered an estimated 96.8 % reduction of small shallow-water fish and 79.8 to 86.7% reduction of large deep-water fish. Like Sinnemahoning Portage Creek, fast recovery is

not probable given the low residual population, diminished forage base and lower reproductive capacity. Warmwater game fish such as rock bass and smallmouth bass are expected to take one generation to recover and growth rates suggest that six-year recovery to baseline is a reasonable recovery prediction. Small shallow water fish reach maturity faster and do not live as long and a three-year linear recovery to baseline is projected. Table 18 summarizes predicted future injury, which is estimated to be 97,174 fish in riffles, 52,432 fish in runs and 15,240 fish in pools for a total future injury projected at 164,846 fish. Table 19 tracks recovery rates as residual injury as compared to initial 2006 injury.

5.4 Amphibians

Most amphibians do not normally have as much exposed gill tissue as fish, but their skin is sensitive, functions as a respiratory organ, and is not as well protected as the skin of fish, which typically is covered with scales. Caustic injury to aquatic amphibians is expected where fish are killed.

Discovery of four dead adult hellbenders in the Driftwood Branch of Sinnemahoning Creek was an extraordinary finding and death was attributed to sodium hydroxide exposure. Decomposition was occurring and was similar to decomposition of the numerous dead fish near DB06 and DB07. A total of 36 hellbenders (Table 16) were estimated to be killed immediately after the pollution event in 2006 over 19.64 miles of the Driftwood Branch

The life span of a hellbender is not well known. Consultation with herpetologists Christopher Urban, PFBC, and Peter Petokas, Lycoming College, (personal communication) yielded a range of 25 to 50 years. Longevity of this species will produce slow recovery to baseline, which was estimated at 25 years using the low end of the life span range that was communicated. Future injury is estimated at 429 hellbenders missing from the population over the 25-year recovery and is shown in Table 16.

5.5 Recreational fishing use loss

5.5.a. Sinnemahoning Portage Creek

5.5.a.1 2006 injury

Greene et al. (2006) estimated angling use for wild trout across Pennsylvania in an extensive statewide creel survey effort. Larger streams sustained greater angling effort. Authors found that streams greater than or equal to six meters wide received 84 trips per linear mile. Smaller streams were utilized at a rate of 15 trips per mile. The survey was conducted through Labor Day weekend and 20% of use was found to occur after June 30. Table 19 applies the lower angler use rates to Section 1 of Sinnemahoning Portage Creek (average width 3.3 meters) and the higher use rate to Sections 2 and 3. Injury to recreational fishing for wild trout for 2006 after June 30 was estimated to be 160 lost trips.

5.5.a.2 Future injury

Trout stocking is planned to occur in 2007 and beyond, so no lost angling trips for stocked trout are expected. Lost trips for stocked trout could occur, however, due to negative publicity surrounding the train derailment and fish kill. Restoration actions should clearly report what is

being done and the state of recovery that has been reached to address potential avoidance of this water.

Significant loss of fishing trips for wild trout has occurred and is expected to continue in the future. Although angling for wild trout may lag behind population recovery, the conservative assumption is made that as catchable fish are available, anglers will fish for them. Future angling for wild trout is not projected to occur until 2010, when wild trout entering the population are expected to reach legal size. Loss of fishing trips is therefore expected to be the same in 2007, 2008 and 2009. Following this time, angling is projected to recover at the same rate (Table 19) that the trout population (Table 17 and Figure 4) recovers. Table 18 displays lost future trips while taking into account population recovery and size of available fish. A total of 2,793 future lost trips is expected, making the estimated present and future injury total to be 2,953 lost fishing trips for wild trout.

5.5.b Driftwood Branch Sinnemahoning Creek and Sinnemahoning Creek
5.5.b.1 2006 injury
Fishing trips for trout or warmwater fish were estimated to be zero in the Driftwood Branch of Sinnemahoning Creek in 2006 after June 30. This estimate is consistent with observations of use, public reaction to the pollution event and Bald Eagle Creek survey (PFBC – unpublished data), which did not monitor fishing use past the month of August. No future trout stocking events have been cancelled, so as stated previously, no future estimate of lost recreational use for stocked trout is included in this report.

The Driftwood Branch of Sinnemahoning Creek contains 37.26 hectares of Riffles, 32.07 hectares of runs and 45.78 hectares of pools (or 284.44 *acres* total). Applying the Bald Eagle Creek angler use results of 2 trips for stocked trout per acre in July and August and 19 trips per acre for all other species, the estimate of 4224 lost angler trips in the Driftwood Branch between Sinnemahoning Portage Creek and the Bennetts Branch is produced as the 2006 lost fishing use injury.

5.5.b.2 Future injury
Future injury is based on an initial reduction of smallmouth bass of 86.7 % in the Driftwood Branch. Future injury does not include lost angling for stocked trout since stocking will be resumed by the PFBC in 2007. Additionally, since fishing for bass and panfish usually occurs in runs and pools, Bald Eagle Creek survey information was transferred only to runs and pools for future injury estimation. This reduction in area of 33% was not part of the Bald Eagle Creek survey, but was applied to the Driftwood Branch since run and pool habitat have been observed to support the vast majority of bass and panfish angling.

PFBC has concluded that some smallmouth bass moved downstream into Sinnemahoning Creek, but for this injury component, assumption of their return is unlikely given the degraded condition of the food base. Additionally, PFBC is not assuming any additional angling use of Sinnemahoning Creek since avoidance rather than attraction is the typical response to a resource suffering an acute pollution event. Methodology used for future angler use injury is very similar to that used for wild trout in Sinnemahoning Portage Creek. Return to angler use baseline, as

predicted by the transferred Bald Eagle Creek survey results, was assumed to first be linked to return of legal-sized individuals to the population beyond the 13.3% of fish remaining after the fish kill. Once these larger fish are available in 2010, angler use tracks the population recovery predicted in Table 18.

Angler use of 88 trips per acre was applied to the 192.37 acres of run and pool habitat to yield expected use of 11,927 trips per year. Injury of 86.7% translates to 10,341 lost trips per year in 2007, 2008 and 2009, when initially, fish are small. Table 20 provides all lost angler use estimates for the Driftwood Branch. Future lost fishing use injury is estimated to be 36,152 trips. Past and future injury totals 40,376 trips.

Section 6. Conclusion

The report is based on recent assessments, relevant historical information and principles that are used by PFBC staff to manage fish, reptiles, amphibians, aquatic life and recreational fishing statewide.

