APPENDIX B

Stream Photos
During the Habitat Assessment Survey

Habitat Assessment Photographs: Reach 1

Photo 1. Gravels for trout spawning in Reach 1.

Photo 2. Overview of stream substrate in Reach 1 for trout spawning.

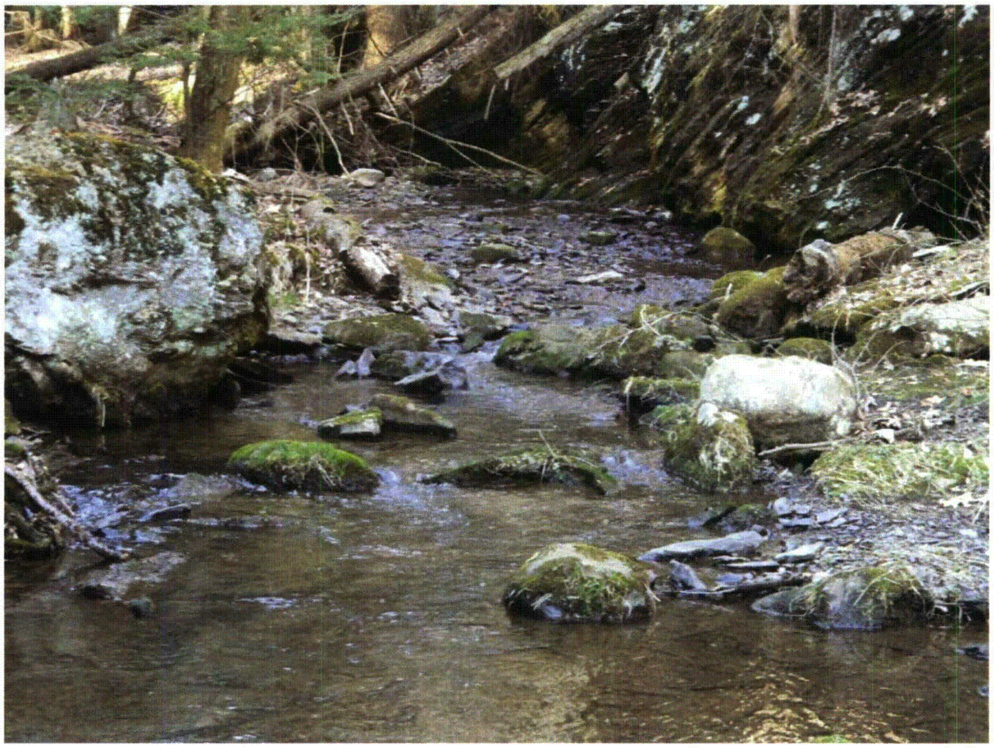

Photo 3. Reach 1 looking downstream.

Photo 4. Emergent vegetation in Reach 1, indicating periodic low water periods and stream bottom exposure.

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Photo 5. Reach 1 looking downstream.

Photo 6. Reach one looking upstream.

Photo 7. Gravels for trout spawning in Reach 2.

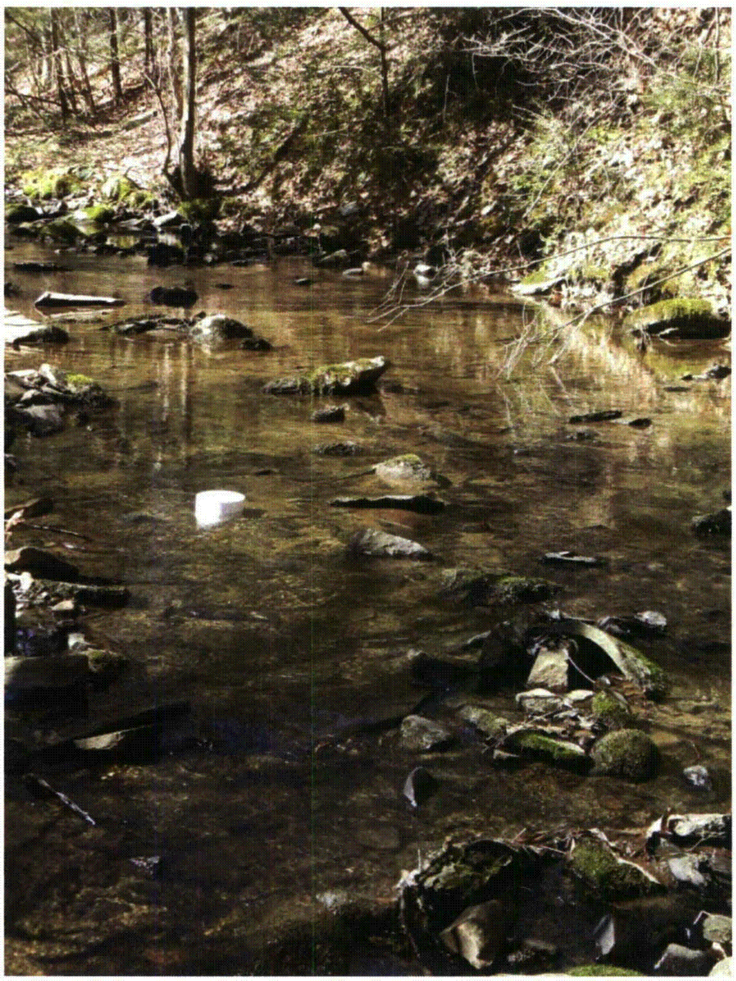

Photo 8. Overview of stream habitat in Reach 2.

Photo 9. Walker Run, Reach 2.

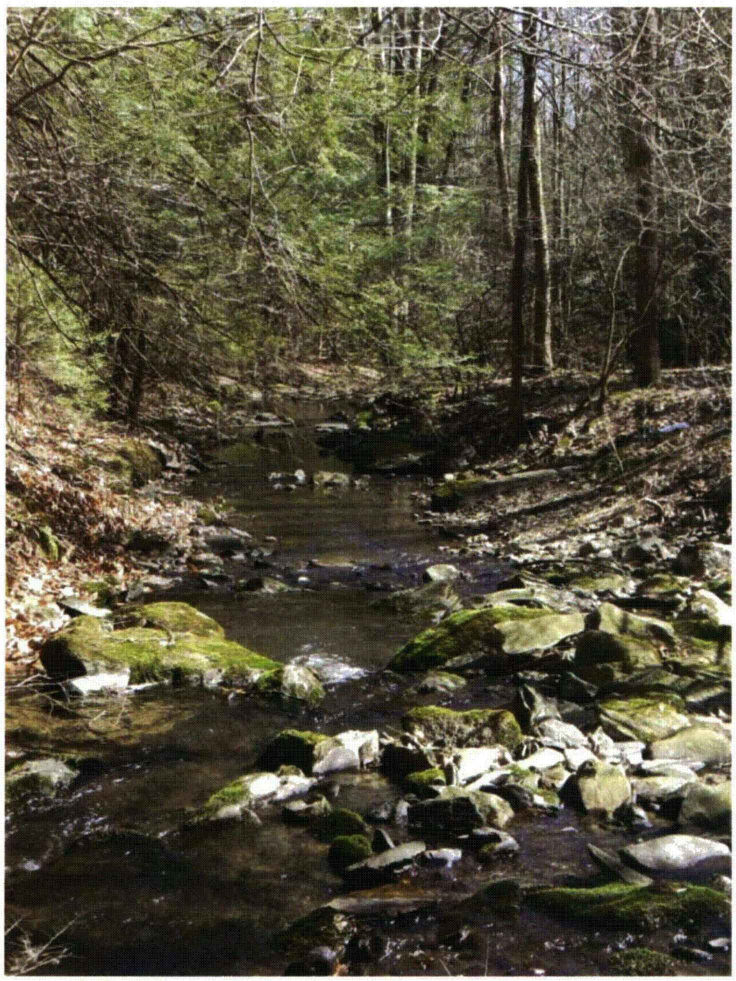

Photo 10. Walker Run, Reach 2

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Photo 11. Close-up of substrate at Reach 2.

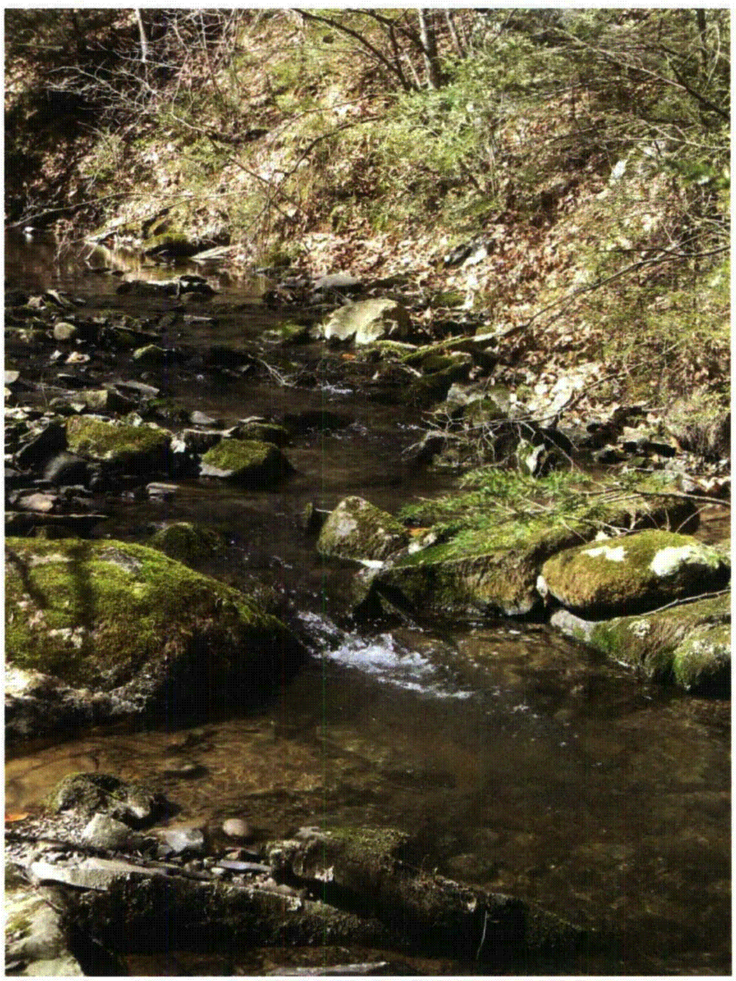

Photo 12. Walker Run, Reach 2.

Photo 13. Substrate in Reach 3.

Photo 14. Gravel and cobble in stream at Reach 2.

