LITTLE LEHIGH CREEK

STREAM RESTORATION PROJECT

1999

By: Wildlands Conservancy

Funding Provided By:
PA Department of Environmental Protection
Watershed Restoration and Assistance Program

Little Lehigh Creek Stream Restoration Project, 1999
List of Project Participants

Wildlands Conservancy would like to thank the following individuals and organizations. Their assistance and dedication have made this project possible:

Pennsylvania Department of Environmental Protection, Watershed Restoration and Assistance Program

Dr. Brendan O'Brien (landowner)

PA Fish & Boat Commission, Habitat Management Section – (plan development, permitting, technical guidance, and on-site assistance during construction)

Lance Leonhardt – (pre-project aquatic survey, data analysis)

Hilltop Excavating, Inc.

Kids Peace – (planning and construction)

Valley Youth House – (planning and construction)

Parkland High Grassroots Environmental Club – (planning and construction)

Trout Unlimited – (planning and construction)

First Presbyterian Church – (planning and construction)

Tom Hays – (planning and construction)

Weis Market – ($20 gift certificate for lunches)

Walley's Deli – (sandwiches, chips and soda totaling $53.19)

Cavaluzzo's Pizza Steak & Sub – (8 pizzas totaling $54.91)

Seventh Street Deli – (sandwiches totaling $47.70)

INTRODUCTION

In April 1999, Wildlands Conservancy received a grant through the Pennsylvania Department of Environmental Protection's Watershed Restoration and Assistance Program (WRAP) in the amount of $7,842.00 to implement a stream restoration project on Little Lehigh Creek. The objectives of the project were to address non-point source pollution, provide bank stabilization, improve overall water quality, and restore lost habitat for fish and aquatic macro-invertebrates. These objectives were achieved through the establishment of a riparian buffer and through the construction of in-stream habitat improvement and bank stabilization devices.

Little Lehigh Creek, a major tributary of the Lehigh River, has a drainage area of 107.5 square miles. The creek originates in Longswamp Township, Berks County, and flows 24 miles through Lower Macungie Township and the City of Allentown, Lehigh County, where it flows into the Lehigh River. Pennsylvania Department of Environmental Protection's Chapter 93, Water Quality Standards designates Little Lehigh Creek as a high-Quality Cold-Water Fishery. It is listed as a high-priority stream on the Section 303(d) list of impaired streams. The predominant land uses within the watershed are agricultural and residential development followed closely by commercial use and urban development. Siltation is the main cause of impairment induced by these land uses.

The project work site is 800' in length and is located on the property of Dr. Brendan O'Brien in Lower Macungie Township, Lehigh County. The project is located directly upstream of a 2.08 mile stretch designated by Pennsylvania Fish and Boat Commission as "Delayed Harvest Artificial Lures Only". Dr. Brendan O'Brien has signed a landowner agreement, which has allowed Wildlands Conservancy to complete the stream restoration project. He has also agreed to change his lawn maintenance practices to ensure the longevity and success of the devices.

During the riparian buffer phase of the project, a no-mow zone of 540 feet in length and 15 feet to 30 feet in width was created. Within the zone 180 square yards of jute matting, turf grass seed, six pounds of wetland meadow mix with annual ryegrass and 240 native trees, shrubs and herbaceous plants were used to stabilize eroded stream banks and provide immediate habitat benefits to wildlife. During the in-stream habitat restoration phase of the project, five in-stream devices were constructed from logs, oak lumber and stone to stabilize 132 linear feet of stream bank and provide naturalistic habitat for fish and aquatic macro-invertebrates.

This report explains each phase of the stream restoration project in chronological order. These phases consist of pre-project data collection (aquatic survey and habitat assessment), in-stream habitat restoration and riparian buffer establishment. Photographs are presented which illustrate the in-stream habitat restoration and riparian buffer phases of the project. The project budget is also summarized. Pre-project data sheets, standard drawings of in-stream devices and site drawings are included within Appendix A. A press release is also attached.

PRE-PROJECT DATA

Pre-project data consisting of a habitat assessment and aquatic survey were collected to aid in the development of an overall management strategy and to provide a comparison for evaluating the overall success of the stream restoration project. Pre-, during and post-project photographs were also used as a tool to compare pre- and post-project conditions.

Aquatic Survey

On June 16, 1999 Lance Leonhardt, a licensed aquatic biologist completed an aquatic survey of the project site using a 100-1100 V DC backpack electrofishing unit, block nets and dip nets. The aquatic survey was completed on Dr. O'Brien's property, from the iron bridge downstream 150M (450ft.).

Brown trout, rainbow trout and other high water quality dependant species of fish were found in the sample. The number of different species found in the sample was 11. The number of individuals found was 307 and ranged from 45mm to 410mm in length. Average weight of individuals ranged from 1.9g to 212.2g. From the baseline data collected in the sample, percent composition by individuals and percent composition by weight were calculated. Species collected in the sample were classified based upon habitat tolerance, water quality tolerance and feeding guild, respectively (Appendix A). A post-project aquatic survey is scheduled for June 2000 and will be used as a tool for evaluating the overall success of the stream restoration project. It is anticipated that the results of the post-project survey will indicate an increase in the number of high water quality dependant species and an increase in species diversity (number of different species), species richness (number of individuals within each species) and total biomass (weight).

Habitat Assessment

On September 21, 1998 Wildlands Conservancy staff completed a habitat assessment on a 900' section encompassing the project site using a version of US EPA's Rapid Bioassessment Protocols that had been modified by The Pennsylvania Fish and Boat Commission, Habitat Management Section. In the assessment, a series of physical habitat-related parameters were evaluate4d and numerically scored to identify specific habitat-related limiting factors existing within the riparian zone and stream channel to determine which parameters would be addressed through the stream restoration project (Appendix A). Depending upon the final numeric score, the reach would be classified as poor, marginal, sub optimal or optimal in regard to the quality and quantity of desirable fish and aquatic macro-invertebrate habitat. The reach was assessed using a "glide/pool" type assessment form, meaning areas of low gradient and slow (less than I meter/secon) water velocities were most prevalent.

Results of the 1998 habitat assessment yielded a total score of 93/200, placing the reach in the category of "marginal" in regard to fish and aquatic macro-invertebrate habitat. Major limiting factors impacting the reach appeared to be a lack of available cover, lack in pool variability, sediment deposition, lack of stream bank vegetation, bank instability and a lack of an established riparian buffer. These parameters would be addressed through in-stream habitat restoration and riparian buffer establishment.

A post-project habitat assessment is scheduled for September 2000. It is anticipated that the results of the post-project habitat assessment will yield an increase in total score, reflecting an improvement in the quality and quantity of desirable fish and macro-invertebrate habitat.

IN-STREAM HABITAT RESTORATION

The in-stream phase of the restoration project was designed in cooperation between Wildlands Conservancy and The Pennsylvania Fish and Boat Commission Habitat Management Section, and implemented with the cooperation of several other participants (refer to list of participants). This phase of the project addressed sources of non-point source pollution through the construction of several devices placed within the immediate stream channel. These devices were designed from natural materials to achieve bank stabilization, while providing diverse and immediate habitat benefits for fish and aquatic macro-invertebrates. The location, components, function and long term expectations of each device are individually explained. For further illustration of each device, refer to the detailed standard drawings (Appendix A).
The device descriptions are arranged chronologically in order of construction, which commenced at the 243' mark of the Dr. Brendan O'Brien property along the left stream bank (facing downstream). Refer to site drawing (Appendix A).