A summary of injury caused by the June 30, 2006 Norfolk Southern train derailment in the village of Gardeau, McKean County, Pennsylvania is provided below and is summarized in more detail in Table 21:

- Aquatic macroinvertebrates
  - Sinnemahoning Portage Creek
    Section 1 sustained a 98% invertebrate kill
    Section 2 sustained a 91% invertebrate kill
    Section 3 sustained a 63% invertebrate kill.
- Fish
  - Sinnemahoning Portage Creek - coldwater fish, projecting injury until 2012
    367,707 fish were estimated to be killed in 2006 in Sinnemahoning Portage Creek
    374,277 fish are estimated to be lost in the future due to lack of breeding adults
  - Driftwood Branch of Sinnemahoning Creek - Warmwater fish, projecting future injury until 2012
    149,334 fish were estimated to be killed in 2006 in the Driftwood Branch
    164,846 fish are estimated as future injury due to severe loss of forage and adults

- Amphibians
  - Driftwood Branch of Sinnemahoning Creek – Hellbenders killed, projecting future injury until 2030
    An estimated 36 hellbenders were killed over 19.64 mi. of the Driftwood Branch
    429 hellbenders will be lost from the population in 25 years of projected recovery
- Lost recreational use
  - Fishing, projecting future injury until 2012
    Trout fishing – a total of 2953 trips for wild trout have been estimated to be lost
    160 lost trips in 2006
    2,793 trips from 2007 until 2012, when the wild trout are projected to return to baseline
    Warmwater species fishing - 40,375 fishing trips total are estimated to be lost
    4,224 lost trips for all kinds of fishing in 2006
    36,152 future lost bass and panfish trips until 2012, when recovery is expected

The above resource categories were evaluated in other locations, but injuries were not estimated where resources were not determined to have measurably fallen below baseline conditions and injury was not apparent.

Section 7. References

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Figure 1. Norfolk Southern Train Derailment Site and Pennsylvania Fish and Boat Commission aquatic biological assessment stations, July 10-24, 2006.

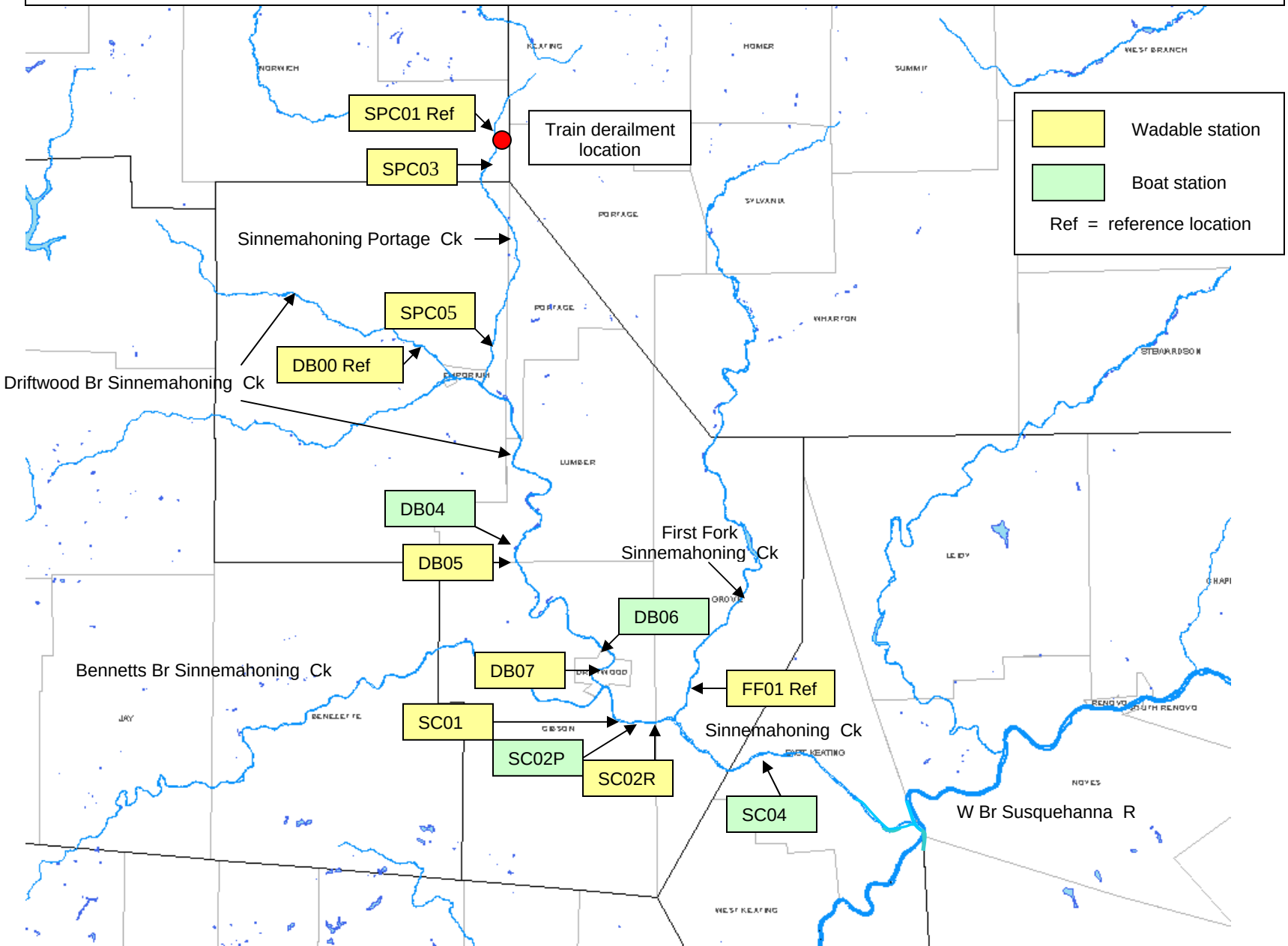

Figure 2. Norfolk Southern train derailment investigation Rapid Bioassessment Protocol Habitat scores, July 2006