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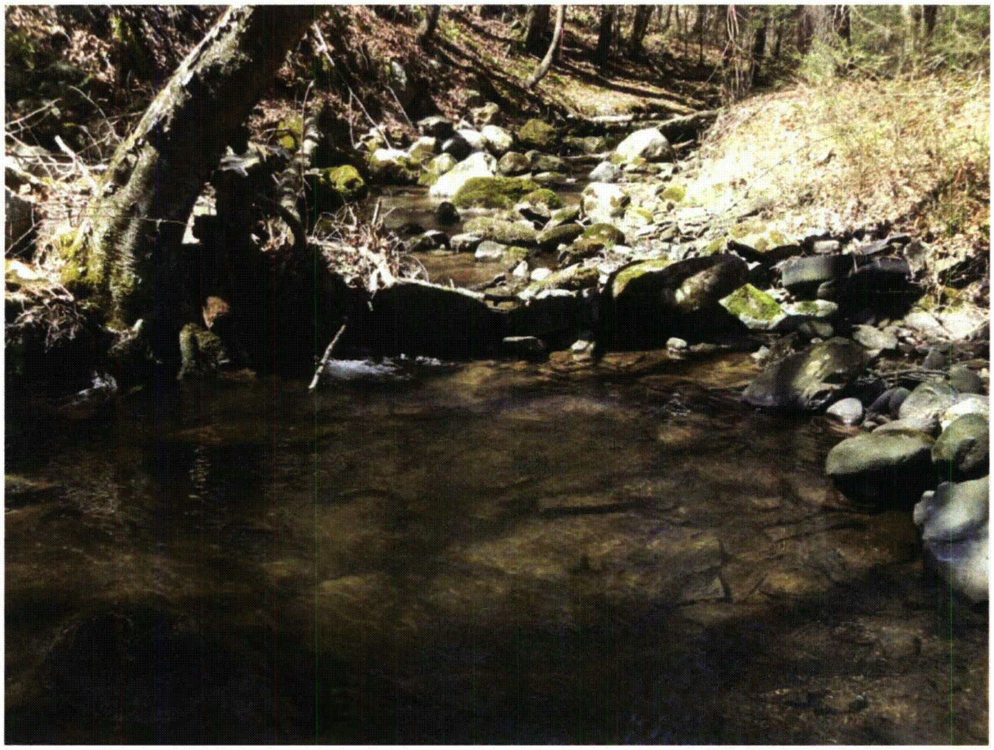


Photo 15. Substrate at Reach 3.

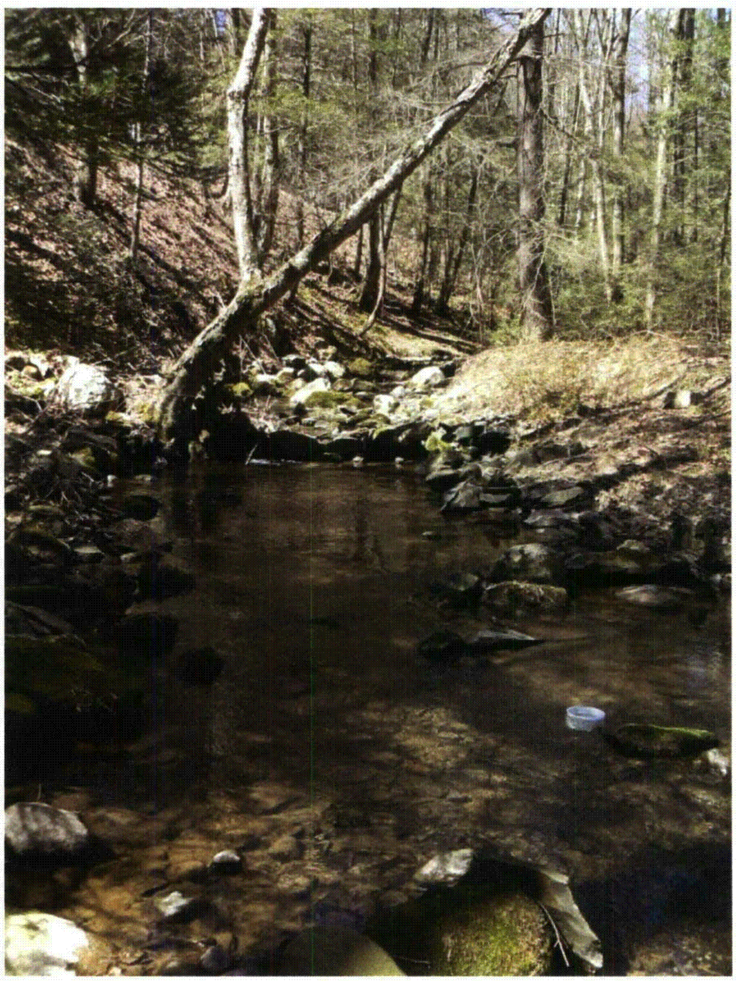


Photo 16. Walker Run, Reach 3.

Habitat Assessment Photographs: Reach 3

Photo 17. Substrate and habitat at Reach 3.

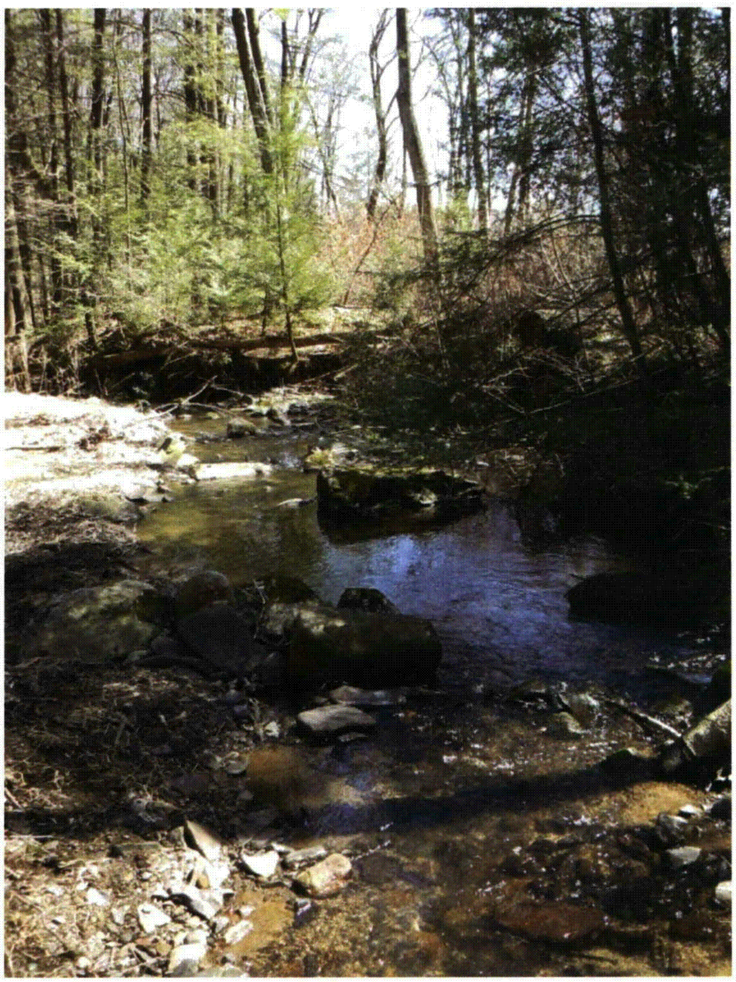


Photo 18. Walker Run, Reach 3.

Photo 19. Gravel and cobble in Reach 4.

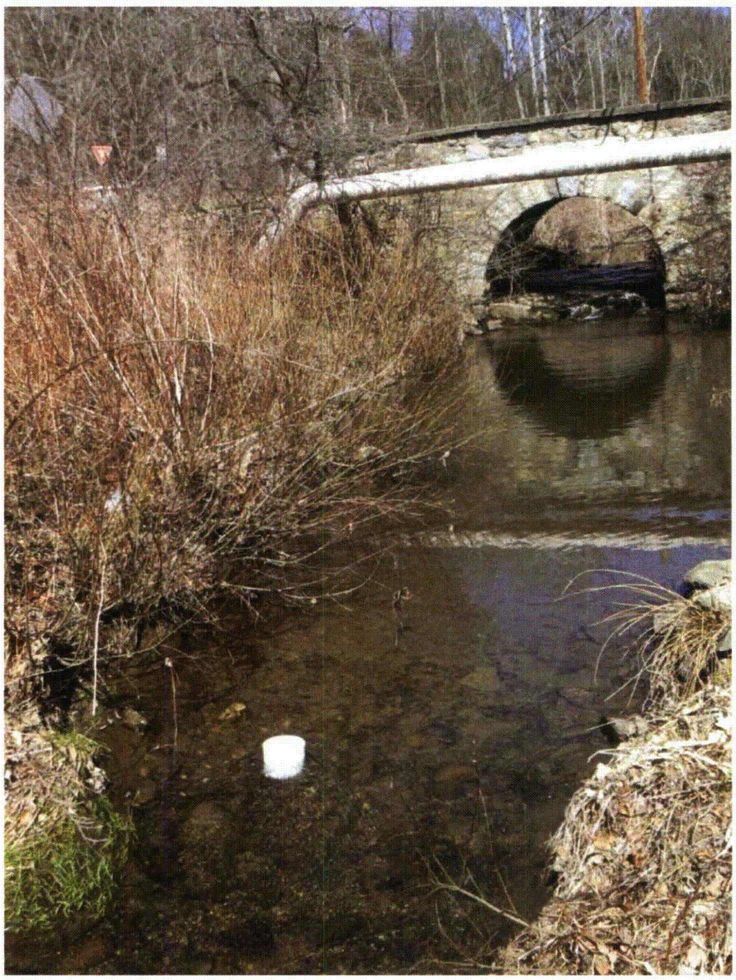


Photo 20. Overview of Reach 4.

Photo 21. Eroding streambanks in Reach 4.

Photo 22. Substrate and bank conditions at Reach 4.

Photo 23. Walker Run, Reach 4.

Photo 24. Substrate in Reach 5.

Photo 25. Habitat conditions and streambank erosion in Reach 5.

Photo 26. Substrate at Reach 5.

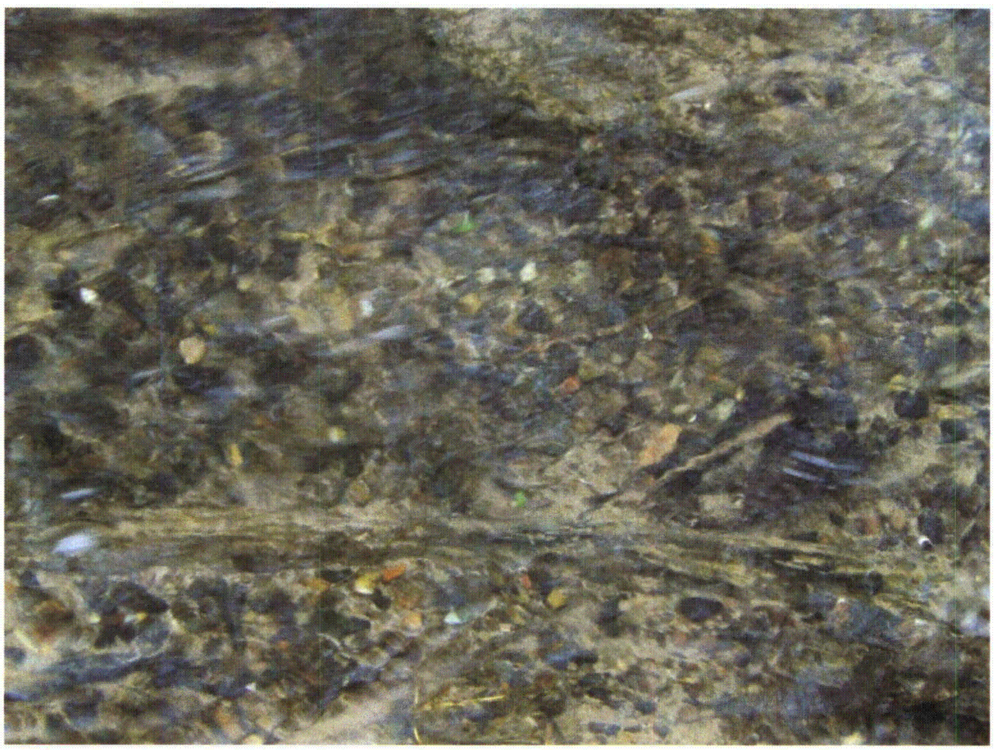


Photo 27. Substrate at Reach 5.