Stacked Deflector

A stacked deflector (dimensions 11'x 18") consisting of logs, oak lumber and stone was constructed to achieve several objectives. Primarily, the stacked deflector would provide bank stability to 22 linear feet of eroded stream bank containing several large trees. Prior to the project, the root systems of these trees had been exposed to high flows, posing an immediate threat of loss (Figure 2).

The stacked deflector should provide future stability to the stream bank by directing the flow of water away from the banks and toward the center of the stream channel. This redirected flow should result in the scouring of a deeper, well-defined channel of *slightly* increased velocity. As a result, fine sediment should be transported and should settle out along the same stream bank downstream of the device, where vegetative establishment should occur, ultimately narrowing the stream channel and improving fish and aquatic macro-invertebrate habitat.

This device (similar to all other devices within the reach) was constructed low relative to the stream banks to allow the movement of water *over* the device during high

flow episodes, as would a floodplain. The device is designed not to channel the force of high water. With the movement of water over the device during high flow, fine sediment should settle among the stones within the interior of the device where it will ultimately vegetate, become stabilized and camouflage the device. Since oak lumber was used as flooring within the device, it should provide immediate overhead cover for fish, as would an undercut bank. With the placement of this device, reduction of non-point source pollution, stream narrowing and immediate habitat benefits for fish and macro-invertebrates should result (Figure 1).

Figure 1 – A stacked deflector with oak flooring provides overhead cover for fish and narrows the stream channel.

Modified Bank Cribbing

As an alternative to using riprap, which offers little habitat value for fish, logs and oak lumber were utilized in the construction of modified bank cribbing. In simple terms, bank cribbing is a type of device designed to imitate the natural type cover of an undercut bank while creating a stable surface to protect a stream bank from future erosion.

Beginning at the 265' mark, modified bank cribbing was constructed to stabilize a length of severely eroded stream bank while offering overhead cover for fish (Figure 2). This cribbing (approximately 60 feet in length and 5 feet in width) was filled with stone and tapered into the bank with and approximate 3:1 grade (Figure 3). A well-defined channel of *slightly* increased velocity should develop along the face of the cribbing, facilitating the transport of fine sediment off of the more desirable stream bottom substrate (cobble and gravel) improving macro-invertebrate habitat. Similar to the

stacked deflector discussed previously, the modified bank cribbing is expected to vegetate as fine sediment is deposited during high flows among the stones within the device.

Figure 2 – Proposed site of modified bank cribbing. Note the severely eroded stream bank and lack of in-stream habitat.

Figure 3 – Construction of modified bank cribbing with oak flooring and stone.

Figure 4 – Modified bank cribbing with seeded jute matting. Jute matting minimizes future soil erosion and provides moisture retention essential to the development of newly planted seed.

Figure 5 – Modified bank

Figure 6 – Modified bank cribbing with seeded jute matting one month after construction. A stable undercut bank has been established. The grass will provide future stability to the stream banks during high flow.

Upstream Single Logs

Another type of device used to provide naturalistic habitat for fish and aquatic macro-invertebrates is an upstream single log. Tow upstream single logs were placed at the 360' and 372' marks and secured to the stream banks using stone. These logs were situated at an upstream angle (approximately 30 degrees relative to bank) and tilted to allow the tips of the logs to rest on stream bottom. Since water typically falls off of objects at a 90-degree angle, placement of logs in this fashion should direct flow away from the stream bank and toward the center of the stream channel, as would a deflector. By doing this, both logs stabilized approximately 30 linear feet of stream bank. In addition to deflecting water, these devices should offer additional cover by scouring a pool in the vicinity of the log and mimicking natural woody habitat (Figure 7).

Figure 7 – Placement of upstream single logs deflects water from an eroded stream bank and provides naturalistic woody habitat for fish and aquatic macro-invertebrates. A scour pool will develop around the tips of the logs, offering overhead cover for fish.

Multi-Log Deflector

A multi-log deflector, consisting of two logs and stone, was constructed at the 507' mark to address an eroded length of bank in which a large tree was threatened. In the construction of this device, two logs were crossed and pinned to one another using 2' re-bar (reinforcement rod) and secured in the stream banks using stone. The upper most (top) log was angled upstream (similar angle as upstream single logs) and tilted downward from the stream bank to the tip of the log. This device should function similar to an upstream log in directing the flow of water away from the stream bank (and threatened tree) and toward the center of the stream channel. This device stabilized approximately 20 linear feet of stream bank and should also provide fish habitat by imitating natural woody debris (Figure 8).

Figure 8 – Placement of a multi-log deflector directs water away from a severely eroded stream bank and imitates the woody habitat that was previously lacking in this section of the Little Lehigh Creek.

Figure 9– Stone was used to stabilize this eroded area adjacent to the multi-log deflector. The area was contributing silt to the stream and was negatively impacting aquatic habitat.

RIPARIAN BUFFER ESTABLISHMENT

The riparian planting phase of the restoration project was planned by Wildlands Conservancy staff and Eagle Scout Tom Hays, and was implemented with the cooperation of several other participants (refer to list of project participants).
In this phase of the project, non-point sources of pollution were addressed through the establishment of a no-mow zone of approximately 540' in length and varying from 15' to 30' in width. A total of 240 native trees, shrubs and herbaceous plants were planted within this no-mow zone (Figure 10, Appendix A). Six pounds of wetland meadow and turf grass seed were also planted in specific areas of the no-mow zone. The entire seeded area was stabilized using 180 square yards of biodegradable jute matting (woven from coconut fiber) to minimize surface erosion while providing moisture retention for the newly planted seed (Figures 4-7).

The addition of the native vegetation within the no-mow zone should not only stabilize the stream banks, but should provide shade to the reach. This should not only improve fish and aquatic macro-invertebrate habitat within the stream, but should provide habitat for wildlife as well.

Figure 10 – A total of 39 dedicated volunteers assisted in the planting of 240 native trees, shrubs and herbaceous material. Vegetation along stream banks minimizes soil erosion and provides shade to the stream, maintaining the cool stream temperatures essential to fish and aquatic insects. Stream bank vegetation also serves as a buffer, offering habitat for wildlife and protecting the stream from the negative impacts of land uses such as agriculture and development.

CONCLUSION

In April 1999, Wildlands Conservancy received a grant through the Pennsylvania Department of Environmental Protection's Watershed Restoration and Assistance Program (WRAP) to implement a stream restoration project. The project site was an 800' section on the Little Lehigh Creek located on the property of Dr. Brendan O'Brien in Lower Macungie Township, Lehigh County.

Wildlands Conservancy staff planned and implemented the Little Lehigh Stream Restoration Project with permitting and technical assistance from the Pennsylvania Fish and Boat Commission Habitat Management Section. Also assisting in the implementation of the stream restoration project were 39 volunteers from 14 local organizations and the general public. The objectives of the project were to address non-point source pollution, stabilize eroded stream banks, improve overall water quality, and restore lost habitat for fish and aquatic macro-inverebrates. These objectives were achieved through the establishment of a riparian buffer and through the construction of in-stream habitat improvement and bank stabilization devices.