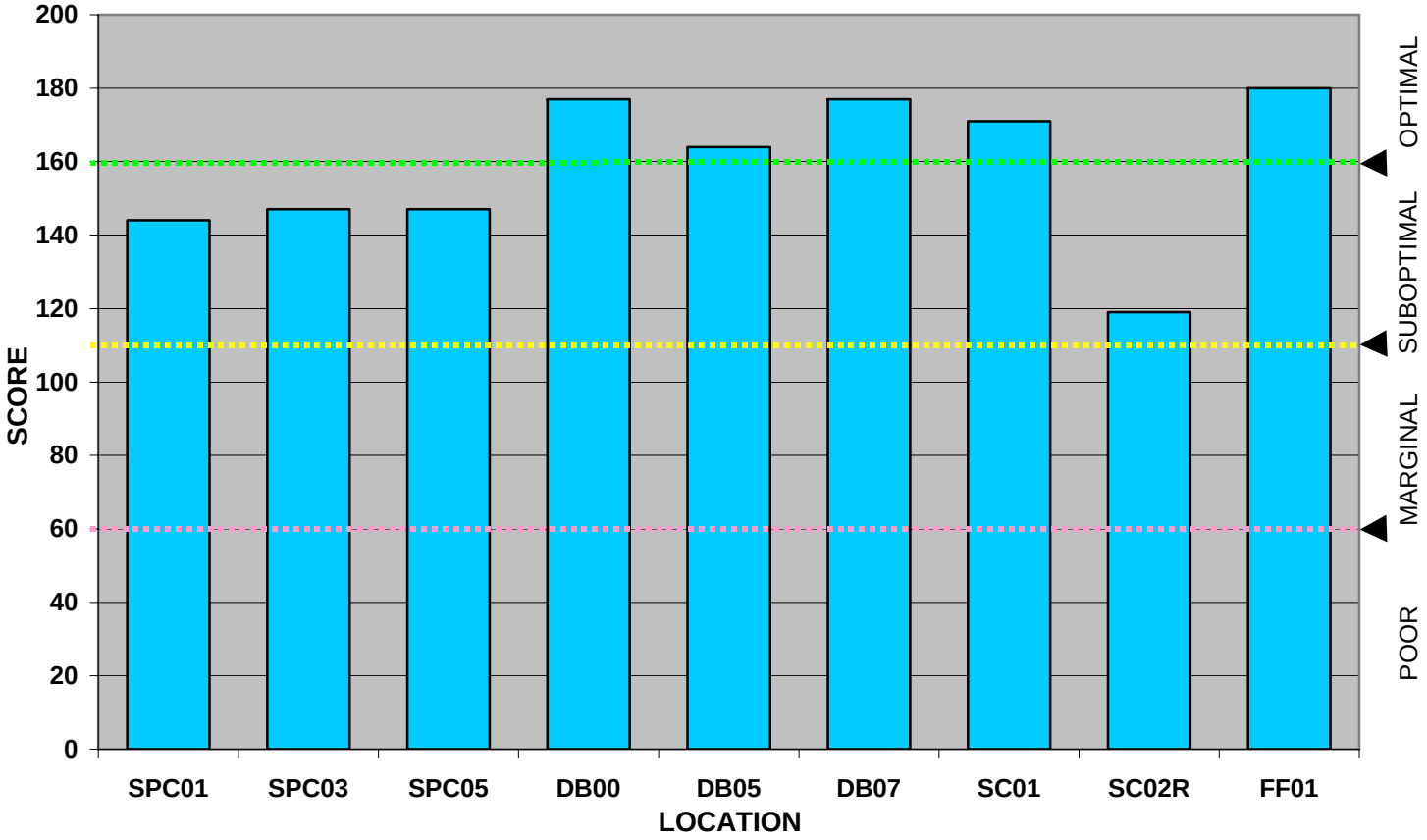

Figure 3. Photograph of dead adult hellbender found in the Driftwood Branch of Sinnemahoning Creek at Station DB07 near the village of Driftwood, July 12, 2006.

Figure 4. Percentage of trout present and missing in affected areas of Sinnemahoning Portage Creek before and after the June 30, 2006 Norfolk Southern train derailment.

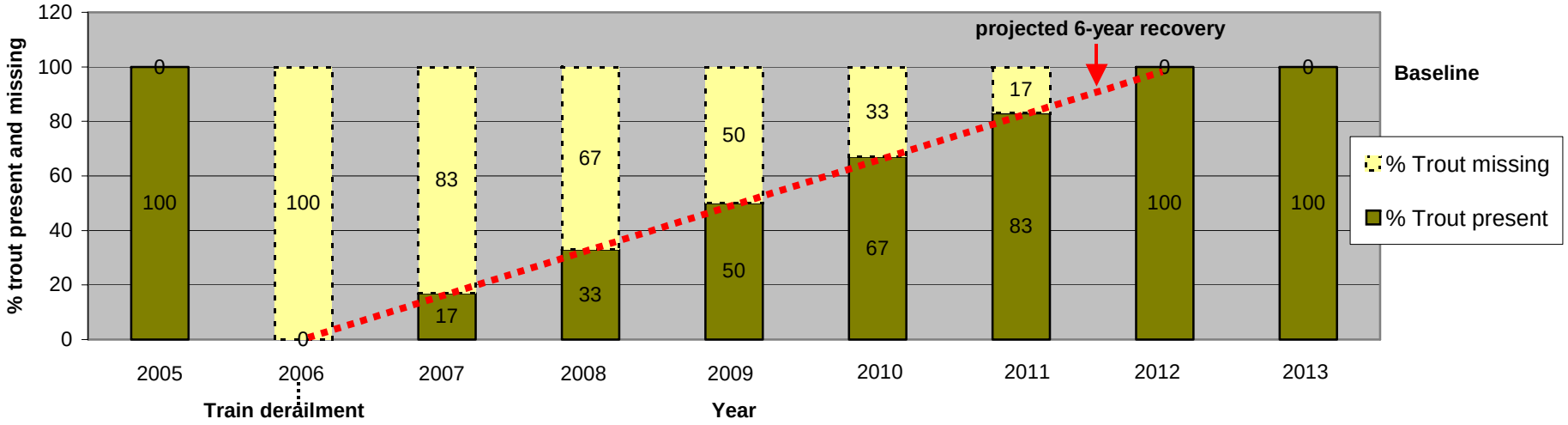

Figure 5. Percentage of nongame fish present and missing in affected areas of Sinnemahoning Portage Creek before and after the June 30, 2006 Norfolk Southern train derailment.

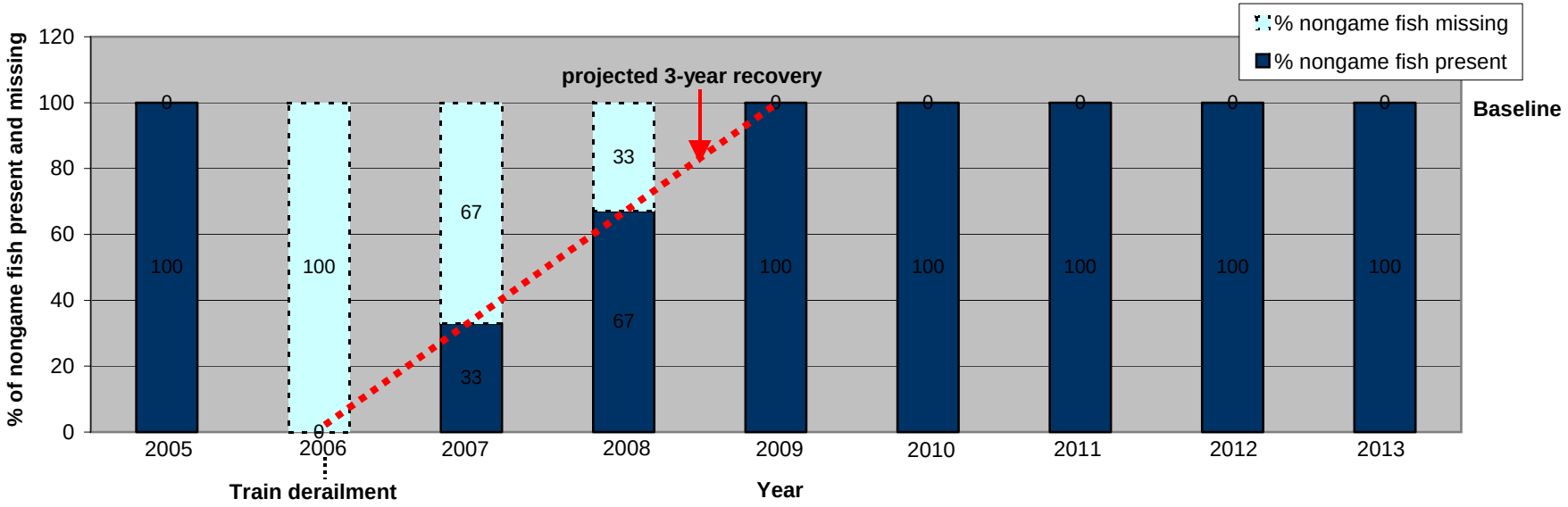

Table 1. Aquatic biological investigation stations associated with the Norfolk Southern train derailment, July 2006.