Photo 28. Eroding streambanks at Reach 5.

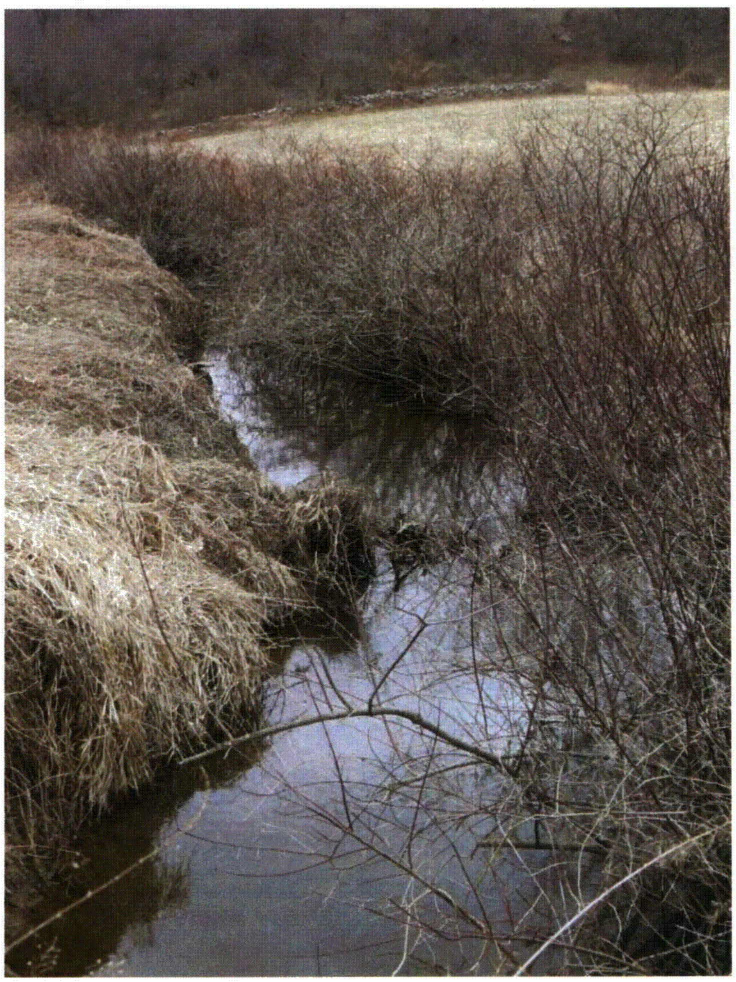


Photo 29. Overview of Walker Run, Reach 5.

Photo 30. Walker Run, Reach 5 vegetation.

Photo 31. Overview of Walker Run, Reach 5.

Photo 32. Substrate in Reach 6.

Photo 33. Best available substrate in Reach 5 for trout.

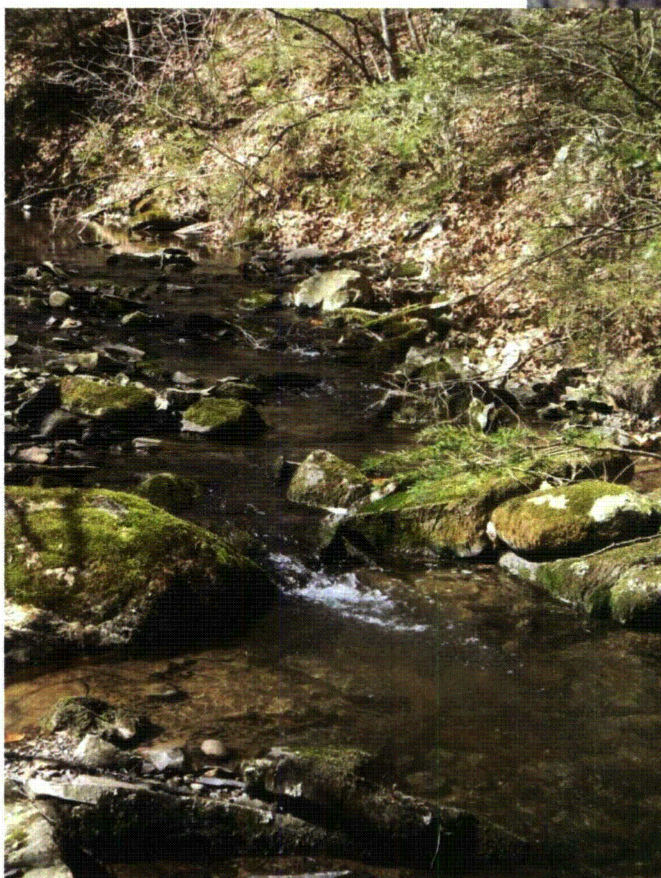
Photo 34. Reach 6 looking downstream.

Photo 35. Reach 6 looking upstream towards road crossing.

Photo 36. Cobble substrate at Reach 6.

Photo 37. Reach 6 looking upstream towards road crossing.

Walker Run
Trout Enhancement Plan



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Walker Run Trout Enhancement Plan

A. Introduction:

This Trout Enhancement Plan has been developed for the section of Walker Run (Luzerne County, Pennsylvania) extending from the upstream end at Beach Grove Road to the forested area just upstream of an existing beaver dam (see stream restoration conceptual design drawings).

The overarching goal of this Trout Enhancement Plan is to increase the area of desired habitat for adult and young brown trout, and the area of desired habitat for brown trout spawning. The Plan also incorporates an approach for re-populating the restored sections of Walker Run. This approach may involve a redistribution of wild brown trout, a trout egg planting program, a fingerling stocking program, or some combination of these efforts. A trout monitoring program is also essential to document the outcomes of these trout enhancement efforts.

The relatively low stream gradient also limits the degree to which excavation during restoration can reach historic gravels in the buried floodplain and streambed. While excavation to historic gravels can be accomplished in upstream reaches, it can make a tie-in difficult or impossible at the downstream reach area that is not being restored. Consequently, it will likely be necessary to import appropriate stream bottom substrate (i.e., gravels) to enhance and expand trout spawning habitat.

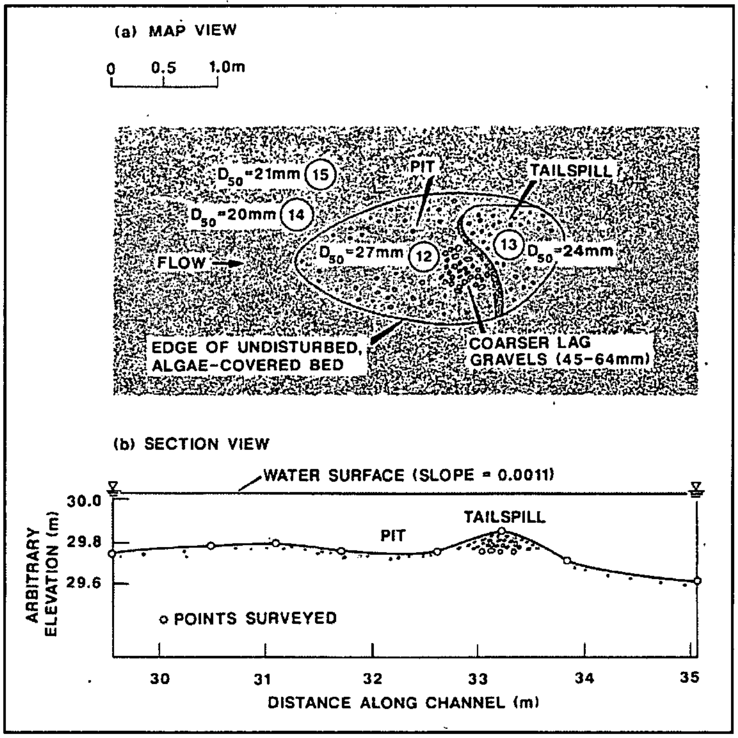
B. Brown Trout Spawning Habitat Criteria:

Brown trout spawn by creating depressions in gravel-dominated stream bottoms, where they lay and bury their eggs for protection and incubation. The female digs a pit (see Figure 1) by turning on her side and using her tail to create strong movements that cause smaller sized gravel and fine sediments to become entrained in the water and move downstream. The gravels will deposit downstream of the created pit in the tailspill area, while the fine sediments will be carried further downstream. After she creates the pit, the female will lay her eggs in the pit and they will immediately be fertilized by her accompanying male. Once the eggs are fertilized, the female will dig upstream of the pit so that her fertilized eggs are covered with gravel. The gravel provides protection for the eggs, and the interstitial spaces between the gravel allow for currents to provide dissolved oxygen to the eggs and carry away metabolic wastes when the eggs begin to develop (description from Kondolf et. al., 1993).[1]

Brown trout in Spring Creek, central Pennsylvania, were found to spawn between the last week in October to the middle of December, with peak spawning occurring in mid-November (Beard and Carline,

[1] Kondolf, G.M., M.J. Sale, and M.G. Wolman. 1993. Modification of fluvial gravel size by spawning salmonids. Water Resources Research, vol. 29 (7): 2265-2274.

Figure 1. Typical brown trout redd morphology. From Kondolf et. al. (1993).[1]



1991).[2] The eggs hatch and the young fry emerge by wriggling through the gravel spaces in the spring. Course sand and fine gravel can fill these gravel spaces and inhibit the emergence of the fry.

Kondolf and Wolman (1993)[3] found that spawning habitat selection by brown trout and other salmonids are based on a number of factors, including substrate gravel size, water depth and velocity, cover, and the presence of upwelling or downwelling currents.

Suitable spawning substrate (gravels) and cover were found to be the most important environmental variables influencing the density of age-0 brown trout in the Au Sable River in Michigan (McRae and Diana, 2005).[4]

Beard and Carline (1991)[5] found that the availability of spawning habitat was the primary factor influencing the density of brown trout in Spring Creek, central Pennsylvania, and that suitable spawning

[2] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.
[3] Kondolf, G.M. and M.G. Wolman. 1993. The sizes of salmonid spawning gravels. Water Resources Research, Vol. 29(7): 2275-2285.
[4] McRae, B.J. and J.S. Diana. 2005. Factors influencing density of age-0 brown trout and brook trout in the Au Sable River, Michigan. Transactions of the American Fisheries Society, vol. 134: 132-140.
[5] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.

habitat with a low percentage of fine particles in the stream substrate was a key factor influencing suitability. Spring Creek on average had 7% of the spawning substrate (i.e. redds) comprised of particles less than 0.8 mm.