As part of the riparian buffer establishment phase of the project, a no-mow zone of 540 feet in length and 15 feet to 30 feet in width was created. Within the zone 180 square yards of jute matting, turf grass seed, six pounds of wetland meadow mix with annual ryegrass and 240 native trees, shrubs and herbaceous plants were used to stabilize eroded stream banks and provide immediate habitat benefits to wildlife. During the in-stream habitat restoration phase of the project, five in-stream devices were constructed from logs, oak lumber and stone to stabilize 132 linear feet of stream bank and provide naturalistic habitat for fish and aquatic macro-invertebrates.

The Little Lehigh Stream Restoration Project will serve as a demonstration site for future stream restoration projects, educating resource professionals, local and state government and the general public. It is anticipated that the results of the post project habitat assessment and aquatic survey will show improvements in the quality and quantity of desirable fish and aquatic macro-invertebrate habitat, and an increase in species diversity and abundance. These improvements will have positive impacts not only on the Little Lehigh Creek, but on the Lehigh River as well.

Appendix

I. **Site Location Map**

II. **Aquatic Survey**

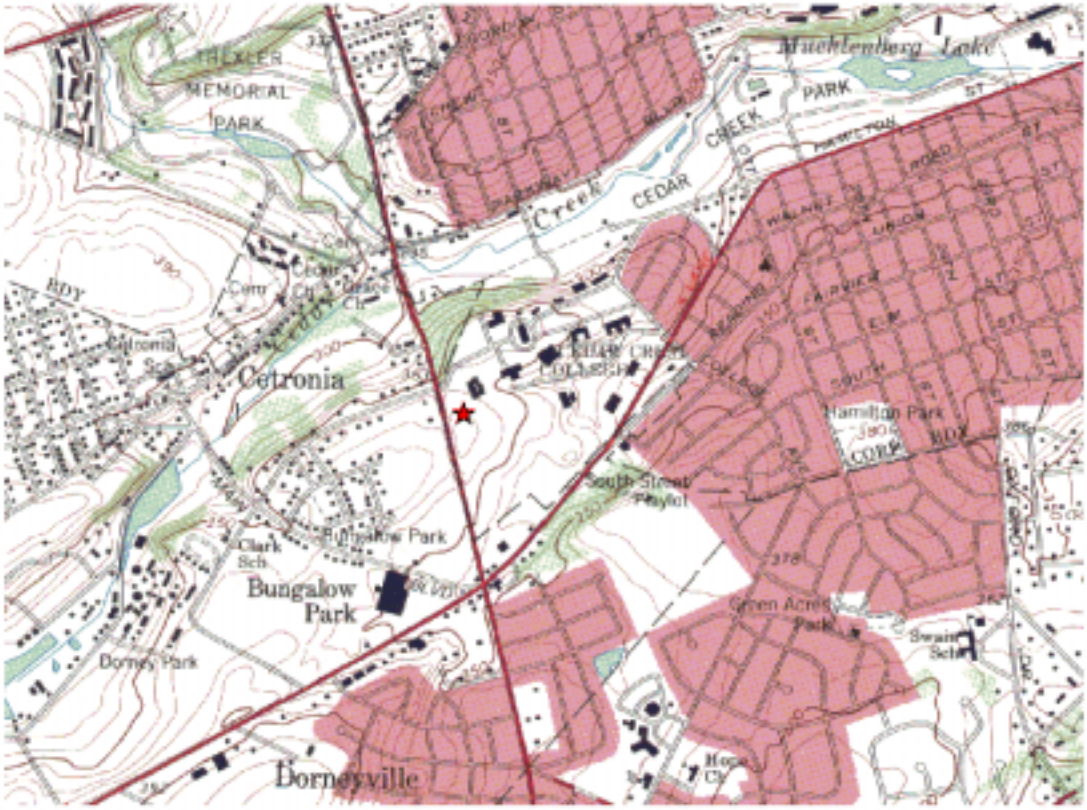
III. **Habitat Assessment**

IV. **Standard Drawings**

V. **Riparian Species List**

Little Lehigh Creek Stream Restoration Project

ALLENTOWN WEST



0.5 0 0.5 1 Miles

Wildlands Conservancy

N
W E
S

Site: Little Lehigh Creek @ O'Brien Residence
Date: June 16, 1999
Investigator: Lance Leonhardt
Sampling Gear: Electrofishing backpack 100-1100 V DC/ Blocknets/Dip nets
Sampling length: 100m (downstream from dam) X 12m

Common Name	Scientific Name	# of Individuals in Sample	Range in Total Length (mm)	Tolerance Guild		Feeding Guild		Temperature Guild	
				IBI#1	IBI#2	IBI#1	IBI#2	IBI#1	IBI#2
Brown Trout	*Salmo trutta*	40	60-350	I	I	P	TC	SC	Ct
Rainbow Trout	*Oncorhynchus mykiss*	2	225-250	I	I	P	TC	SC	C
White Sucker	*Catostomus commersoni*	30	75- 410	T	T	O	GF	E	E
Blacknose Dace	*Rhinichthys attratulus*	67	45- 70	O	T	I	GF	E	E
Longnose Dace	*Rhinichthys cataractae*	8	60- 85	I	M	I	BI	SC	Ct
Cutlips Minnow	*Exoglossum maxillingua*	62	50-130	I	I	I	BI	SC	E
Golden Shiner	*Notemigonus crysoleucas*	4	65-135	T	T	O	GF	E	W
Common Shiner	*Luxilus cornatus*	1	110	O	M	O	GF	E	E
Tessellated Darter	*Etheostoma olmstedi*	90	55-85	O	M	I	BI	SC	E
Rock Bass	*Ambloplites rupestris*	2	65-160	I	M	P	TC	E	E
Green Sunfish	*Lepomis cyanellus*	1	105	T*	T	O*	GF	E*	W
Total # Species in Sample = 11		Total # Individuals in Sample = 307							

- **adapted for Ross**

(Attributes used for F-IBI #1) Ross et. al. USGS Biological Resources Division, Research Cevelopment Laboratory, Wellsboro, PA

Tolerance Guild
T = tolerant (able to tolerate environmental degradation)
I = Intolerant (sensitive to a wide range of environmental stresses)
O = Other (either intermediate in tolerance or conflicting tolerance designations in the literature)

Temperature Guild
SC = stenothermal cool/coldwater
E = eurythermal

Feeding Guilds
I= Insectivore
O= Omnivore
P = Piscivore

(**Attributes used for F-IBI # 2**) Leonhardt (Adapted in-part from: Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities, ed Simon, Table12.)