Stream	Station	Reference	River Mile	Electrofishing method	Downstream limit		Description
					Latitude	Longitude	
Sinnemahoning Portage Creek	SPC01	Yes	10.82	Wade-backpack	41° 38' 44"	78° 12' 53"	Upstr derailment site
	SPC03		10.21	Wade-backpack	41° 38' 14"	78° 12' 48"	Downstr derailment site
	SPC05		1.52	Wade-backpack	41° 31' 42"	78° 12' 54"	Historical station upstr Salt Run
Driftwood Br Sinnemahoning Ck	DB00	Yes	22.06	Wade-backpack	41° 31' 18"	78° 15' 40"	Behind Cameron County Fairgrounds at Emporium
	DB04		10.31	Boat	41° 25' 01"	78° 11' 42"	Pool upstr DB05 and Sterling Run bridge
	DB05		10.07	Wade-backpack	41° 24' 49"	78° 11' 49"	35 m upstr Sterling Run br to 100 m upstr
	DB06		2.72	Boat	41° 21' 37"	78° 08' 12"	Johnson Run to RR bridge at upstr limit of Driftwood
	DB07		0.84	Wade-backpack	41° 20' 43"	78° 08' 27"	200 m downstr DB06RR br extending 107 m upstr
Sinnemahoning Creek	SC01		12.9	Wade-backpack	41° 18' 59"	78° 05' 53"	Mouth of Grove Run extending 161m upstr
	SC02P		12.59	Boat	41° 19' 05"	78° 05' 21"	Pool and assocated run at RR br upstr Sinnemahoning
	SC02R		12.33	Wade-backpack	41° 19' 08"	78° 05' 04"	South side split riffle just upstr SR2001 "Wykoff" Bridge
	SC04		5.5	Boat	41° 17' 57"	77° 59' 01"	Mouth Montour Run to mouth Commissioner Run
First Fork Sinnemahoning Ck	FF01	Yes	0.9	Wade-backpack	41° 19' 43"	78° 04' 19"	Historical IBI station 3.7 mi upstr mouth

Table 2. Norfolk Southern train derailment investigation Rapid Bioassessment Protocol habitat scores, July 2006.

		Location								
		Sinnemahoning Portage Creek			Driftwood Branch Sinnemahoning Creek			Sinnemahoning Creek		First Fk Sinn
	Habitat Parameter	SPC01	SPC03	SPC05	DB00	DB05	DB07	SC01	SC02R	FF01
1	Epifaunal Substrate/Available Cover	15	13	13	18	15	18	16	13	16
2	Embeddedness	17	18	18	17	16	18	16	18	18
3	Velocity/Depth Regime	16	17	17	15	14	16	14	8	14
4	Sediment Deposition	15	17	17	19	17	19	15	10	19
5	Channel Flow Status	14	16	16	19	20	20	18	12	18
6	Channel Alteration	15	14	14	19	15	15	18	8	19
7	Frequency of Riffles (or bends)	16	14	14	19	18	18	18	16	19
8	Bank Stability left bank	5	8	8	7	10	10	9	9	9
	right bank	5	5	5	8	10	10	10	9	10
9	Vegetative Protection left bank	8	8	8	8	8	9	8	4	9
	right bank	6	5	5	9	9	10	10	6	10
10	Riparian Veg. Zone Width left bank	5	9	9	9	7	8	9	2	9
	right bank	7	3	3	10	5	6	10	4	10
Total score		**144**	**147**	**147**	**177**	**164**	**177**	**171**	**119**	**180**

Table 3. Riffle, run and pool habitat areas determined by GIS analysis on the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek between the mouth of Sinnemahoning Portage Creek and the mouth of the First Fork of Sinnemahoning Creek.

Stream	Riffle	Run	Pool	Total
Driftwood Branch Sinnemahoning Creek				
Number of habitat units	36	62	61	159
Linear distance in meters	9929	9590	12259	31778
Area in hectares	37.26	32.07	45.78	115.11
% of area	32.4%	27.9%	39.8%	100.0%
Sinnemahoning Creek				
Number of habitat units	12	13	4	29
Linear distance in meters	1876	1873	2080	5829
Area in hectares	11.38	10.9	14.76	37.04
% of area	30.7%	29.4%	39.8%	100.0%

Table 4. Station locations for macroinvertebrate assessments of Sinnemahoning Portage Creek and tributaries following the June 30, 2006 Norfolk Southern train derailment.

Station Name	Location	Latitude*	Longitude*
SPC 01 (Reference)	Sinnemahoning Portage Creek approximately 0.75 miles upstream from Big Fill Hollow confluence	41° 39' 31.9" N	78° 12' 28.0" W
BF 02 (Reference)	Big Fill Hollow approximately 100 meters upstream of spill location	41° 38' 36.7" N	78° 12' 40.2" W
SPC 03	Sinnemahoning Portage Creek approximately 400 meters downstream of Big Fill Hollow confluence	41° 38' 24.5" N	78° 12' 45.0" W
SPC 04	Sinnemahoning Portage Creek approximately 25 meters upstream of the Gardeau Road bridge crossing	41° 37' 14.4" N	78° 13' 26.3" W
PR 05 (Reference)	Parker Run approximately 200 meters upstream of mouth	41° 37' 15.5" N	78° 13' 31.6" W
SPC 06	Sinnemahoning Portage Creek approximately 200 meters upstream from Cowley Run confluence	41° 35' 36.9" N	78° 12' 9.9" W
SPC 07	Sinnemahoning Portage Creek approximately 250 meters upstream from Fourmile Run confluence	41° 33' 9.1" N	78° 12' 20.5" W
SPC 08	Sinnemahoning Portage Creek approximately 0.25 miles upstream from Salt Run confluence	41° 31' 38.5" N	78° 12' 55.9" W
SPC 09	Sinnemahoning Portage Creek approximately 200 meters upstream from confluence of Driftwood Branch Sinnemahoning Creek	41° 30' 22.5" N	78° 13' 19.3" W

Table 5. Metric calculations for macroinvertebrate samples collected in Sinnemahoning Portage Creek and tributaries.

Metric	SPC 01	BF 02	SPC 03	SPC 04	PR 05	SPC 06	SPC 07	SPC 08	SPC 09
Subsample Size	101	97	37	18	103	100	102	97	103
Density (per m²)	2646	588	56	27	1092	227	840	1008	1092
Taxa Richness	19	19	11	5	16	14	10	11	11
Modified EPT Index	9	11	0	2	7	3	3	3	1
Density change from reference	Reference		-98%			-91%	-63%		
PFBC Fisheries Mgt. Section	1		1	1		2	3	3	3

Tables 4 and 5 adapted from Dudzic (2006)

Table 6. Station locations for macroinvertebrate assessments of the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek following the June 30, 2006 Norfolk Southern train derailment.