The size of available streambed gravels can limit the spawning success of brown trout. The morphology of a typical brown trout redd (the area prepared by an adult brown trout for egg deposition, fertilization, and subsequent incubation and emergence) is shown in Figure 1. Gravels that are too large cannot be moved by the trout, and the pit where the eggs would be deposited cannot be constructed. An excess of fine sediments can fill in the interstitial spaces between gravels, inhibiting egg incubation and emergence by reducing water flows through the gravels which deliver dissolved oxygen to the eggs and carry off metabolic wastes. Fine sediment deposition between gravels can also block emergence of fish after hatching. An excess of fine sediments is a common problem when there is a source of fine sediment erosion from upstream sources such as agricultural runoff, road construction, streambank erosion, sediment deposition from dam construction, etc.

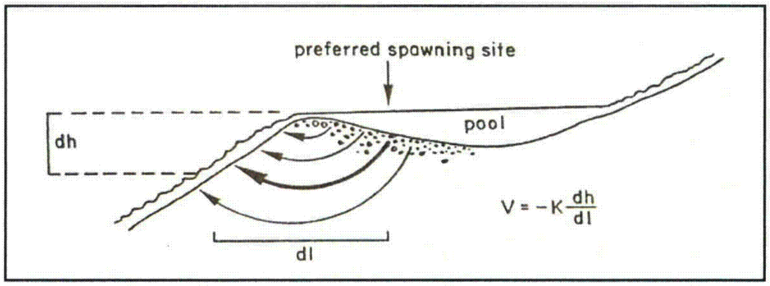
Kondolf and Wolman (1993)[1] found the median gravel size for brown trout redds in 17 studies to be about 18 mm. However, **the size range for gravels in these redds typically ranged from a 25th percentile of about 13 mm to a 75th percentile of about 22 mm**. In general, they conclude that salmonids can spawn in gravels with a median diameter up to about 10 percent of their body length.

Another important aspect of substrate for brown trout and other salmonids is that the substrate size has to be moveable by an adult trout for redd construction. There is therefore **an upper limit to the substrate sizes, which is generally about 10 percent of the adult body length**. It should be noted that an area can still be utilized for spawning if it has only one or a few larger rocks that can remain if there is adequate gravel substrate surrounding those rocks. Space needs to be available adjacent to these rocks, however, for the female to excavate the pit for egg deposition.

The absence of downwelling or upwelling currents can result in trout not spawning in areas with seemingly adequate gravel sizes (cited by Kondolf, 2000). **Upwelling currents can be important for spawning success in gaining streams** where the stream bottom surface is at or slightly below the water table. **Downwelling currents, which can also be important for spawning success**, can occur where the lower elevation of the downstream riffle creates a hydraulic gradient that induces the downward flow of water at the tail end of the pool (see Figure 2).

A significant accumulation of fine sediments (less than 1 mm) can reduce permeability of the substrate to upwelling or downwelling currents (Kondolf, 2000)[6]. The absence of these currents can lead to inadequate dissolved oxygen levels between the gravels, and inadequate exchange of metabolic wastes from the gravels to the overlying water.

Figure 2. Typical groundwater flow (downwelling) through redd gravels. From Kondolf (2000).[6]



After eggs hatch, the alevins live in the intergravel environment for a period of time, and then migrate through the gravel to the surface. Pore spaces between the gravels need to be connected for successful emergence. If fine sediments block these pore spaces, the alevins cannot reach the overlying water. Kondolf (2000)[6] cited data indicating that sediments between 1 mm and 10 mm can block these interstitial pores and inhibit trout emergence.

Kondolf (2000)[6] found that **the percentage of spawning substrate less than 1 mm in size was 14%** for a 50% fry emergence rate for salmonids, which is close to the 12% standard cited by others as the threshold for positive incubation effects. The accumulation of fine sediment particles between larger gravel particles is the primary factor influencing successful spawning of brown trout. Beard and Carline (1991)[7] **recommend that a measure of substrate embeddedness be included in habitat suitability analyses for brown trout** because of the negative impacts of the filling of interstitial spaces between gravel particles. Substrate embeddedness is defined as the degree to which fine sediments surround course substrates on the surface of a streambed (Sylte and Fischenich, 2002).[8] We have completed an extensive sediment embeddedness survey of Walker Run and its unnamed tributary to capture this key spawning habitat characteristic.

Other characteristics for suitable spawning habitat, in addition to suitable gravel composition, a low percentage of fine particles (less than 1 mm), and sufficient upwelling or downwelling to maintain interstitial pores for fry emergence and oxygen/metabolic waste exchange, include: water velocity, water depth, and cover. Brown **trout spawning typically occurs in the pool to riffle transition** (see Figure 2 for an example diagram), in an area where there is a grade change that can facilitate downwelling or upwelling currents. Riffle and pool habitats were the preferred habitat types for brown

[6] Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society, vol. 129: 262-281.
[7] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.
[8] Sylte, T. and C. Fischenich. 2002. Techniques for measuring substrate embeddedness. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-36), Ecosystem Management and Restoration Research Program, U.S. Army Corps of Engineers, Research and Development Center, Vicksburg, Mississippi.

trout found by Zimmer and Power (2006)[9] in the Credit River, Ontario. They also found that upstream segments of the Credit River were preferred over downstream segments for spawning.

Zimmer and Power (2006)[9] documented water depths in brown trout redds to range from 27 to 52 cm, and water velocities to range from 23 to 50 cm/sec for the Credit River in Ontario. Beard and Carline (1991)[10] found **average water depths of 28 cm** and **average water velocities of 37 cm/sec** for brown trout in Spring Creek, central Pennsylvania. They did not find a strong correlation between redd densities and stream gradient (ibid).

Woody debris and undercut banks were the preferred types of cover for brown trout spawning areas found by Zimmer and Power (2006)[9] in the Credit River, Ontario, although the majority of spawning areas in their study had no available cover.

C. Brown Trout Habitat Criteria – Adult and Young Fish:

Beard and Carline (1991) [10] found that wild brown trout densities in Spring Creek, central Pennsylvania, were not correlated to habitat criteria such as water depth, pool area, cover, and substrate. They found that brown trout densities were poorly correlated with the habitat variables in the brown trout habitat suitability index (HIS) model. They did find, however, that **brown trout densities were correlated with redd densities,** which were strongly influenced by **spawning substrate suitability**. They concluded that brown trout do not disperse widely from their natal areas.

McRae and Diana (2005)[11] found a positive relationship between the density of juvenile brown trout and emergent vegetation. The majority of brown trout in their study of the Au Sable River, Michigan, were collected from vegetated habitats. In addition to **cover from predatory pressures**, macroinvertebrate production is typically higher in vegetated habitats in this river and thereby provides a critical food base for the trout. Also important to brown trout survival in the summer are suitable water temperatures, indicating that **canopy cover is critical for summer trout survival**.

Stoneman and Jones (2000)[12] found **water temperature to be the most important factor** influencing trout biomass. Other important predictive habitat factors influencing trout biomass were the **percentage of pool habitats**, substrate size, and cover.

The importance of water temperature during summer, spawning substrate, cover, and percentage of pool habitat to brown trout populations are therefore the focus for enhancing Walker Run for juvenile and adult brown trout.

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[9] Zimmer, M.P. and M. Power. 2006. Brown trout spawning habitat selection preferences and redd characteristics in the Credit River, Ontario. Journal of Fish Biology, vol. 68: 1333-1346.
[10] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.
[11] McRae, B.J. and J.S. Diana. 2005. Factors influencing density of age-0 brown trout and brook trout in the Au Sable River, Michigan. Transactions of the American Fisheries Society, vol. 134: 132-140.
[12] Stoneman, C.L. and M.L. Jones. 2000. The influence of habitat features on the biomass and distribution of three species of southern Ontario stream salmonines. Transactions of the American Fisheries Society, vol. 129: 639-657.

D. Walker Run Brown Trout Habitat - Existing Characteristics:

The spring 2009 fisheries and habitat assessment surveys provide important information on the trout distribution in Walker Run and the habitat quality. Six reaches were surveyed, shown in Figure 3. Three of those reaches (1 through 3) were upstream of Beach Grove Road, and are outside of the proposed stream restoration segment. The next two reaches (4 and 5) are within the proposed stream restoration segment, while reach 6 is downstream of the proposed stream restoration segment.

The number of collected brown trout decreased as you move downstream in Walker Run (Figure 4). The one exception to this decreasing trend is reach 5, where 17 trout were collected from the upstream end of that reach.

The number of young brown trout, less than 100 mm, also decreased as you move downstream in Walker Run (Figure 5). This decreasing trend also had an exception in reach 5, where 5 trout less than 100 mm were collected from the upstream end of that reach.

The habitat assessment results show two different stream segments in Walker Run. The segment of Walker Run upstream of Beach Grove Road has optimal or near-optimal habitat quality (Table 1), while the downstream segment (reaches 4 through 6) has marginal habitat quality. With the exceptions of the trout collected in the upstream end of reach 5, the trout collection results corroborate the habitat assessment results.

Significant habitat quality differences between these two stream segments center on significantly higher embeddedness, greater sediment deposition, poor bank stability, poor vegetative protection, and narrow riparian vegetation widths in the downstream section (Table 1). These marginal to poor habitat characteristics are important to brown trout spawning, particularly substrate embeddedness and sediment deposition. Poor bank stability can also be a source of sediment deposition in the stream.

A sediment embeddedness and substrate characterization survey was conducted at 7 locations on Walker Run in the fall 2009. Seven transects, across the stream and perpendicular to stream flow, were surveyed at each location. The seven transects were located at 25 ft increments over a 150-ft stretch of stream at each location. Nine survey points were located across each transect, for a total of 441 sediment embeddedness and substrate characterization survey points. Survey results for sediment embeddedness are summarized in Table 2. Survey results for substrate characterizations are also summarized in Table 2. Only two of the seven Walker Run stream segments had embeddedness ratings greater than 3 (indicating relatively low embeddedness). These two segments were located upstream and immediately downstream of the Beach Grove Road crossing with Walker Run. The remainder of the Walker Run stream segments had poor sediment embeddedness, and high percentages of fine particles. The average gravel component of the stream substrate was also below 10 percent at these seven downstream stream segments.

These existing habitat characteristics, particularly sediment embeddedness and stream substrate composition, for the segment of Walker Run downstream of Beach Grove Road document the need for trout habitat enhancement through stream restoration. Sediment embeddedness, sediment deposition,

spawning gravels, pool habitats, cover, riparian zones, and canopy cover all need to be addressed in the trout habitat enhancement plan.

E. Brown Trout Habitat Enhancement Recommendations:

The existing habitat issues of sediment embeddedness, sediment deposition, inadequate spawning gravels, scarce pool habitats, inadequate cover, narrow riparian zones, and open to partially open canopy cover all need to be addressed in the trout habitat enhancement plan for Walker Run. The segment of Walker Run targeted for habitat enhancements extends from the Beach Grove crossing to the lower Market Street crossing. Reference to the stream restoration conceptual design plans provides details on how these habitat enhancements will be implemented.