Tolerance (to environmental perturbations)
T = Tolerant
M = Intermediate
I = Intolerant (sensitive to a wide range of environmental stresses)

Temperature Guild
C= Coldwater
Ct = Coldwater transitional
E = Eurythermal (inhabits C-W waters)
W = Warmwater

Feeding Guilds
GF = Generalist Feeder
BI = Benthic Insectivore
TC = Top Carnivore
WC = Water column insectivore

F-IBI # 1 (adapted from Ross, van Snik Gray, Bennett: A Coldwater Index of Biotic Integrity for Tributaries of the Middle and Upper Delaware River, USGS Biological Resources Division, Research Cevelopment Laboratory, Wellsboro, PA) (under revision)

Category	Metric	Stream Order	Scoring: 5 (best)	3	1 (worst)	Stream Site/Date: Little Lehigh O'Brien Residence 6/16/99
Species richness and community composition	1. Number of stenothermal cool/coldwater species	2 (3) 4	>4 >5 >7	4 5 5-7	<4 <5 <5	3 (5 species)
	2. Number of eurythermal species	2 (3) 4	<4 <4 <4	4 4-7 4-11	>4 >7 >11	3 (6 species)
	3. Presence of brook trout[1]		Present		Absent	1
	4. Percent of individuals as salmonids[2]		>55%	20-55%	<20%	1 (13.6%)
	5. Proportion of individuals as stenothermal cool/coldwater species[3]		>80%	50-80%	<50%	3 (65.7%)
	6.Number of intolerant species[4]	2 (3) 4	>3 >4 >5	3 4 4-5	<3 <4 <4	5 (5 species)
	7. Percent individuals as white sucker[5]		<10%	10-30%	>30%	5 (9.7%)
Trophic composition	8. Percent individuals as omnivores		<20%	20-45%	>45%	5 (11.7%)
	9.Percent of individuals as insectivorous cyprinids[4]		>45%	45-20%	<20%	3 (44.9%)
Fish abundance and condition	10. Individuals per square meter	2 (3) 4	>0.08 >0.15 >0.28	0.05-0.08 0.10-0.15 0.17-0.28	<0.06 <0.10 <0.17	5 (.25)
	11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies[4]		<2%	2-5%	>5%	5

[1] Metric from Steedman (1988)
[2] Metric from Maret et al. (1997)
[3] Metric adapted from Lyons et al. (1996)
[4] Metric from Karr et al. (1986)
[5] Metric from New Jersey (Northern) IBI

Scoring: Excellent = 60-57 Good = 52-48 Fair = 44-39 Poor = 35-28 Very Poor = 23-12

Total score: 42.5 FAIR

(multiply initial total x 1.091 adjustment factor to get final total)

F-IBI # 2 (Leonhardt: A F-IBI for 1-4 Order Coldwater Streams in southeastern, PA.)

Category	Metric	Stream Order	Scoring: 5 (best)	3	1 (worst)	Stream site/Date: Little Lehigh O'Brien Residence 6/16/99
Species richness and community composition	1 .Number of coldwater/coldwater transition species [1]		>3	2-3	0-1	3 (3 species)
	1. Number of eurythermal/warmwater species[2]	2 (3) 4	<4 <4 <4	4 4-7 4-11	>4 >7 >11	1 (8species)
	3. Presence of brook trout[3]		Present		Absent	1
	4. Percent of individuals as salmonids[4]		>55%	20-55%	<20%	1(13.6%)
	5. Proportion of individuals as coldwater/coldwater transition species[5]		>88%	42-88%	<42%	1 (16.2%)
	6. % Intolerant individuals[1]		>43%	10-43%	<10%	3 (33.8%)
	7. Percent individuals as white sucker[6]		<10	10-30	>30	5 (9.7%)
Trophic composition	8. Percent individuals as generalist feeders[6]		<20%	20-45%	>45%	3 (33.5%)
	9.Percent of individuals as benthic insectivores[7]		> 45%	20-45%	<20%	5 (52%)
Fish abundance and condition	10. Individuals per square meter[2]	2 (3) 4	>0.08 >0.15 >0.28	0.05-0.08 0.10-0.15 0.17-0.28	<0.06 <0.10 <0.17	5 (.25)
	11. Percent of individuals with disease, tumors, fin damage, and skeletal anomalies[8]		<2%	2-5%	>5%	5
	12. Number of warmwater individuals per sample [1] (adjust proportionally for lesser/greater sampling lengths)[1]		<6 (50m) <12 (100m) <16 (150m)	6-20 (50m) <12-40 (100m) 16-60 (150m)	>20 (50m) >40 (100m) >60 (150m)	5 (5)
[1] Metric adapted from Mundahl and Simon (1999) [2] Metric adapted from Ross et al. (2000) [3] Metric from Steedman (1988) [4] Metric from Maret et al. (1997) [5] Metric adapted from Lyons et al. (1996) [6] Metric from New Jersey (Northern) IBI [7] Metric adapted from Leonard and Orth (1986) [8] Metric from Karr et al. (1986) **Scoring: Scoring: Excellent = 60-57 Good = 52-48 Fair = 44-39 Poor = 35-28 Very Poor = 23-12**						**Total score = 38** **FAIR/POOR**

Excellent: Comparable to best situations with the least human disturbance: intolerant native coldwater species common; brook trout are the primary top carnivores and are present in good numbers; exotic salmonids are absent or uncommon; tolerant species may be present in low to moderate numbers.

Good: Evidence for some environmental degradation and reduction in biotic integrity; brook trout uncommon or absent; exotic salmonids often dominate, keeping the abundance of top carnivores high; tolerant species may be common but do not dominate.

Fair: The stream reach has experienced moderate environmental degradation, and biotic integrity has been significantly reduced; total species richness is often relatively high , but intolerant and native stenothermal coldwater species are usually uncommon; exotic salmonids may be common to abundant, but tolerant eurythermal species or warmwater species or both are usually more abundant.

Poor and Very Poor : Major environmental degradation has occurred, and biotic integrity has been severely reduced: total species richness may be relatively high, but intolerant native species are usually absent, tolerant eurythermal species or warmwater species or both dominate. (Adapted in part from Lyons and Wang 1996)

STREAM HABITAT ASSESSMENT DATA SHEET **Total Score: 81**

Little Lehigh Creek / O'Brien Property 9/21/98
Stream/Site **Date**

1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover (high and low gradient)	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potent potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for lo for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE _2__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

2 EMBEDDEDNESS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2.a Embeddedness (high gradient)	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-70% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE _5__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

3a VELOCITY/DEPTH COMBINATIONS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3a. Velocity/Depth Regimes (high gradient)	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is > 0.5m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE _5__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

4 SEDIMENT DEPOSITION

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
	Little or no	Some new increase in	Moderate deposition of new	Heavy deposits of fine

4. Sediment Deposition (high and low gradient)	enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constructions and bends; moderate depositions of pools prevalent.	material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE _8__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

5 CHANNEL FLOW STATUS

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Flow Status (high and low gradient)	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE _19__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

6 CHANNEL ALTERATION

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration (high and low gradient)	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE _15__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

7a FREQUENCY OF RIFFLES (OR BENDS)

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7a.Frequency of Riffles (or bends) (high gradient)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffle infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE _5__	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

8 BANK STABILITY (condition of banks)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable, infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _4__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _5__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