Station Name	Location	Latitude*	Longitude*
Reference	Driftwood Branch Sinnemahoning Creek about 300m upstream from Emporium STP outfall	41° 30' 25.65" N	78° 13' 42.89" W
STP	Driftwood Branch Sinnemahoning Creek about 50m upstream from Portage Creek confluence and below STP outfall	41° 30' 20.19" N	78° 13' 29.22" W
Portage	Driftwood Br Sinnemahoning Creek about 125m downstream from the confl with Portage Ck	41° 30' 12.08" N	78° 13' 21.27" W
Wayside Memorial	Driftwood Branch Sinnemahoning Creek @ Wayside Memorial near Lumber Twp line	41° 29' 1.3" N	78° 12' 4.7" W
Cameron	Driftwood Branch Sinnemahoning Creek about 200m upstream from railroad bridge in Cameron	41° 267 09.6" N	78° 10' 45.8" W
Stillhouse	Driftwood Branch Sinnemahoning Creek about 300m upstream from confluence with Stillhouse Run	41° 26' 3.58" N	78° 11' 2.41" W
Wash Mason	Driftwood Branch Sinnemahoning Creek about 200m upstream from the confluence with Wash Mason Run	41° 24' 12.7" N	78° 11' 40.6" W
Sterling Run	Driftwood Branch Sinnemahoning Creek about 100m upstream from the bridge at Sterling Run	41° 24' 50.2" N	78° 11' 48.67" W
Johnson Run	Driftwood Br Sinnemahoning Ck about 300m upstr from the confluence with Johnson Run	41° 21' 33.3" N	78° 08' 07.2" W
Keating	Sinnemahoning Creek at Keating -- WQN 418	41° 15' 36" N	77° 54' 50" W
First Fork	First Fork Sinnemahoning Creek at WQN 419	41° 19' 21" N	78° 04' 44" W

* Latitude and longitude for stations sampled were determined in the office with Terrain Navigator or recorded in the field with GPS units.

Table 7. Metric calculations for macroinvertebrate samples collected in Driftwood Branch Sinnemahoning, First Fork Sinnemahoning, and Sinnemahoning Creeks.

Metric	Reference	STP	Portage	Wayside Memorial	Cameron	Stillhouse	Wash Mason	Sterling Run	Johnson Run	Keating	First Fork
Density (per m²)	886	5512	1003	928	911	1583	852	1212	1427	978	1244
Taxa Richness	15	6	16	11	17	17	16	12	21	17	18
HBI	5.43	9.31	5.83	6.23	5.37	7.46	7.32	5.49	4.16	5.14	4.84
% Dominant Family	0.24	0.84	0.48	0.60	0.27	0.55	0.52	0.43	0.23	0.28	0.39
EPT Index	8	2	8	3	8	7	9	8	11	12	12

Tables 6 and 7 adapted from Friday (2006)

Table 8. Catch from three wadable electrofishing stations on Sinnemahoning Portage Creek, July 10, 2006.

	Station					
	SPC01T *		SPC01		SPC03	SPC05
Area in Ha.	0.062	0.062	0.031	0.031	0.04	0.137
Species	Run 1	Run 2	Run 1	Run 2	Run 1	Run 1
Brook trout (*Salvelinus fontinalis*)	62	11	n/a	n/a	0	0
Brown trout (*Salmo Trutta*)	8	1	n/a	n/a	0	0
Blacknose dace (*Rhinichthys atratulus*)	n/a	n/a	314	192	0	0
Longnose dace (*Rhynichthys cataractaes*)	n/a	n/a	25	27	0	0
Creek chub (*Semotilus atromaculatus*)	n/a	n/a	2	0	0	0
Fallfish (*Semotilus corporalis*)	n/a	n/a	0	1	0	0
Cutlips minnow (*Exoglossum maxillingua*)	n/a	n/a	2	0	0	0
Fantail darter (*Etheostoma flabellare*)	n/a	n/a	1	0	0	0
Sculpin (*Cottus* sp.)	n/a	n/a	14	10	0	0
Total	**70**	**12**	**358**	**230**	**0**	**0**

* 200m reach trout only

Table 9. Fish population estimates per hectare for Sinnemahoning Portage Creek stations, July 10, 2006

	Station			
	SPC01 (Reference)		SPC03	SPC05
Species		95% C.I.	0	0
Brook trout (*Salvelinus fontinalis*)	1194	1177-1258	0	0
Brown trout (*Salmo Trutta*)	145	145-161	0	0
Blacknose dace (*Rhinichthys atratulus*)	25774	20226-31323	0	0
Longnose dace (*Rhynichthys cataractaes*)	3355	*	0	0
Creek chub (*Semotilus atromaculatus*)	65		0	0
Fallfish (*Semotilus corporalis*)	32		0	0
Cutlips minnow (*Exoglossum maxillingua*)	65		0	0
Fantail darter (*Etheostoma flabellare*)	32		0	0
Sculpin (*Cottus* sp.)	1194	774 - 2387	0	0
Total	**31855**		**0**	**0**

* Estimate terminated at 2X total catch for area sampled

Table 10. Catch from one electrofishing run on six wadable stations on the First Fork of Sinnemahoning Creek Driftwood Branch of Sinnemahoning Creek, and Sinnemahoning Creek, July 11-12, 2006.

	Station					
	FF01 Ref.	DB00 Ref.	DB05	DB07	SC01	SC02R
Species Area in Ha.	0.415	0.385	0.482	0.49	1.01	0.696
Brown trout (*Salmo trutta*)	0	7	0	0	0	0
Smallmouth bass (*Micropterus dolomieu*)	35	2	0	3	20	12
Rock bass (*Ambloplites rupestris*)	0	0	0	1	1	0
Chain pickerel (*Esox niger*)	1	0	0	0	0	0
Bluegill (*Lepomis macrochirus*)	0	0	0	3	0	0
Pumkinseed (*Lepomis gibbosus*)	0	0	0	1	0	0
White sucker (*Catostomus commersoni*)	1	83	0	0	0	1
Northern hogsucker (*Hypentelium nigricans*)	2	21	0	0	4	19
Blacknose dace (*Rhinichthys atratulus*)	1	180	3	0	1	2
Longnose dace (*Rhynichthys cataractaes*)	14	39	13	0	16	13
River chub (*Nocomis micropogon)*	241	244	4	11	138	71
Creek chub (*Semotilus atromaculatus*)	0	26	3	0	1	0
Fallfish (*Semotilus corporalis*)	1	0	0	0	0	0
Roseyface shinner (*Notropis rubellus*)	5	4	0	0	15	5
Common shiner (*Luxilus cornutus*)	6	100	0	0	2	0
Cutlips minnow (*Exoglossum maxillingua*)	52	79	0	0	14	7
Bluntnose minnow (*Pimephales notatus)*	0	41	0	0	3	41
Central stoneroller (*Campostoma anomalum*)	90	152	30	7	403	235
Fantail darter (*Etheostoma flabellare*)	152	71	0	0	20	17
Greenside darter (*Etheostoma blennioides*)	39	4	0	0	6	18
Tesselated darter (*Etheostoma olmstedi*)	5	5	0	0	0	0
Shield darter (*Percina peltata*)	0	0	0	0	0	0
Brown bullhead (*Ameiurus nebulosus*)	0	0	1	0	0	0
Margined madtom (*Noturus insignis*)	253	47	5	0	41	55
Sculpin (*Cottus* sp.)	0	137	0	0	0	1
Total	**898**	**1242**	**59**	**26**	**685**	**497**

Table 11. Fish population abundance per hectare of riffle based on one electrofishing run for the First Fork of Sinnemahoning Creek, Driftwood Branch of Sinnemahoning Creek, and Sinnemahoning Creek, July 11-12, 2006.