The analysis in this plan indicates that spawning gravels of an appropriate size range, coupled with low substrate embeddedness and adequate upwelling or downwelling, are key spawning habitat characteristics for wild brown trout populations. The findings of McRae and Diana (2005)[13] and Beard and Carline (1991)[14] document that suitable spawning habitat is the most critical predictor of wild brown trout spawning success and population densities. The presence of adequate cover, pool habitats, and canopy cover in riparian zones are habitat characteristics that are presently lacking in the restoration segment of Walker Run. Additionally, streambank erosion is significant in much of the restoration segment of Walker Run, and causes the movement of sediment through the stream and temporary deposition in some areas of the stream.

Restoration and Creation of Spawning Habitat. A cornerstone to this trout enhancement plan for Walker Run is the expansion of appropriate spawning areas. The stream restoration conceptual design has divided the stream into upper and lower restoration reaches. The upper restoration reach extends from the Beach Grove Road crossing downstream to the first Market Street bridge (see conceptual restoration design drawings). The downstream restoration reach begins at that point and extends downstream to the beginning of the existing forest, which is just upstream of the existing beaver dam. The beaver dam is to be removed in the stream restoration project.

[13] McRae, B.J. and J.S. Diana. 2005. Factors influencing density of age-0 brown trout and brook trout in the Au Sable River, Michigan. Transactions of the American Fisheries Society, vol. 134: 132-140.
[14] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.

Figure 3. **Location of fish sampling and habitat assessment reaches (sites) on Walker Run for surveys completed in the spring 2009.**

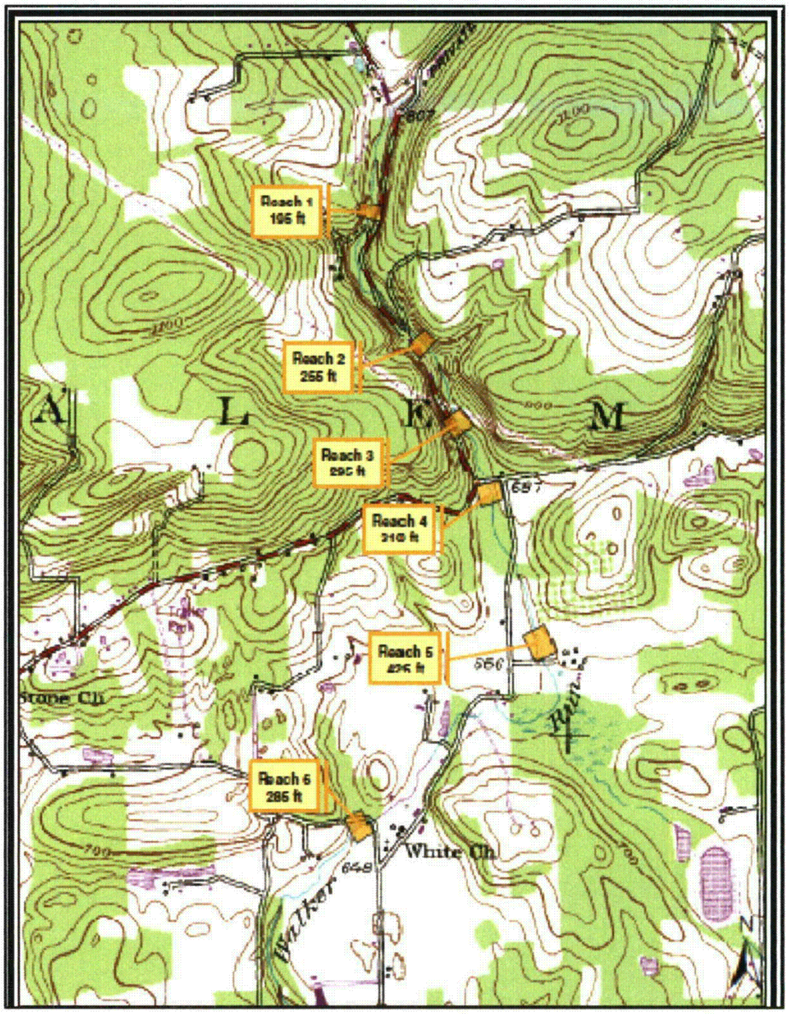

Figure 4. Brown trout captured during March 2009 electrofishing survey of Walker Run. Site 1 is the most upstream site, at 0 miles.

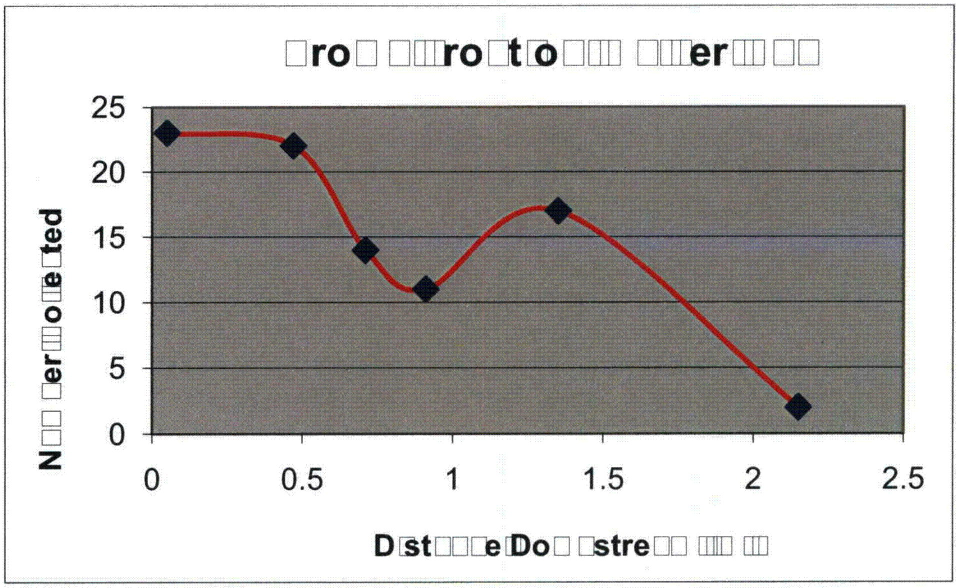

Figure 5. Brown trout less than 100 mm captured during March 2009 electrofishing survey of Walker Run. Site 1 is the most upstream site, at 0 miles.

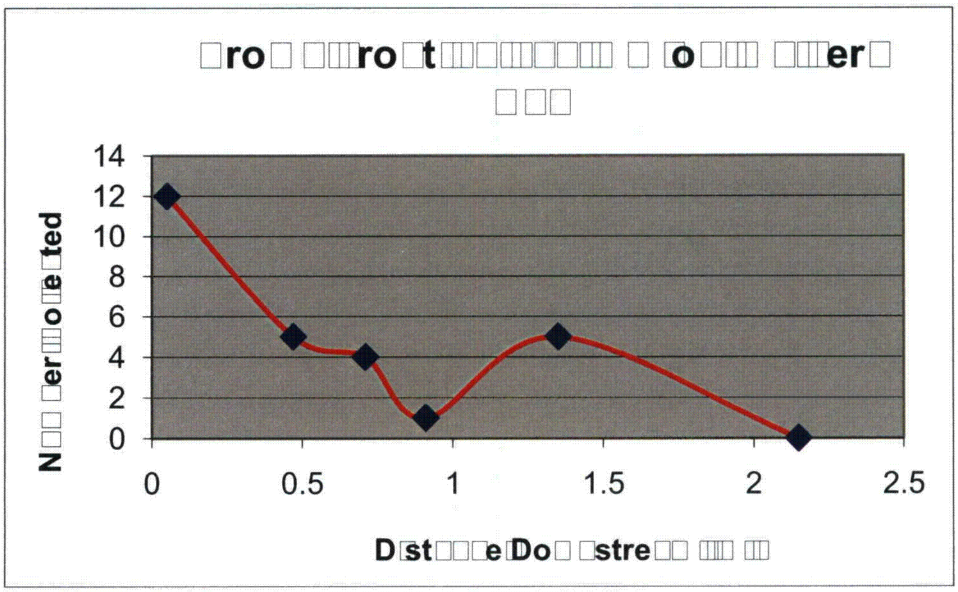

Table 1. Habitat assessments on six reaches of Walker Run.

[illegible] Habitat assessments of Walker Run using EPA's RBP parameters and characterizations.

[illegible]	[illegible]	[illegible]	[illegible]
Epifaunal substrate / available cover	14	12	13
Embeddedness / Pool Substrate (LG)	15	12	14
Velocity / Depth Regime / Pool Variability (LG)	17	14	14
Sediment deposition	16	12	13
Channel Flow Status	12	11	13
Channel alteration	20	20	20
Frequency of Riffles	14	18	14
Bank stability	19	18	15
Vegetative protection	18	18	20
Riparian vegetation zone width	20	20	15
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Epifaunal substrate / available cover	12	10	9	
Embeddedness / Pool Substrate (LG)	9	7	7	
Velocity / Depth Regime / Pool Variability (LG)	9	6	7	
Sediment deposition	12	7	8	
Channel Flow Status	11	18	11	Optimal: 20 to 16
Channel alteration	17	6	13	Suboptimal: 15 to 11
Frequency of Riffles / Channel Sinuosity (LG)	7	3	11	Marginal: 10 to 6
Bank stability	5	5	4	Poor: 5 to 0
Vegetative protection	7	7	5	
Riparian vegetation zone width	5	6	8	
[illegible]	[illegible]	[illegible]	[illegible]	

LG denotes low gradient streams (sites 4 through 6)

Figure 6. Location of stream embeddedness survey reaches on Walker Run for surveys completed in the fall 2009.