9 BANK VEGETATIVE PROTECTION

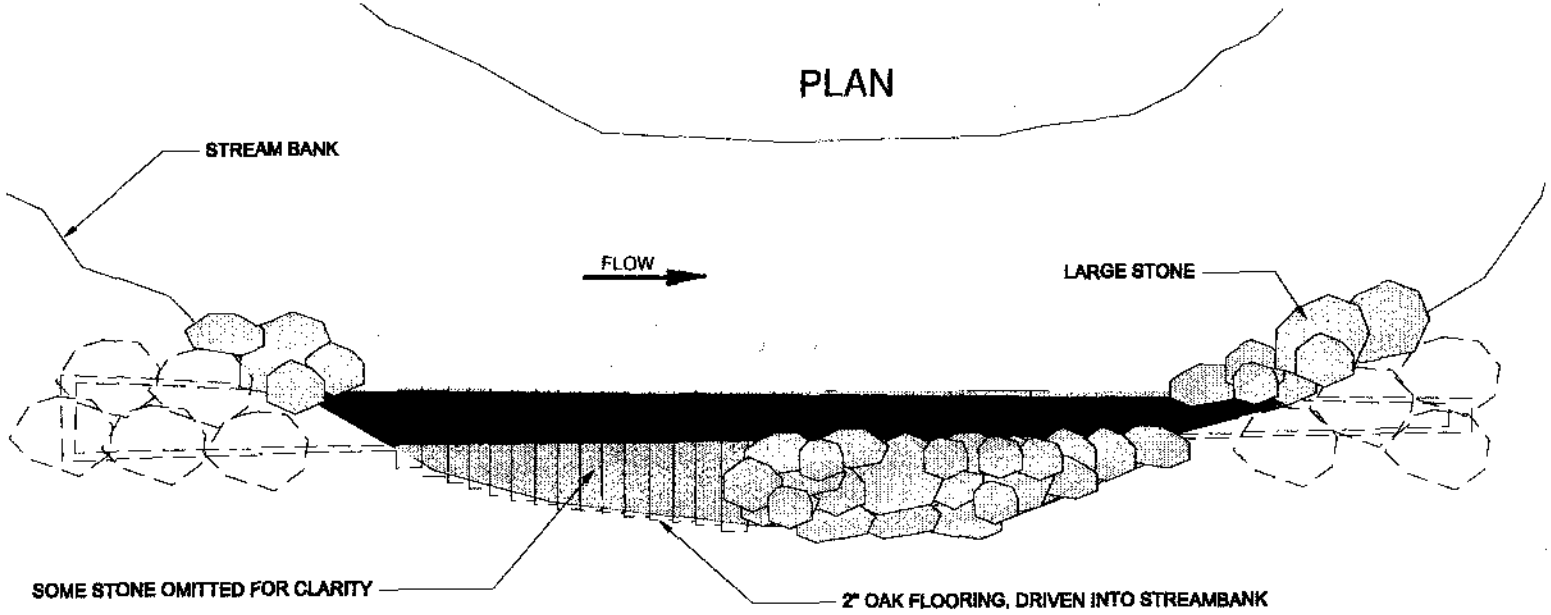
Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
9. Vegetative Protection (score each bank) Note: Determine left or right side by facing downstream (high and lowgradient)	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegeation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 cm. or less in average stubble height.
SCORE _1__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _4__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

10 RIPARIAN VEGETATIVE ZONE WIDTH

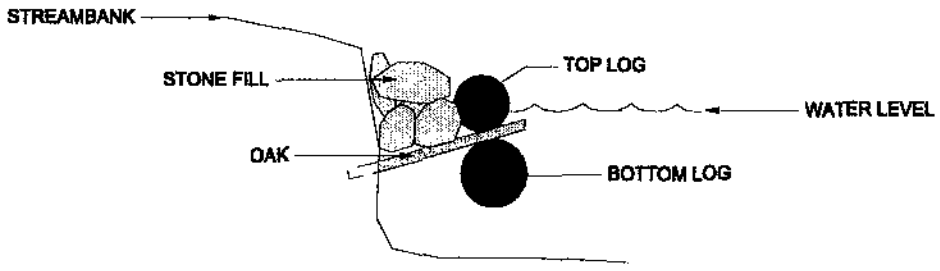
Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
10. Riparian Vegetative Zone Width (score each bank riparian zone) (high and low gradient)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _0__ (LB)	**Left Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**
SCORE _8__ (RB)	**Right Bank 10 9**	**8 7 6**	**5 4 3**	**2 1 0**