	Station					
Species	**FF01 Ref.**	**DB00 Ref.**	**DB05**	**DB07**	**SC01**	**SC02R**
Brown trout (*Salmo trutta*)	0	18	0	0	0	0
Smallmouth bass (*Micropterus dolomieu*)	84	5	0	6	20	17
Rock bass (*Ambloplites rupestris*)	0	0	0	2	1	0
Chain pickerel (*Esox niger*)	2	0	0	0	0	0
Bluegill (*Lepomis macrochirus*)	0	0	0	6	0	0
Pumkinseed (*Lepomis gibbosus*)	0	0	0	2	0	0
	0	0	0	0	0	0
White sucker (*Catostomus commersoni*)	2	216	0	0	0	1
Northern hogsucker (*Hypentelium nigricans*)	5	55	0	0	4	27
	0	0	0	0	0	0
Blacknose dace (*Rhinichthys atratulus*)	2	468	6	0	1	3
Longnose dace (*Rhynichthys cataractaes*)	34	101	27	0	16	19
River chub (*Nocomis micropogon)*	581	634	8	22	137	102
Creek chub (*Semotilus atromaculatus*)	0	68	6	0	1	0
Fallfish (*Semotilus corporalis*)	2	0	0	0	0	0
Roseyface shinner (*Notropis rubellus*)	12	10	0	0	15	7
Common shiner (*Luxilus cornutus*)	14	260	0	0	2	0
Cutlips minnow (*Exoglossum maxillingua*)	125	205	0	0	14	10
Bluntnose minnow (*Pimephales notatus)*	0	106	0	0	3	59
Central stoneroller (*Campostoma anomalum*)	217	395	62	14	399	338
Fantail darter (*Etheostoma flabellare*)	366	184	0	0	20	24
Greenside darter (*Etheostoma blennioides*)	94	10	0	0	6	26
Tesselated darter (*Etheostoma olmstedi*)	12	13	0	0	0	0
Shield darter (*Percina peltata*)	0	0	0	0	0	0
Brown bullhead (*Ameiurus nebulosus*)	0	0	2	0	0	0
Margined madtom (*Noturus insignis*)	610	122	10	0	41	79
Sculpin (*Cottus* sp.)	0	356	0	0	0	1
Total	**2162**	**3226**	**122**	**53**	**678**	**714**

Table 12. Daytime boat electrofishing effort and catch for four stations in the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, July 11-24, 2006.

	Station			
	DB04	DB06	SC02P	SC04
Species Time in sec	1442	2799	1692	2798
Brook trout (Salvelinus fontinalis)	0	0	0	0
Brown trout (Salmo trutta)	0	0	0	0
Rainbow trout (Oncorhynchus mykiss)	0	1	1	0
Smallmouth bass (Micropterus dolomieu)	4	23	47	87
Rock bass (Ambloplites rupestris)	0	0	9	9
Pumpkinseed (Lepomis gibbosus)	0	0	0	0
Bluegill (Lepomis macrochirus)	0	0	0	0
White sucker (Catostomus commersoni)	4	0	0	4
Northern hogsucker (Hypentelium nigricans)	0	2	0	1
Blacknose dace (Rhinichthys atratulus)	0	0	0	0
Longnose dace (Rhynichthys cataractae)	0	0	0	0
River chub (Nocomis micropogon)	1	0	9	3
Creek chub (Semotilus atromaculatus)	0	0	0	0
Fallfish (Semotilus corporalis)	2	0	5	0
Roseyface shiner (Notropis rubellus)	0	0	0	0
Common shiner (Luxilus corntus)	0	0	1	0
Cutlips minnow (Exoglossum maxillingua)	0	0	0	0
Bluntnose minnow (Pimephales notatus)	1	0	3	0
Central stoneroller (Campostoma anomalum)	0	1	7	0
Fantail darter (Etheostoma flabellare)	1	0	0	1
Greenside darter (Etheostoma blennioides)	0	0	0	0
Tesselated darter (Etheostoma olmstedi)	0	0	0	0
Shield darter (Percina peltata)	0	0	0	0
Brown bullhead (Ameiurus nebulosus)	0	0	0	0
Margined madtom (Noturus insignis)	0	1	0	1
Sculpin spp. (Cottus sp.)	0	0	0	0
Total	**13**	**28**	**82**	**106**

Table 13. Daytime boat electrofishing catch per hour for four stations on the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, July 11-24, 2006, and in historical samples from 1998 and 2003.

	2006	2006	2006	2006	1998	2003	2003	2003
Species	**DB04**	**DB06**	**SC02P**	**SC04**	**DB04**	**DB06**	**SC02P**	**SC04**
Brook trout (*Salvelinus fontinalis*)	0	0	0	0	0	1		X
Brown trout *(Salmo trutta)*	0	0	0	0	3	1		
Rainbow trout (*Oncorhynchus mykiss*)	0	1	2	0	0	1		
Smallmouth bass (*Micropterus dolomieu*)	10	30	100	112	65	116	18	68
Rock bass (*Ambloplites rupestris*)	0	0	19	12	0	23	22	30
Pumpkinseed (*Lepomis gibbosus*)	0	0	0	0	0			
Bluegill (*Lepomis macrochirus*)	0	0	0	0	0			
Black crappie *(Pomoxis nigromaculatus)*								X
White sucker (*Catostomus commersoni*)	10	0	0	5	12	X		
Northern hogsucker (*Hypentelium nigricans*)	0	3	0	1	33	X	X	X
Common carp *(Cyprinus carpio)*								X
Blacknose dace *(Rhinichthys atratulus)*	0	0	0	0	0			
Longnose dace *(Rhynichthys cataractae)*	0	0	0	0	0	X		
River chub *(Nocomis micropogon)*	2	0	19	4	68	X	X	
Creek chub *(Semotilus atromaculatus)*	0	0	0	0	0			
Fallfish *(Semotilus corporalis)*	5	0	11	0	0	X		
Roseyface shiner *(Notropis rubellus)*	0	0	0	0	0	X	X	X
Common shiner *(Luxilus corntus)*	0	0	2	0	0		X	X
Cutlips minnow *(Exoglossum maxillingua)*	0	0	0	0	3	X	X	
Bluntnose minnow *(Pimephales notatus)*	2	0	6	0	0			X
Central stoneroller *(Campostoma anomalum)*	0	1	15	0	0	X	X	X
Fantail darter *(Etheostoma flabellare)*	2	0	0	1	0	X		
Greenside darter *(Etheostoma blennioides)*	0	0	0	0	0			
Tesselated darter *(Etheostoma olmstedi)*	0	0	0	0	0			
Shield darter *(Percina peltata)*	0	0	0	0	0			
Brown bullhead *(Ameiurus nebulosus)*	0	0	0	0	0			
Margined madtom *(Noturus insignis)*	0	1	0	1	0	X		
Sculpin spp. *(Cottus* sp.*)*	0	0	0	0	0			
Total	**31**	**36**	**174**	**136**	**184**	**143**	**40**	**97**

X = Present, but not enumerated

1998 and 2003 data source - PFBC unpublished data

Table 14. Adjustment of historical smallmouth bass catch, based on 164.7% increase between historical and 2006 samples at SC04 and PFBC (2006c) reference.