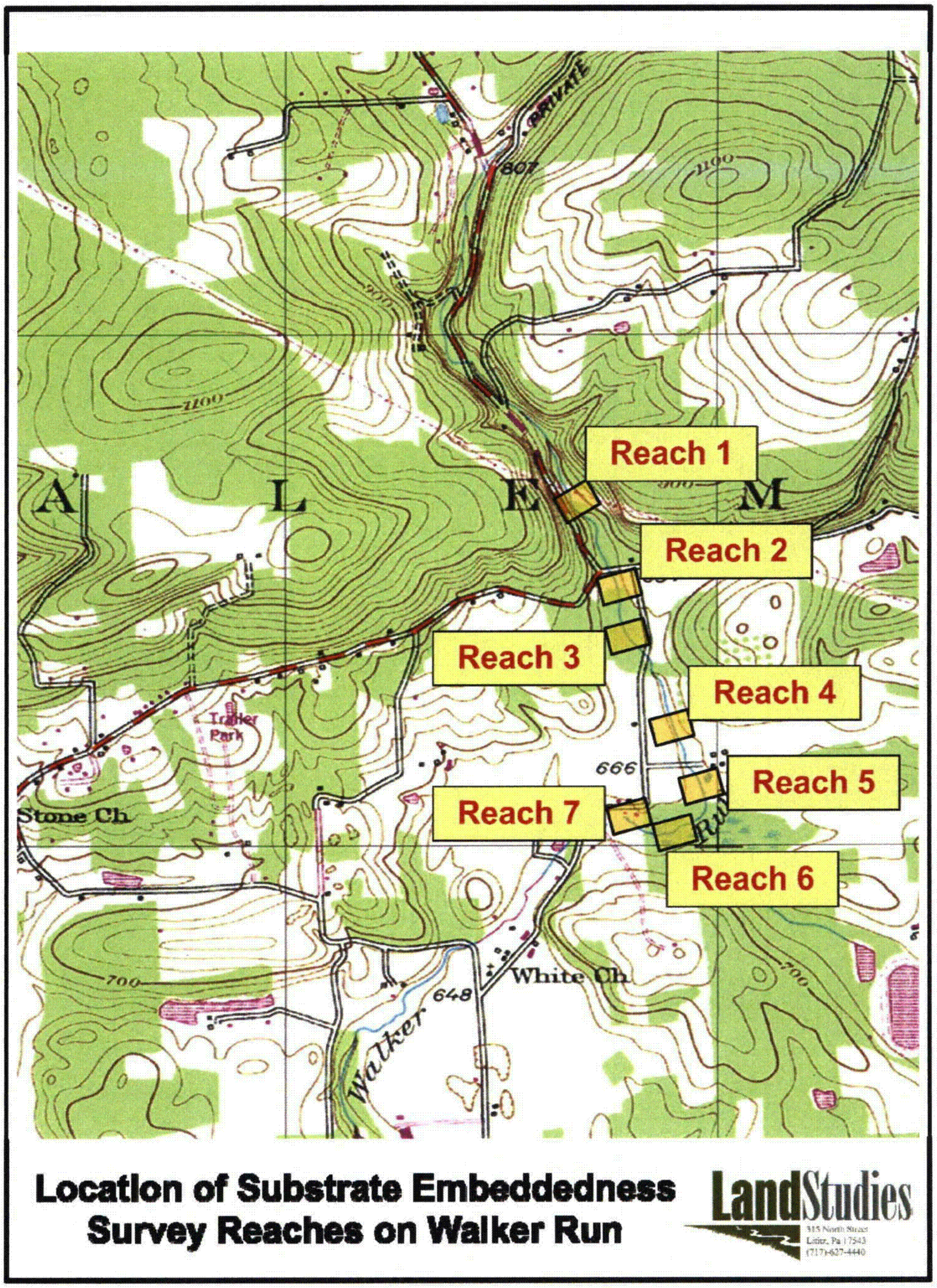

Table 2a. Sediment embeddedness and stream substrate composition survey results (page 1 of 2).

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]														
S1	TA	10.5	0.15	Riffle	cobble/gravel	18.0	4.3	7.5%	0.0%	15.0%	25.0%	60.0%	0.0%	0.0%
S1	TB	13.6	0.24	Riffle	cobble/gravel	30.0	3.7	17.5%	10.0%	15.0%	30.0%	40.0%	0.0%	0.0%
S1	TC	19.5	0.24	Riffle	cobble/gravel	25.0	3.9	15.0%	5.0%	20.0%	40.0%	40.0%	0.0%	0.0%
S1	TD	10.3	0.29	Riffle	gravel/cobble	20.0	4.2	15.0%	5.0%	20.0%	25.0%	20.0%	0.0%	0.0%
S1	TE	9.2	0.43	Shallow Pool	cobble/sand	60.0	2.5	17.5%	5.0%	25.0%	10.0%	40.0%	0.0%	0.0%
S1	TF	8.1	0.20	Riffle	gravel/cobble	15.0	4.5	7.5%	0.0%	15.0%	40.0%	30.0%	0.0%	0.0%
S1	TG	7.8	0.32	Glide	cobble/gravel	30.0	3.7	30.0%	20.0%	20.0%	20.0%	45.0%	0.0%	0.0%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]														
S2	TA	11.0	0.16	Riffle	cobble/gravel	35.0	3.5	40.0%	32.5%	15.0%	35.0%	40.0%	0.0%	0.0%
S2	TB	8.5	0.13	Riffle	gravel/cobble	30.0	3.7	35.0%	25.0%	20.0%	50.0%	30.0%	0.0%	0.0%
S2	TC	6.0	0.24	Riffle	gravel/cobble	40.0	3.4	15.0%	0.0%	30.0%	35.0%	30.0%	0.0%	0.0%
S2	TD	5.8	0.38	Riffle	cobble/sand	50.0	2.9	17.5%	0.0%	35.0%	15.0%	30.0%	0.0%	0.0%
S2	TE	7.0	0.34	Riffle	gravel/cobble	45.0	3.2	16.3%	5.0%	22.5%	37.5%	30.0%	0.0%	0.0%
S2	TF	5.0	0.26	Riffle	gravel/cobble	22.5	4.1	7.5%	0.0%	15.0%	50.0%	25.0%	0.0%	0.0%
S2	TG	6.4	0.36	Shallow Pool	silt/sand	75.0	1.9	62.5%	50.0%	25.0%	5.0%	15.0%	0.0%	0.0%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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S3	TA	8.5	0.15	Shallow Pool	sand/silt	90.0	1.4	57.5%	30.0%	55.0%	10.0%	0.0%	0.0%	0.0%
S3	TB	7.4	0.19	Run	sand/gravel	70.0	1.7	30.0%	10.0%	40.0%	25.0%	0.0%	0.0%	0.0%
S3	TC	7.3	0.55	Shallow Pool	sand	85.0	1.5	20.0%	5.0%	30.0%	5.0%	0.0%	15.0%	0.0%
S3	TD	8.3	0.63	Pool	rubble/silt	100.0	1.0	10.0%	10.0%	0.0%	0.0%	0.0%	90.0%	0.0%
S3	TE	10.2	0.66	Shallow Pool	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S3	TF	8.2	0.44	Shallow Pool	silt/sand	100.0	1.0	80.0%	70.0%	20.0%	10.0%	0.0%	0.0%	0.0%
S3	TG	6.5	0.75	Shallow Pool	silt	100.0	1.0	70.0%	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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S4	TA	7.7	0.24	Riffle	rubble/cobble	70.0	2.2	11.3%	10.0%	2.5%	2.5%	12.5%	20.0%	0.0%
S4	TB	7.9	0.32	Run	silt/cobble	100.0	1.0	60.0%	50.0%	20.0%	0.0%	25.0%	0.0%	0.0%
S4	TC	7.5	0.44	Run	cobble/sand	100.0	1.0	22.5%	15.0%	15.0%	0.0%	20.0%	0.0%	0.0%
S4	TD	10.3	0.35	Run	sand/silt	100.0	1.0	47.5%	30.0%	35.0%	0.0%	0.0%	0.0%	0.0%
S4	TE	8.3	0.45	Run	cobble/sand	85.0	1.5	20.0%	5.0%	30.0%	0.0%	37.5%	15.0%	0.0%
S4	TF	12.1	0.43	Shallow Pool	sand/rubble	100.0	1.0	42.5%	15.0%	55.0%	0.0%	0.0%	20.0%	0.0%
S4	TG	10.5	0.78	Pool	cobble/sand	90.0	1.4	27.5%	20.0%	15.0%	0.0%	40.0%	0.0%	0.0%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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S5	TA	9.1	0.27	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TB	9.5	0.35	Shallow Pool	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TC	9.5	0.32	Shallow Pool	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S5	TD	8.2	0.36	Shallow Pool	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TE	8.6	0.41	Shallow Pool	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S5	TF	13.0	0.33	Shallow Pool	sand/silt	100.0	1.0	67.5%	35.0%	65.0%	0.0%	0.0%	0.0%	0.0%
S5	TG	9.0	0.26	Shallow Pool	sand/silt	100.0	1.0	62.5%	25.0%	75.0%	0.0%	0.0%	0.0%	0.0%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2b. Sediment embeddedness and stream substrate composition survey results (page 2 of 2).

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S6	TA	15.0	2.26	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TB	14.5	1.91	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TC	21.5	1.73	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TD	16.0	2.46	Pool/Backwater	silt/sand	100.0	1.0	95.0%	90.0%	10.0%	0.0%	0.0%	0.0%	0.0%
S6	TE	14.5	2.31	Pool/Backwater	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S6	TF	16.0	2.39	Pool/Backwater	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S6	TG	15.4	2.32	Pool/Backwater	silt/sand	100.0	1.0	95.0%	90.0%	10.0%	0.0%	0.0%	0.0%	0.0%
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S7	TA	7.8	0.79	Pool/Backwater	sand/silt	100.0	1.0	75.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%
S7	TB	8.9	0.73	Run	sand/silt	100.0	1.0	50.0%	30.0%	40.0%	0.0%	0.0%	0.0%	0.0%
S7	TC	7.4	0.46	Run	sand/silt	100.0	1.0	50.0%	30.0%	40.0%	0.0%	0.0%	35.0%	0.0%
S7	TD	5.9	0.34	Run	sand/gravel	72.5	2.1	25.0%	0.0%	50.0%	12.5%	0.0%	0.0%	0.0%
S7	TE	4.4	0.61	Run	sand/gravel	100.0	1.0	36.3%	5.0%	62.5%	10.0%	0.0%	5.0%	0.0%
S7	TF	4.3	0.45	Riffle	sand/gravel	87.5	1.4	33.8%	2.5%	62.5%	15.0%	10.0%	7.5%	0.0%
S7	TG	4.5	0.20	Riffle	sand/gravel	70.0	2.2	22.5%	0.0%	45.0%	30.0%	20.0%	0.0%	0.0%
□□	□	□□□	□□□	□□□	s□□d/s□□t□r□□e□	□□□□	□□	□□□□	□□□□	□□□□	□□□	□□□	□□□	□□□

* *Percent fines (particles < 1.0 mm) calculated as the sum of the median percent silt and clay and 1/2 the median percent sand.*

The upper stream segment is targeted as the primary focus area for enhancing trout spawning habitat. This is based on the extent of existing riparian forest in this segment. Spawning areas will be established using a wider width to depth ratio in the stream channel (averaging 12 to 16 ft wide) with water depths averaging 0.6 to 1.1 ft deep. These water depths are based on reference reaches for Walker Run and existing trout spawning habitat upstream of Beach Grove Road. In the literature review for this study, Zimmer and Power (2006)[15] documented water depths in brown trout redds to range from 27 to 52 cm, and water velocities to range from 23 to 50 cm/sec for the Credit River in Ontario. Beard and Carline (1991)[16] found average water depths of 28 cm and average water velocities of 37 cm/sec for brown trout in Spring Creek, central Pennsylvania. The water depths for spawning areas in this restoration project correspond to these literature findings.

Kondolf and Wolman (1993)[17] found the median gravel size for brown trout redds in 17 studies to be about 18 mm. However, the size range for gravels in these redds typically ranged from a 25th percentile of about 13 mm to a 75th percentile of about 22 mm. We recommend that the 25th to 75th percentiles for imported spawning gravels for Walker Run be 10 mm to 20 mm in length. Median body length of adult trout captured in Walker Run in spring 2009 was 24.0 cm, with the minimum adult body length for spawners assumed to be 20 cm. Consequently the upper size range for imported gravel for restored or created spawning beds should be 2.4 cm (10 percent of the body length). We therefore recommend that imported gravel for spawning beds have an upper limit of 1 inch. Given the trout sizes in Walker Run, the 25th to 75th percentiles for imported spawning gravels has been slightly lowered from the Kondolf and Wolman (1993) findings.

The absence of downwelling or upwelling currents can result in trout not spawning in areas with seemingly adequate gravel sizes (cited by Kondolf, 2000[18]). Upwelling currents can be important for spawning success in gaining streams where the stream bottom surface is at or slightly below the water table. Downwelling currents, which can also be important for spawning success, can occur where the lower elevation of the downstream riffle creates a hydraulic gradient that induces the downward flow of water at the tail end of the pool. Spawning areas in this upper restoration reach will be designed to reflect the intergravel movement of water as illustrated in Figure 2.