BANK CRIB STANDARD DRAWING

PLAN

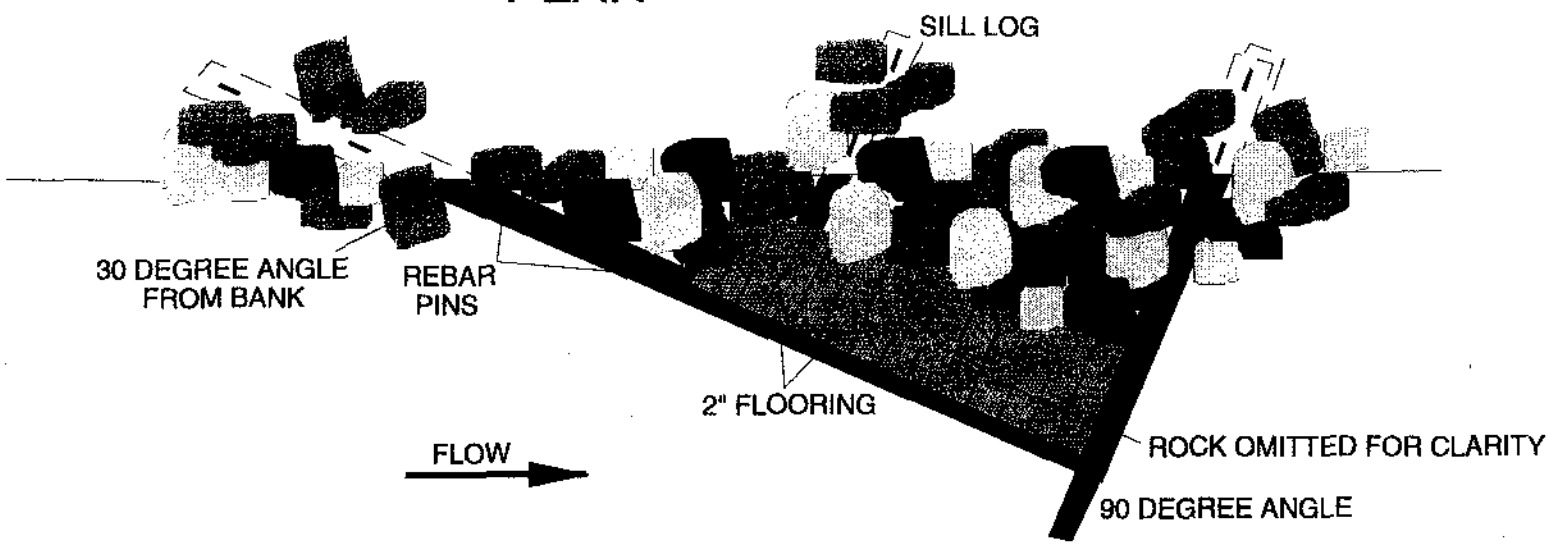


SECTION



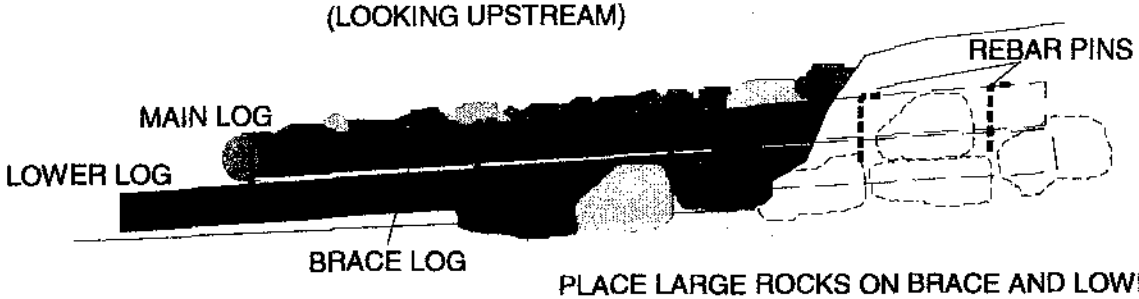
STACKED DEFLECTOR STANDARD DRAWING

PLAN



SECTION

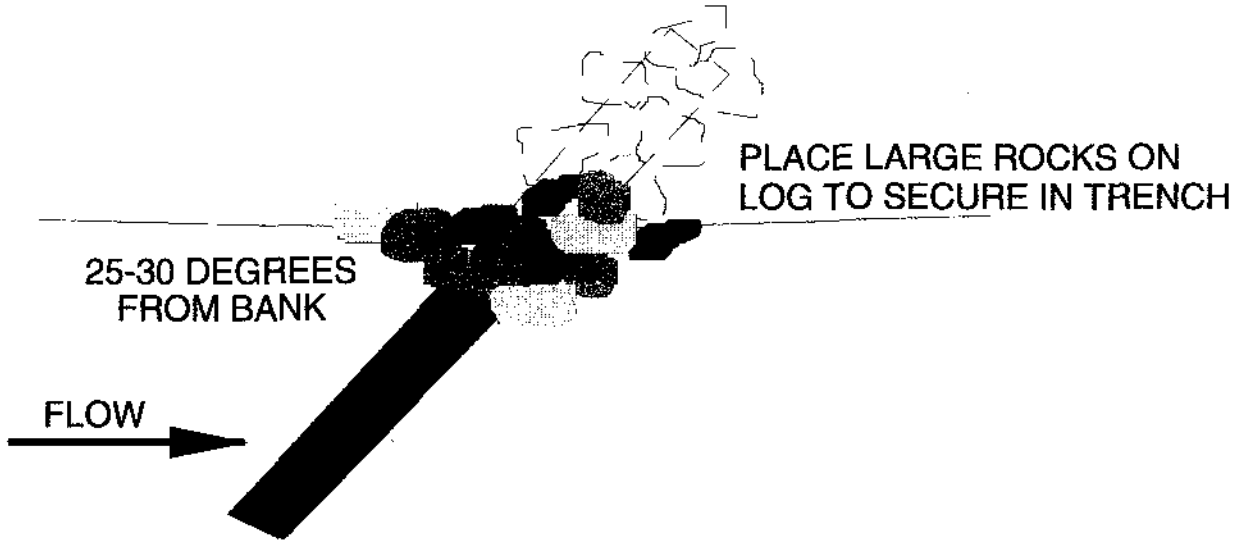
(LOOKING UPSTREAM)



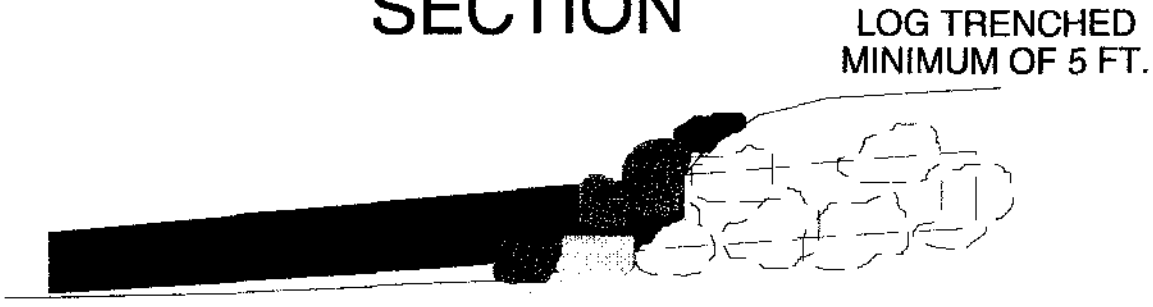
PLACE LARGE ROCKS ON BRACE AND LOWER LOGS TO SECURE IN TRENCHES.

SINGLE LOG DEFLECTOR STANDARD DRAWING

PLAN



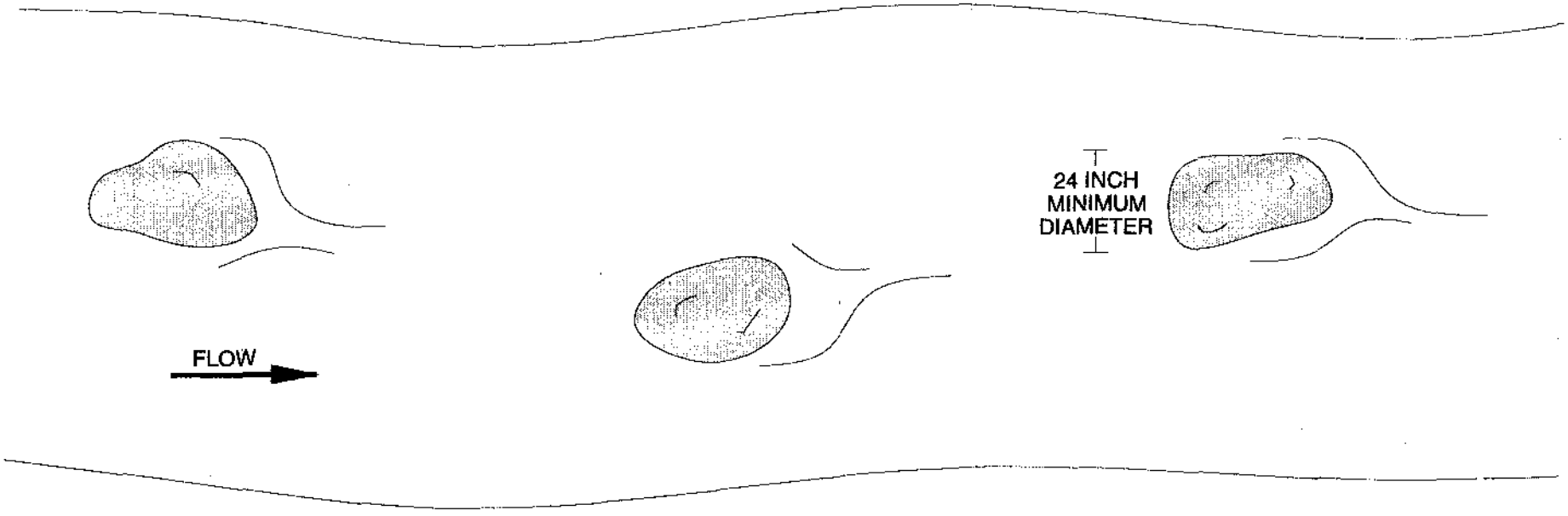
SECTION



NOTE: LOG POINTED UPSTREAM WITH BUTT END
BRACED IN TRENCH WITH LARGE ROCK

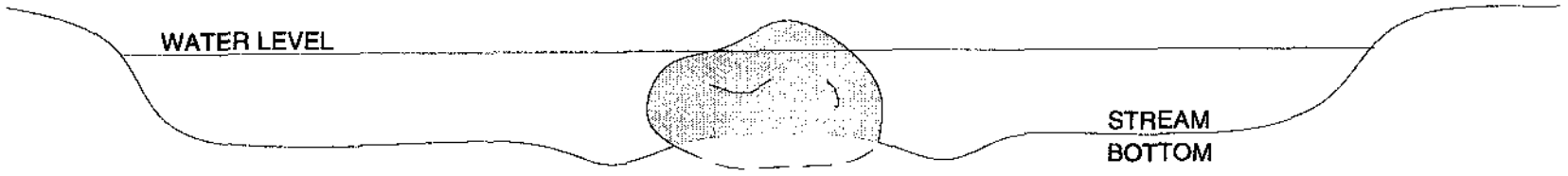
RANDOM BOULDER PLACEMENT
STANDARD DRAWING