	2006	2006	2006	2006	1998	2003	2003	2003
Species	**DB04**	**DB06**	**SC02P**	**SC04**	**DB04**	**DB06**	**SC02P**	**SC04**
Brook trout (*Salvelinus fontinalis*)	0	0	0	0	0	1		X
Brown trout *(Salmo trutta)*	0	0	0	0	3	1		
Rainbow trout (*Oncorhynchus mykiss*)	0	1	2	0	0	1		
Smallmouth bass (*Micropterus dolomieu*)	10	30	100	112	107	191	30	112
Rock bass (*Ambloplites rupestris*)	0	0	19	12	0	23	22	30
Pumpkinseed (*Lepomis gibbosus*)	0	0	0	0	0			
Bluegill (*Lepomis macrochirus*)	0	0	0	0	0			
Black crappie *(Pomoxis nigromaculatus)*								X
White sucker (*Catostomus commersoni*)	10	0	0	5	12	X		
Northern hogsucker (*Hypentelium nigricans*)	0	3	0	1	33	X	X	X
Common carp *(Cyprinus carpio)*								X
Blacknose dace *(Rhinichthys atratulus)*	0	0	0	0	0			
Longnose dace *(Rhynichthys cataractae)*	0	0	0	0	0	X		
River chub *(Nocomis micropogon)*	2	0	19	4	68	X	X	
Creek chub *(Semotilus atromaculatus)*	0	0	0	0	0			
Fallfish *(Semotilus corporalis)*	5	0	11	0	0	X		
Roseyface shiner *(Notropis rubellus)*	0	0	0	0	0	X	X	X
Common shiner *(Luxilus corntus)*	0	0	2	0	0		X	X
Cutlips minnow *(Exoglossum maxillingua)*	0	0	0	0	3	X	X	
Bluntnose minnow *(Pimephales notatus)*	2	0	6	0	0			X
Central stoneroller *(Campostoma anomalum)*	0	1	15	0	0	X	X	X
Fantail darter *(Etheostoma flabellare)*	2	0	0	1	0	X		
Greenside darter *(Etheostoma blennioides)*	0	0	0	0	0			
Tesselated darter *(Etheostoma olmstedi)*	0	0	0	0	0			
Shield darter *(Percina peltata)*	0	0	0	0	0			
Brown bullhead *(Ameiurus nebulosus)*	0	0	0	0	0			
Margined madtom *(Noturus insignis)*	0	1	0	1	0	X		
Sculpin spp. *(Cottus* sp.*)*	0	0	0	0	0			
Total	**31**	**36**	**174**	**136**	**184**	**217**	**52**	**142**

X = Present, but not enumerated

1998 and 2003 data source - PFBC unpublished data

Table 15. Estimated daytime boat electrofishing catch per hectare for four stations on the Driftwood Branch of Sinnemahoning Creek and Sinnemahoning Creek, July 11-24, 2006, June 1989 and July 2003.

	2006	2006	2006	2006	1998	2003	2003	2003
Species	**DB04**	**DB06**	**SC02P**	**SC04**	**DB04**	**DB06**	**SC02P**	**SC04**
Brook trout (*Salvelinus fontinalis*)	0	0	0	0	0	1		X
Brown trout *(Salmo trutta)*	0	0	0	0	2	1		X
Rainbow trout (*Oncorhynchus mykiss*)	0	1	1	0	0	1		
Smallmouth bass (*Micropterus dolomieu*)	7	19	66	74	70	126	20	74
Rock bass (*Ambloplites rupestris*)	0	0	13	8	0	15	15	20
Pumpkinseed (*Lepomis gibbosus*)	0	0	0	0	0	0		
Bluegill (*Lepomis macrochirus*)	0	0	0	0	0	0		
Black crappie *(Pomoxis nigromaculatus)*								X
White sucker (*Catostomus commersoni*)	7	0	0	3	8	X		
Northern hogsucker (*Hypentelium nigricans*)	0	2	0	1	22	X	X	X
Common carp *(Cyprinus carpio)*								X
Blacknose dace *(Rhinichthys atratulus)*	0	0	0	0	0	0		
Longnose dace *(Rhynichthys cataractae)*	0	0	0	0	0	X		
River chub *(Nocomis micropogon)*	2	0	13	3	45	X	X	
Creek chub *(Semotilus atromaculatus)*	0	0	0	0	0	0		
Fallfish *(Semotilus corporalis)*	3	0	7	0	0	X		
Roseyface shiner *(Notropis rubellus)*	0	0	0	0	0	X	X	X
Common shiner *(Luxilus corntus)*	0	0	1	0	0	0	X	X
Cutlips minnow *(Exoglossum maxillingua)*	0	0	0	0	2	X	X	
Bluntnose minnow *(Pimephales notatus)*	2	0	4	0	0	0		X
Central stoneroller *(Campostoma anomalum)*	0	1	10	0	0	X	X	X
Fantail darter *(Etheostoma flabellare)*	2	0	0	1	0	X		
Greenside darter *(Etheostoma blennioides)*	0	0	0	0	0	0		
Tesselated darter *(Etheostoma olmstedi)*	0	0	0	0	0	0		
Shield darter *(Percina peltata)*	0	0	0	0	0	0		
Brown bullhead *(Ameiurus nebulosus)*	0	0	0	0	0	0		
Margined madtom *(Noturus insignis)*	0	1	0	1	0	X		
Sculpin spp. *(Cottus* sp.*)*	0	0	0	0	0	0		
Total	**23**	**24**	**115**	**91**	**149**	**144**	**35**	**94**

Table 16. Present and future injury to hellbenders in the Driftwood Branch of Sinnemahoning Creek projected over 25 years.

Year	2006	2007	2008	2009	2101	2011	2012	2013	2014	2015	2016	2017	2018	2019
Damage	100%	96%	92%	88%	84%	80%	76%	72%	68%	64%	60%	56%	52%	48%
	36	35	33	32	30	29	27	26	24	23	22	20	19	17

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Future Total	Grand Total
Damage	44%	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	0%		
	16	14	13	12	10	9	7	6	4	3	1	0	429	465

Table 17. Estimated current and future injury to trout and nongame fish in Sinnemahoning Portage Creek due to a total kill of fish associated with the Norfolk Southern train derailment and sodium hydroxide release.

Type & Recovery	Year	Current damage 2006		FUTURE DAMAGE 2007		2008		2009		2010		2011		2012		Future Total
		% Damage	Missing Fish	*% Damage*	Missing Fish	*% Damage*	Missing Fish	*% Damage*	Missing Fish	*% Damage*	Missing Fish	*% Damage*	Missing Fish	*% Damage*	Missing Fish	Missing Fish
Trout 6 yr. recovery	Section 1	*100*	1312	*83*	1089	*67*	879	*50*	656	*33*	433	*17*	223	*0*	0	3280
	Section 2	*100*	1182	*83*	981	*67*	792	*50*	591	*33*	390	*17*	201	*0*	0	2955
	Section 3	*100*	1886	*83*	1565	*67*	1264	*50*	943	*33*	622	*17*	321	*0*	0	4715
	Subtotal		**4380**		**3635**		**2935**		**2190**		**1445**		**745**		**0**	**10950**
Other Species 3 yr. recovery	Section 1	*100*	29906	*67*	20037	*33*	9869	*0*	0	*0*	0	*0*	0	*0*	0	29906
	Section 2	*100*	92463	*67*	61950	*33*	30513	*0*	0	*0*	0	*0*	0	*0*	0	92463
	Section 3	*100*	240958	*67*	161442	*33*	79516	*0*	0	*0*	0	*0*	0	*0*	0	240958
	Subtotal		**363327**		**243429**		**119898**		**0**		**0**		**0**		**0**	**363327**
			367707													**374277**

Table 18. Current and future injury of small shallow habitat fish and larger deep habitat fish in the Driftwood Branch of Sinnemahoning Creek associated with the Norfolk Southern train derailment and sodium hydroxide release.