Reduction in Sediment Deposition and Sediment Embeddedness. Kondolf (2000)[19] found that the percentage of spawning substrate less than 1 mm in size was 14% for a 50% fry emergence rate for salmonids, which is close to the 12% standard cited by others as the threshold for positive incubation effects. The accumulation of fine sediment particles between larger gravel particles is the primary factor

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[15] Zimmer, M.P. and M. Power. 2006. Brown trout spawning habitat selection preferences and redd characteristics in the Credit River, Ontario. Journal of Fish Biology, vol. 68: 1333-1346.
[16] Beard, T.D. and R.F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society, vol. 120: 711-722.
[17] Kondolf, G.M. and M.G. Wolman. 1993. The sizes of salmonid spawning gravels. Water Resources Research, Vol. 29(7): 2275-2285.
[18] Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society, vol. 129: 262-281.
[19] Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society, vol. 129: 262-281.

influencing successful spawning of brown trout. Floodplain restoration in both the upper and lower restoration reaches of Walker Run will reduce streambank erosion and the deposition of fine sands among spawning gravels. This should reduce substrate embeddedness and help assure the quality of imported gravels for enhancing spawning habitat in the upper restoration reach.

Streambank erosion is currently significant in the lower restoration reach as well. Floodplain restoration will reduce erosion and transport of fine sands and silts from this reach.

Pool and Cover Habitat. Riffle and pool habitats were the preferred habitat types for brown trout found by Zimmer and Power (2006)[20] in the Credit River, Ontario. Additionally, woody debris and undercut banks were the preferred types of cover for brown trout spawning areas found by Zimmer and Power (2006), although the majority of spawning areas in their study had no available cover. McRae and Diana (2005)[21] found a positive relationship between the density of juvenile brown trout and emergent vegetation. The majority of brown trout in their study of the Au Sable River, Michigan, were collected from vegetated habitats. In addition to cover from predatory pressures, macroinvertebrate production is typically higher in vegetated habitats in this river and thereby provides a critical food base for the trout.

We have utilized these findings to increase the area of habitat, particularly in the lower restoration reach, to increase trout habitat and cover. Stream channels in the lower reach will have a narrower width to depth ratio (averaging 8 to 12 ft wide) with water depths averaging 0.8 to 1.3 ft deep. These narrower channels will be designed with undercut banks and overhanging vegetation to provide shallow pool habitat with significant cover and channel-edge canopy. A higher sinuosity will be incorporated in the lower restoration reach, further providing for undercut bank habitat with vegetative cover.

The existing beaver dam will be removed with the stream restoration, so that the significant existing backwater from that dam will be eliminated and trout habitat with suitable substrate for macroinvertebrate food production will be established.

Trout habitat structures will be installed in both the upper and lower restoration reaches. Examples of anticipated fish habitat structures are provided in the concept restoration plan for Walker Run. Habitat structures to be installed include root wad deflectors, mud sills, log vane deflectors, rock vane deflectors, and rock cross vanes. These habitat structures are critical features in that they provide cover for juvenile and adult brown trout. It was clear from the March 2009 fisheries electrofishing survey of Walker Run that the majority of the juvenile and adult trout were concentrated in a few areas with adequate water depth and cover. These habitat structures, coupled with the stream channel design criteria for the two restoration reaches, will significantly enhance the cover and habitat available for brown trout in this segment of Walker Run.

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[20] Zimmer, M.P. and M. Power. 2006. Brown trout spawning habitat selection preferences and redd characteristics in the Credit River, Ontario. Journal of Fish Biology, vol. 68: 1333-1346.
[21] McRae, B.J. and J.S. Diana. 2005. Factors influencing density of age-0 brown trout and brook trout in the Au Sable River, Michigan. Transactions of the American Fisheries Society, vol. 134: 132-140.

Riparian Zones and Canopy Cover. Critical to brown trout survival in the summer are suitable water temperatures, indicating that canopy cover is critical for summer trout survival. Stoneman and Jones (2000)[22] found water temperature to be the most important factor influencing trout biomass. Significant canopy cover for Walker Run is crucial to maintaining the wild trout population. The presence of forested canopy in the upper restoration reach was a deciding factor for targeting that area for enhancing trout spawning habitat.

We will expand the forested tree canopy in the upper restoration reach through enhanced and restored forested wetlands, while the lower restoration reach will be dominated by emergent wetlands with fewer trees. There will be stream-edge canopy cover in the lower restoration reach from overhanging vegetation. The most downstream segment of the lower restoration reach will be a combination of forested and emergent wetlands, thereby providing more canopy cover there for summer temperature moderation.

F. Brown Trout Re-Population Plan for Walker Run:

A primary goal of the Walker Run stream and floodplain restoration project is to increase and improve habitat for wild brown trout in a 1.1-mile section of the stream. Long term, these stream improvements may result in greater trout population densities. The habitat recommendations discussed in the previous section will be implemented to provide suitable trout habitat for various life stages. The grade, shape, and sinuosity of the designed stream channel will stabilize streambanks and reduce erosion and substrate embeddedness. Native vegetation will be planted within the floodplain providing greater canopy cover to shade the stream and instream fish habitat structures will also be incorporated into the design.

There are several approaches regarding the brown trout repopulation of the restored section of Walker Run. Over time, wild brown trout will likely repopulate this stream section on their own. Additional approaches include the following:

- Natural redistribution of wild brown trout into the restored section from upstream and downstream areas,
- Replacement of wild brown trout by capturing the trout in the project section of stream just prior to restoration, then restocking those same trout into the restored section of stream,
- Assisted redistribution by capturing wild brown trout from upstream and downstream sections of stream and stocking them in the restored section of stream,
- Egg planting efforts, utilizing brood stock captured from Walker Run and similar local streams, for the restored section of stream,
- Fingerling stocking efforts, utilizing brood stock captured from Walker Run and similar local streams, for the restored section of stream.

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[22] Stoneman, C.L. and M.L. Jones. 2000. The influence of habitat features on the biomass and distribution of three species of southern Ontario stream salmonines. Transactions of the American Fisheries Society, vol. 129: 639-657.

Our recommendations are to utilize (1) natural redistribution, (2) replacement, and (3) assisted redistribution for the repopulation of the restored section of Walker Run. Egg planting and fingerling stocking are recommended to be used only if the monitoring (see next section) indicates that the three preferred approaches have been unsuccessful. There are higher economic costs for egg planting and fingerling stocking efforts, as well as genetic and competition risks associated with using hatchery stocks. Utilizing brood stock from Walker Run or other local wild brown trout streams would minimize genetic concerns, but could have an impact on the extant wild brown trout populations in the streams supplying the brood stock.

Replacement Approach. Before construction commences, wild brown trout within the project restoration reach will be collected by electroshocking and relocated to several deep pools north of Beach Grove Road. The large pools near Reach 1 and Reach 2 (see Figure 8) would be good locations to temporarily relocate these captured brown trout. It is expected that restoration activities will be completed in several weeks, so that the relocated brown trout could be recaptured and moved to the restored section of Walker Run shortly thereafter. After release, monitoring will begin according to the schedule listed in the next section of this report.

Assisted Redistribution. After restoration activities are completed on Walker Run, wild brown trout can be collected by electroshocking from upstream and downstream sections of Walker Run and relocated into the restored section of stream. We recommend that a cross-section of brown trout sizes be relocated into the restored section of stream. The number of trout to be redistributed will be determined based on population surveys of the upstream and downstream sections of Walker Run. Numbers will be determined so that impacts to populations in the upstream and downstream sections are minimal. The target number of redistributed trout will also be driven by the number of trout moved to the restored section of stream through the Replacement Approach.

Egg Planting and Fingerling Stocking Efforts. If stocking is considered necessary to reintroduce trout to the restored stream reach, the primary goal should be to supplement Walker Run's existing trout population while still preserving the genetic characteristics of the natural trout population.

Wunderlich and Pantaleo (1995)[23] found that "genetically related behavioral and physiological traits of fish have been altered within the first generation of hatchery experience, and these can cause poor performance in the natural environment and ultimately decrease survival and fitness of the stocked population." Further, they found "there is uncertainty regarding the degree to which behavior learned in the hatchery predisposes hatchery fish to higher risks of predation, lower feeding efficiency, or suboptimal habitat use. These negative characteristics can be passed to the native trout population through interbreeding" (Wunderlich & Pantaleo, 1995).

To maintain genetic character the ideal choice for brood stock is from the existing wild population (Wunderlich and Pantaleo, 1995). Brood stock from Walker Run could be used, with care, to avoid negative impacts to population levels in the stream and to minimize the chance for inbreeding effects.

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[23] Wunderlich, R. and C. Pantaleo. 1995. A review of methods to re-introduce anadromous fish in the Elwha River. U.S. Fish and Wildlife Service. Found at: http://www.fws.gov/wafwo/fisheries/Publications/FP210.pdf

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Drawn By: JS
Checked By: JS
Date: December 2009
Scale: 1" =800'
PLAN SHEET
Sheet Number: 1 OF 1