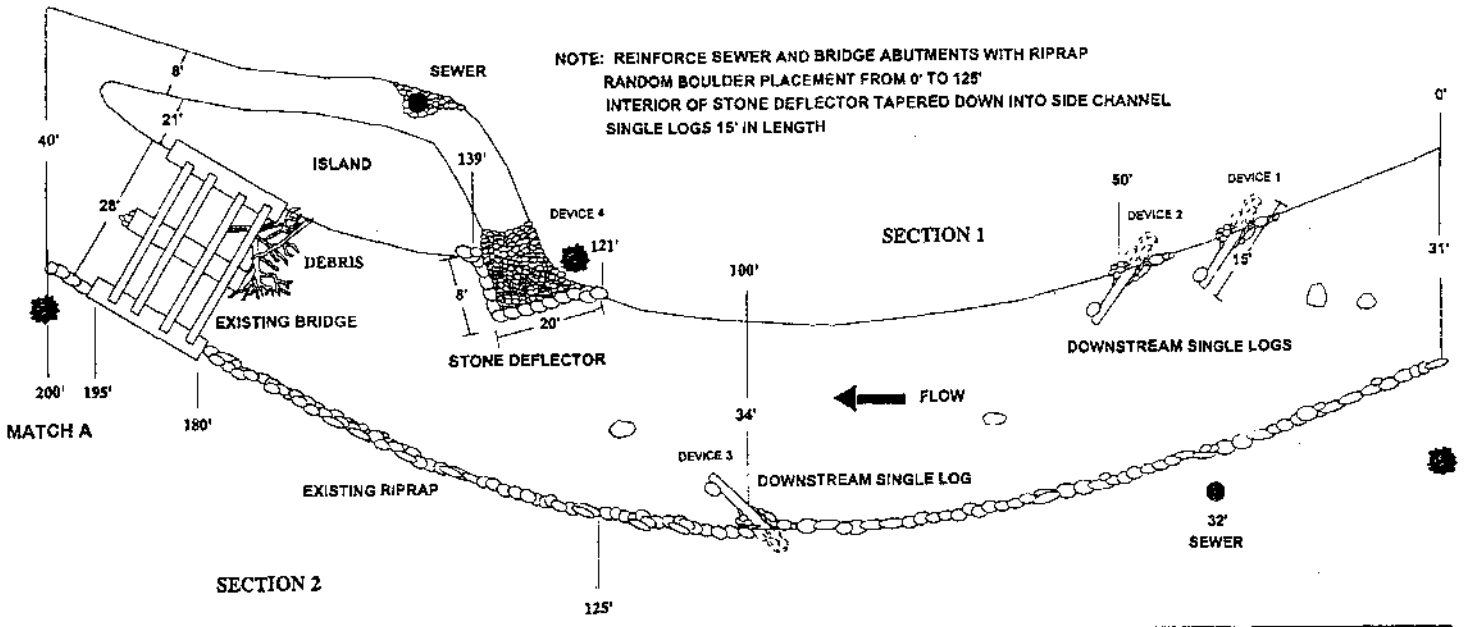
PLAN



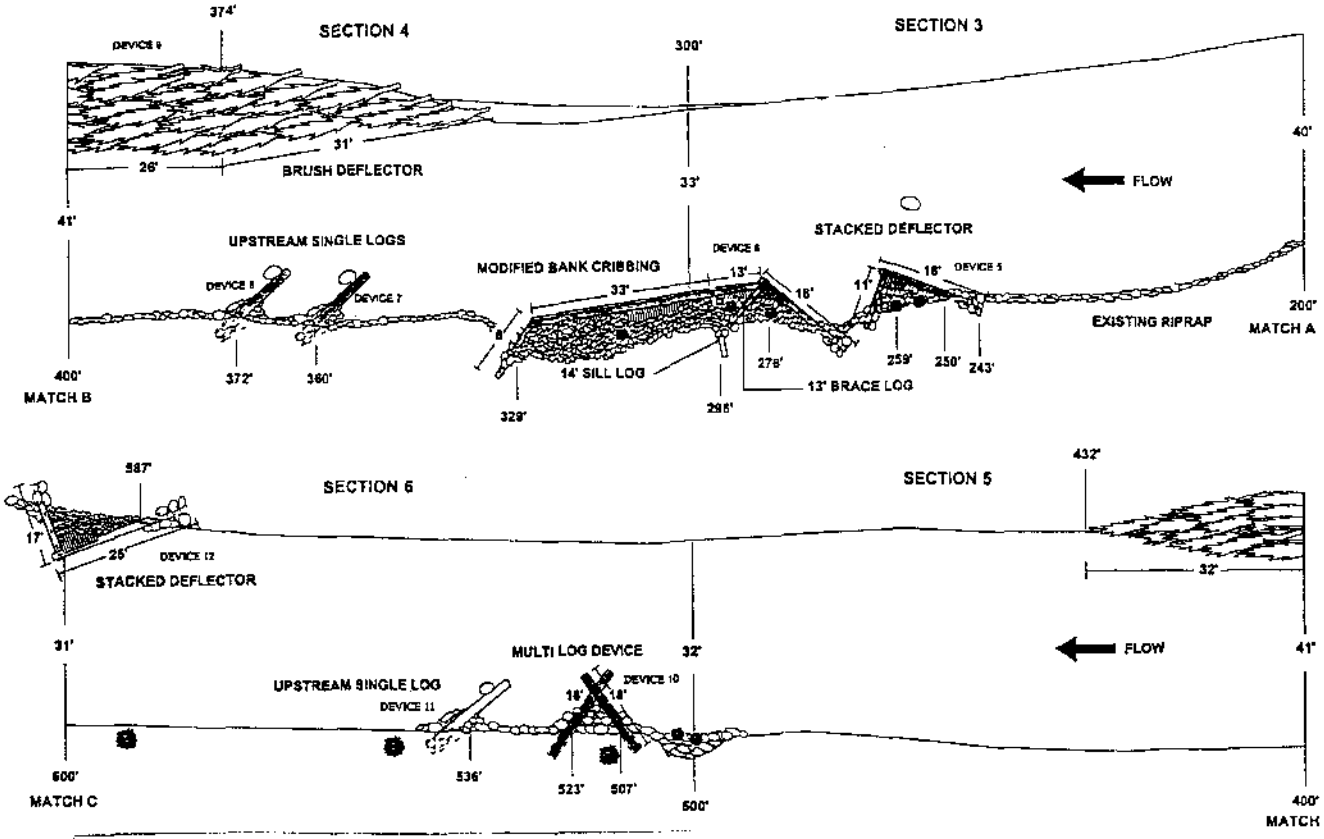
NOTE: PLACE IN THE MIDDLE THIRD OF THE STREAM-WIDTH TO PREVENT FLOW FROM BEING DEFLECTED INTO STREAMBANKS.