Type & Recovery	Year		Current damage		FUTURE DAMAGE												Future Total
			2006		2007		2008		2009		2010		2011		2012		
		Hectares affected	*# fish lost/ha*	Missing Fish	*Residual Damage*	Missing Fish	*Residual Damage*	Missing Fish	*Residual Damage*	Missing Fish	*Residual Damage*	Missing Fish	*Residual Damage*	Missing Fish	*Residual Damage*	Missing Fish	Missing Fish
Small shallow habitat fish 3 yr. recovery	Riffles	*37.26*	*2608*	97174	*67%*	65107	*33%*	32067	*0*	0	*0*	0	*0*	0	*0*	0	97174
	Runs	*32.07*	*1304*	41819	*67%*	28019	*33%*	13800	*0*	0	*0*	0	*0*	0	*0*	0	41819
	Pools	*45.78*	*0*	0	*67%*	0	*33%*	0	*0*	0	*0*	0	*0*	0	*0*	0	0
	Subtotal			**138993**		**93126**		**45868**		**0**		**0**		**0**		**0**	**138993**
Large deep habitat fish 6 yr. recovery	Riffles	*37.26*		0	*83%*	0	*67%*	0	*50%*	0	*33%*	0	*17%*	0	*0*	0	0
	Runs	*32.07*		4245	*83%*	3523	*67%*	2844	*50%*	2123	*33%*	1401	*17%*	722	*0*	0	10613
	Pools	*45.78*		6096	*83%*	5060	*67%*	4084	*50%*	3048	*33%*	2012	*17%*	1036	*0*	0	15240
	Subtotal			**10341**		**8583**		**6928**		**5171**		**3413**		**1758**		**0**	**25853**
				149334													**164846**

Table 19. Estimated lost recreational fishing use for wild trout for Sinnemahoning Portage Creek resulting from the June 30, 2006 Norfolk Southern train derailment.

Section 1 Average width = 3.3 m 15 trips/mi (Greene et al. 2006)

Year	% trips lost	trips/mile	mi. affected	# trips lost
2006[a]	20.0%	15	1.85	6
2007	100.0%	15	1.85	28
2008	100.0%	15	1.85	28
2009	100.0%	15	1.85	28
2010	33.0%	15	1.85	9
2011	17.0%	15	1.85	5
2012	0.0%	15	1.85	0
Total				**104**

Section 2 Average width = 6.85 m 84 trips/mi (Greene et al. 2006)

Year	% trips lost	trips/mile	mi. affected	# trips lost
2006[a]	20.0%	84	2.75	46
2007	100.0%	84	2.75	231
2008	100.0%	84	2.75	231
2009	100.0%	84	2.75	231
2010	33.0%	84	2.75	76
2011	17.0%	84	2.75	39
2012	0.0%	84	2.75	0
Total				**854**

Section 3 Average width = 13.83 m 84 trips/mi (Greene et al. 2006)

Year	% trips lost	trips/mile	mi. affected	# trips lost
2006[a]	20.0%	84	6.42	108
2007	100.0%	84	6.42	539
2008	100.0%	84	6.42	539
2009	100.0%	84	6.42	539
2010	33.0%	84	6.42	178
2011	17.0%	84	6.42	92
2012	0.0%	84	6.42	0
Total				**1995**

Sinnemahoning Portage Creek total estimated lost fishing trips

Year	% trips lost	trips/mile	mi. affected	# trips lost
2006[a]	20.0%	15 - 84	11.02	160
2007	100.0%	15 - 84	11.02	798
2008	100.0%	15 - 84	11.02	798
2009	100.0%	15 - 84	11.02	798
2010	33.0%	15 - 84	11.02	263
2011	17.0%	15 - 84	11.02	136
2012	0.0%	15 - 84	11.02	0
Future total				2793
Total				**2953**

[a] Reflects 20% angler trips taken from July 1 - Sept. 3 (Greene et al. 2006)

Table 20. Estimated past and future lost recreational fishing use injury on the Driftwood Branch of Sinnemahoning Creek associated with the June 30, 2006 Norfolk Southern train derailment.

Year	Jul-Aug 2006	2007	2008	2009	2010	2011	2012	Future Total	Grand Total
expected trips	4224	11927	11927	11927	11927	11927	11927	71562	147348
lost use	100%	86.7%	86.7%	86.7%	29%	14%	0%		
damage in trips	**4224**	**10341**	**10341**	**10341**	**3459**	**1670**	**0**	**36152**	**40376**

Table 21. Pennsylvania Fish and Boat Commission summary of injuries resulting from the June 30, 2006 Norfolk Southern train derailment.

Stream	Injury Type	2006	Future Injury 2007	2008	2009	2010	2011	2012	Future Total	All years
Sinnemahoning Portage Creek										
	Aquatic macroinvertebrates									0-98% inverts killed or missing
	inverts. killed or missing	63-98%	32-49%	0	0	0	0	0	0	2 year recovery
	Fish									
	missing trout	4,380	3,635	2,935	2,190	1,445	745	0	10,950	15,330 trout
	missing nongame fish	363,327	243,429	119,898	0	0	0	0	363,327	726,654 nongame fish
	Subtotal	*367,707*	*247,064*	*122,833*	*2,190*	*1,445*	*745*	*0*	*374,277*	*741,984* fish - all species
	Lost fishing use									
	lost trips	160	798	798	798	263	136	0	2,793	2,953 fishing trips
Driftwood Branch Sinnemahoning Ck										
	Fish									
	Riffles - fish missing	97,174	65,107	32,067					97,174	194,348 riffle fish, all species
	Runs - fish missing	46,064	31,542	16,644	2,123	1,401	722	0	52,432	98,496 run fish, all species
	Pools - fish missing	6,096	5,060	4,084	3,048	2,012	1,036	0	15,240	21,336 pool fish, all species
	Subtotal	*149,334*	*101,709*	*52,795*	*5,171*	*3,413*	*1,758*	*0*	*164,846*	*314,180* all habitats, all species
	Lost fishing use	4,224	10,341	10,341	10,341	3,459	1,670	0	36,152	40,376 fishing trips
	Amphibians									
	hellbenders killed	36	future damage with projected 25 year recovery = 429 hellbenders							465 hellbenders

All streams	**GRAND TOTALS**	**2006**	**Future**		**All years**
	Aquatic macroinvertebrates	0-98%	aquatic invertebrates killed	0-49% aquatic invertebrates missing	0-98% inverts killed or missing Sinn. Portage Creek only
	Fish	517,041	fish - various species and sizes	539,123 fish - various species and sizes	1,056,164 missing fish
	Lost fishing use	4,384	fishing trips lost	38,945 fishing trips lost	43,329 fishing trips lost
	Amphibians	36	hellbenders killed	429 hellbenders missing	465 hellbenders killed or missing