SECTION

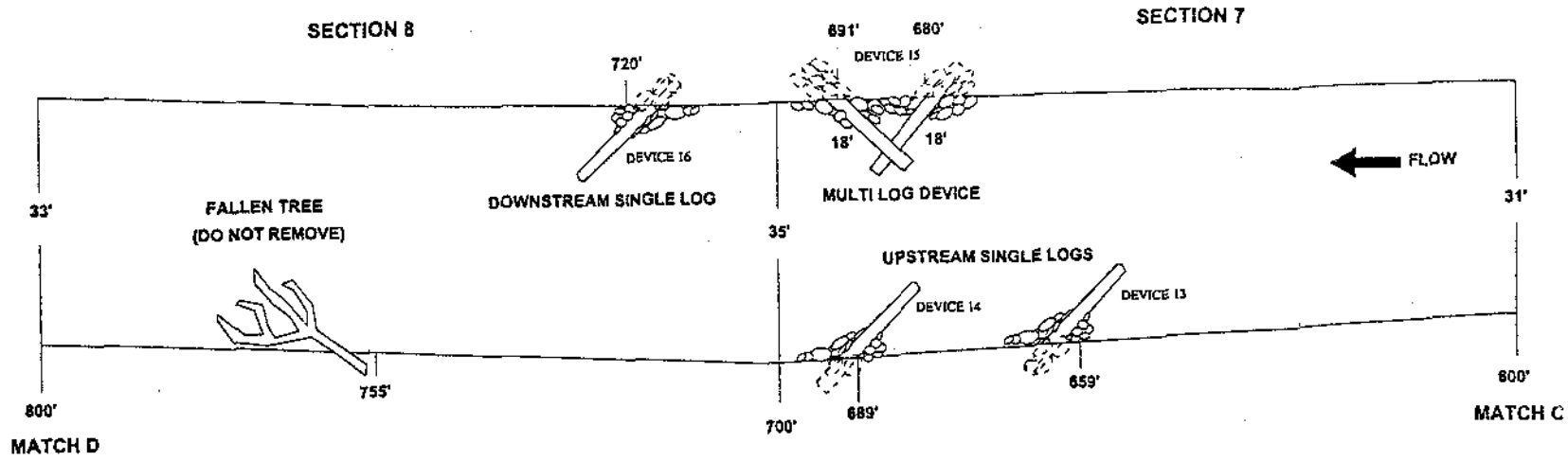


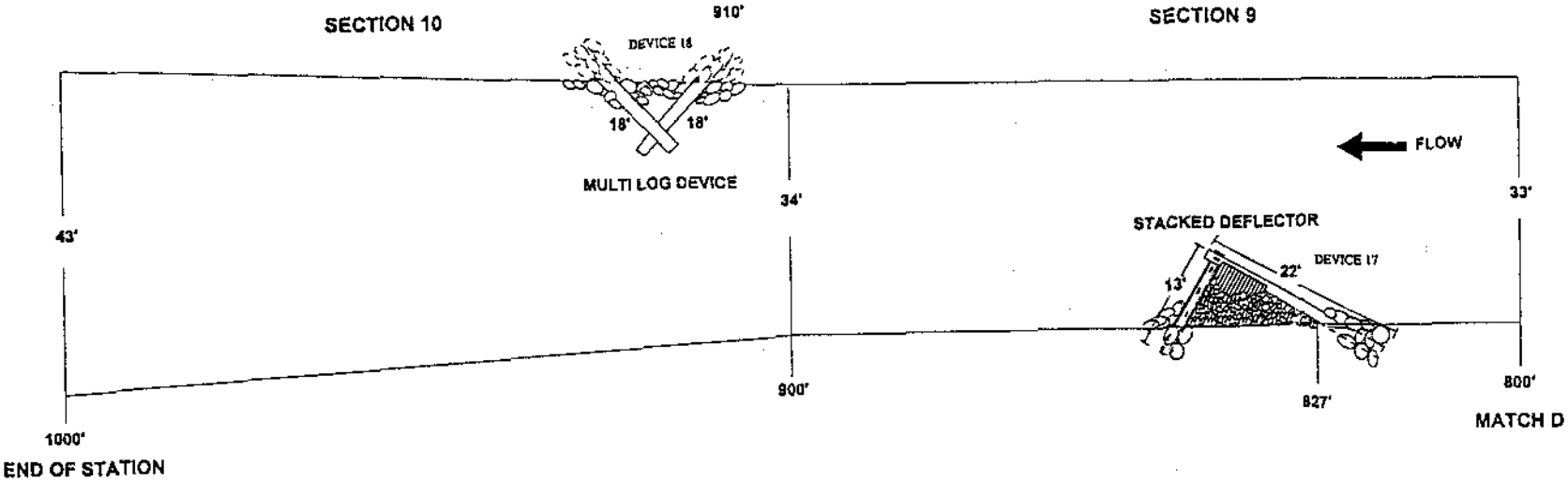


LITTLE LEHIGH CREEK
LEHIGH COUNTY
WILDLANDS CONSERVANCY
FISH HABITAT IMPROVEMENT PLAN
HABITAT MANAGEMENT SECTION
PENNSYLVANIA FISH AND BOAT COMMISSION
DRAWN BY: / DESIGN REVIEW BY: / DATE:
NOT TO SCALE / ALL SIZES APPROXIMATE / FIT IN FIELD



Completed During 1999 Little Lehigh Stream Restoration Project


SECTION 8
SECTION 7
691'
680'
720'
DEVICE 15
DEVICE 16
18'
18'
FLOW
33'
FALLEN TREE
(DO NOT REMOVE)
DOWNSTREAM SINGLE LOG
MULTI LOG DEVICE
31'
35'
UPSTREAM SINGLE LOGS
DEVICE 14
DEVICE 13
755'
659'
800'
689'
800'
700'
MATCH D
MATCH C


SECTION 10
910'
SECTION 9
DEVICE 18
18'
18'
MULTI LOG DEVICE
FLOW
34'
33'
43'
STACKED DEFLECTOR
DEVICE 17
22'
13'
900'
827'
800'
1000'
MATCH D
END OF STATION

FOREST

List of Riparian Plantings for the Little Lehigh Creek Stream Restoration Project

	Scientific Name	Common Name	Quantity
Trees	*Acer rubrum*	Red Maple	5
	Betula nigra	River Birch	6
	Chionanthus virginicus	Fringetree	4
	Fagus grandifolia	American Beech	6
	Fraxinus pennsylvanica	Green Ash	4
	Ostrya virginiana	Ironwood	3
	Platanus occidentalis	American Sycamore	5
Shrubs	*Amelanchier arborea*	Serviceberry	4
	Cephalanthus occidentalis	Buttonbush	6
	Cornus amomum	Silky Dogwood	9
	Cornus serciea	Red-osier Dogwood	5
	Physocarpus opulifolius	Nine Bark	4
	Pyrus arbutifolia	Red Chokeberry	21
	Rhododendron viscosum	Swamp Azalea	6
	Sambucus canadensis	Elderberry	14
	Viburnum dentatum	Arrowwood	5
Herbaceous	*Asclepias incarnata*	Swamp Milkweed	5
	Aster puniceus	Purple Stemmed Aster	5
	Carex stricta	Tussock Sedge	7
	Eupatorium fistulosum	Joe Pye Weed	10
	Lobelia cardinalis	Cardinal Flower	100
	Monarda clinopodia	Beebalm	6