Revisions No.	Date	Description
X	X	X

Project:
Bell Bend Nuclear Power Plant
Salem Township
Luzerne County, PA

Map:
Figure 7
Pressure Transducer
Location Map

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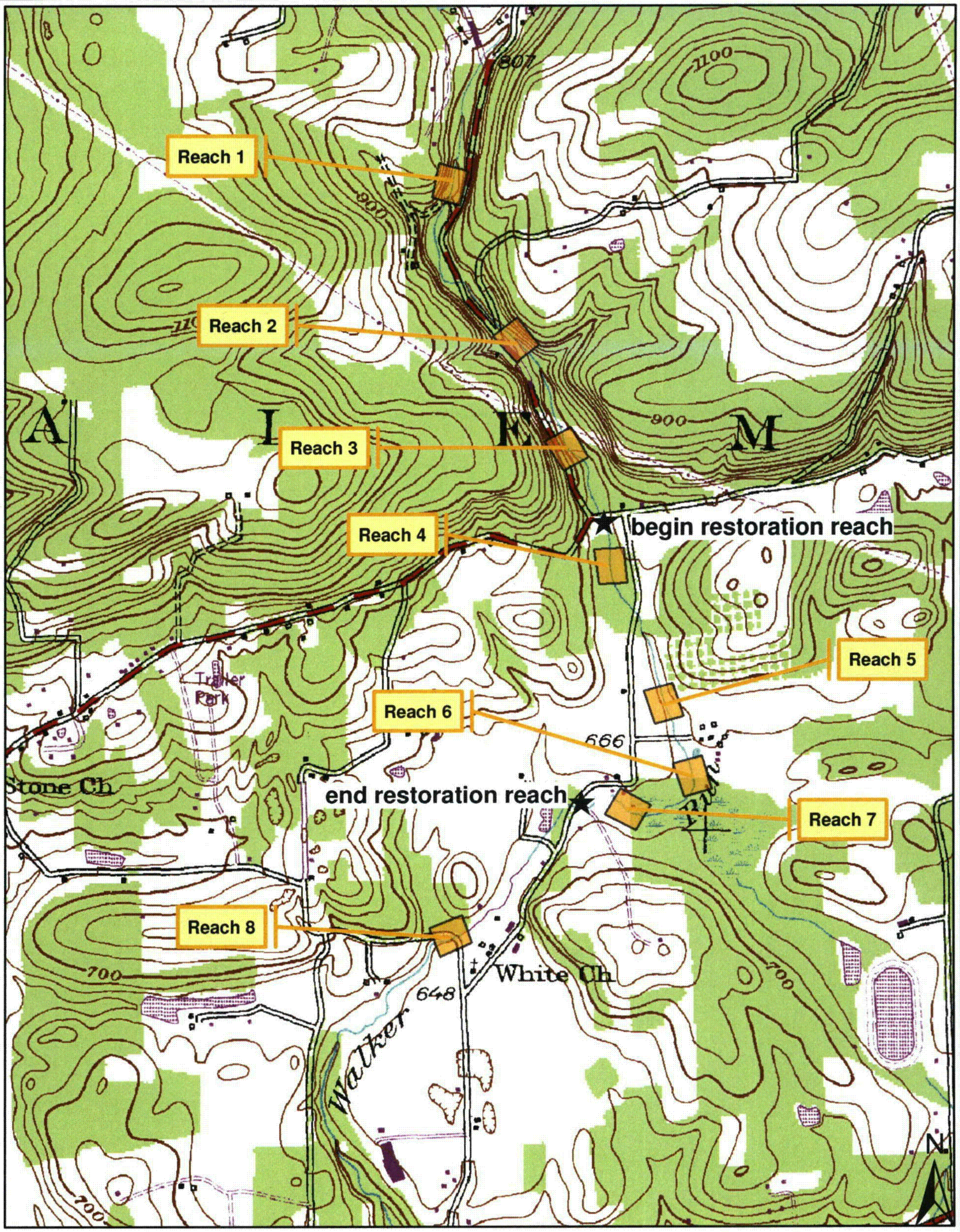

Figure 8: Monitoring Locations on Walker Run

Berwick USGS Topographic Quadrangle

1 inch = 1,500 feet

0 750 1,500 Feet

LandStudies

Wild brown trout from nearby populations that are living in a similar environment could also be used for the brood stock.

There are actions hatcheries can take to minimize effects on local populations. Wunderlich and Pantaleo (1995)[24] recommend the following be implemented to develop the brood stock that supplies the eggs and/or fingerlings:

- An adequate number of brood stock must be available to ensure that the genetic diversity is passed to offspring.
- A 1:1 male to female ratio should be followed to minimize inbreeding.
- Mating should occur randomly.
- Collect 25% or less of the population for the brood stock program to avoid adverse affects to the native population.
- Sample the entire stream for collecting brood stock without regard to sex, age, and other characteristics.
- Only keep the brood stock for one generation in order to minimize the selection for negative genetic characteristics.

In addition to genetics, the size and density of stocked trout and timing of release are important aspects to consider (Wunderlich and Pantaleo, 1995). Minimizing competition between the stocked and wild trout is essential. It is documented that stocked fish larger and further along in development than the wild fish have been known to outcompete and prey upon the wild trout population (Wunderlich and Pantaleo, 1995). On the other hand, stocked trout can be genetically deficient for survival in the wild reducing chances of continued existence and reproduction. Stocked trout can also be negatively impacted by the stress of transport from the hatchery to the stream. Other risks involving stocked trout include the possibility of introducing pathogens to the wild population (Wunderlich and Pantaleo, 1995).

Trout can be stocked as smolts or fingerlings. The advantage of stocking fingerlings as opposed to older fish include increased natural selection, sufficient time for imprinting, a larger gene pool size (smaller fish size means more can be released), and lower cost as a result of less time reared in the hatchery (Wunderlich and Pantaleo, 1995).

There are advantages to stocking eggs rather than fingerlings (Wunderlich and Pantaleo (1995). Stocking eggs eliminates the stress of transport and release on the fish, has potentially low maintenance and costs, potential for high survival rates, and the timing of emergence and behavior is more in tune with natural populations. There are numerous apparatus designed to improve the survival of eggs and sac fry or eggs can simply be placed in the streambed gravels. The Whitlock Vibert (WV) Box is design to hold eggs within the stream and allow stream flow to pass through the box. A study completed by Hashbarger and Porter (1982)[25] demonstrated a greater success rate in direct egg plants because of sediment accumulation in the WV box, stifling the eggs. Egg tubes have also been successful in

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[24] Wunderlich, R. and C. Pantaleo. 1995. A review of methods to re-introduce anadromous fish in the Elwha River. U.S. Fish and Wildlife Service. Found at: http://www.fws.gov/wafwo/fisheries/Publications/FP210.pdf
[25] Hashbarger, T.J. and P.E. Porter. 1982. Embryo survival and fry emergence from two methods of planting brown trout eggs. North American Journal of Fisheries Management, vol. 2: 84-89.

improving egg survival as well as streamside incubators (Wunderlich and Pantaleo, 1995). The survival of direct egg plants is unpredictable due to scouring and sediment filling the intergravel spaces, but can be successful.

It is anticipated that natural redistribution, replacement, and assisted redistribution will be successful in repopulating the restored section of Walker Run. The habitat improvements resulting from the stream and floodplain restoration project will encourage the existing trout population to redistribute in to the restored reach following project completion. Long term, the improved trout habitat should increase reproduction and native brown trout populations within Walker Run. If the monitoring efforts are showing unsuccessful or inadequate redistribution of the native population to the restored section of stream, then egg or fingerling stocking may be necessary. Using wild brown trout populations as brood stock is recommended to maintain the genetic characteristics selected for survival in Walker Run. Monitoring results may help determine whether stocking fingerlings, eggs or both will produce better survival rates.

G. Walker Run Wild Brown Trout Monitoring Plan:

Monitoring is imperative to determine whether brown trout are re-populating the restored section of Walker Run, and to determine the changes in populations of wild brown trout elsewhere in Walker Run.

The following biological and chemical monitoring activities are proposed prior to restoration activities, and for five years following the completion of the Walker Run stream and floodplain restoration project.

1. Continue monitoring water levels and stream water temperatures in Walker Run by maintaining, downloading, and analyzing data from the datalogging pressure transducers currently installed in Walker Run. Six pressure transducers are installed within the project restoration reach, with three additional transducers installed upstream and one transducer installed downstream of the restoration reach. See Figure 7 for the location of these ten pressure transducers on Walker Run, and six other pressure transducers installed on tributaries to Walker Run.
2. Perform a brown trout redd survey in mid-to late-November of each year at the reaches shown in Figure 8. This will provide a measure of the spawning success at the monitored reaches, including the project restoration reach.
3. Perform a fisheries survey in early-to mid-June, once fry are large enough to withstand electroshocking. The fisheries survey should be conducted at the reaches shown in Figure 8. All fish species should be identified, and brown trout should be measured and weighed as well.
4. Perform a macroinvertebrate survey each spring at the reaches shown in Figure 8.
5. Perform a substrate embeddedness survey in July or August at the reaches shown in Figure 8.
6. Monitor water quality in August or early September at the reaches shown in Figure 8. Water quality parameters should include dissolved oxygen, pH, specific conductivity, alkalinity, water temperature, ammonia, nitrite, nitrate, orthophosphate, total phosphorus, and total Kjeldahl nitrogen. Nutrient monitoring is included to document any changes in the stream from watershed land uses.
7. Visual habitat assessment at the reaches shown in Figure 8, using EPA's rapid bioassessment protocols (RBP).

Monitoring activities 2 through 7 will be completed at the eight reaches shown on Figure 8. Four reaches are within the project restoration section, three reaches are located upstream and two reaches are downstream of the restoration reach. This monitoring plan is a comprehensive way to evaluate the wild brown trout populations and habitat characteristics in Walker Run, and specifically to monitor the re-population of the restored section stream. The adaptive management approach advocated here requires that this monitoring information be collected and analyzed, so that decisions regarding re-population approaches can be revisited and adapted to the observed conditions in Walker Run.

Monitoring of the environmental factors known to influence trout populations is essential for interpreting population and distribution changes over time. These monitoring efforts will also allow us to document the success of restoring this section of Walker Run.

These surveys should be performed prior to the initiation of restoration activities. All surveys except the redd survey were completed in 2009. These efforts should continue annually as outlined here until restoration begins. The monitoring program should continue after restoration following the recommendations in this plan.

H. References:

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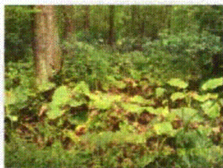
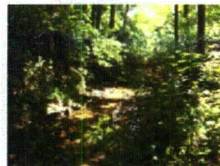
Wetland Functions and Values Assessment





PPL Bell Bend Nuclear Power Plant
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Wetland Functions and Values Assessment

PPL Bell Bend Nuclear Power Plant
Salem Township, Luzerne County, PA
April 2011

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Introduction and Purpose

Wetland functions and values are the roles that a wetland performs resulting from specific characteristics of the wetland and the wetland's watershed. Functions are self-sustaining properties of a wetland ecosystem that exist in the absence of society without regard to subjective human values (The Highway Methodology Workbook Supplement). Values are the worth, merit, quality, or importance of a wetland to society based on either one or more functions and physical characteristics associated with the wetland (The Highway Methodology Workbook Supplement).

The purpose of the Functions and Values Assessment is to provide a comprehensive description of the functions and values of the wetlands delineated within the proposed Bell Bend Nuclear Power Plant (BBNPP) project boundary. There are approximately 155 acres of delineated wetlands within the BBNPP project boundary. Permanent, temporary, and secondary wetland impacts are proposed as a result of BBNPP construction. The functions and values assessment will aid in determining the wetland functions and values that will be reduced or eliminated as a result of BBNPP construction and operation, and will serve as a tool for identifying appropriate measures to mitigate those impacts.

Survey Procedure

The US Army Corps of Engineers' "The Highway Methodology Workbook Supplement: Wetland Functions and Values – A Descriptive Approach" (US Army Corps of Engineers New England District, September 1999), referred to herein as "The Highway Methodology", was used to evaluate wetland functions and values within the BBNPP project boundary (see Figure 1). This descriptive approach to wetland evaluations uses qualitative characteristics to determine if a wetland is suitable for particular functions and values. A pre-established list of considerations or qualifying criteria based on those outlined in The Highway Methodology served as guidance in determining the suitability of each function and value (refer to Appendix A). Functions and/or values may also be listed as principal if they are an important physical component of a wetland ecosystem and/or are considered of special value to society, from a local, regional, and/or national perspective. The selection of a function or value as principal was based on best professional judgment. The Highway Methodology does not contain any numerical weightings, rankings, or averaging of dissimilar wetland function which can cause bias.

The Highway Methodology evaluates 13 functions and values, listed below. Descriptions of each function and value are outlined in Appendix A.

<u>Functions</u>

Groundwater recharge
Groundwater discharge
Floodflow alteration
Fish habitat
Sediment/toxicant/pathogen retention
Nutrient removal/retention/transformation
Production export
Sediment/shoreline stabilization
Wildlife habitat

<u>Values</u>

Recreation
Educational and scientific value
Uniqueness and heritage
Visual quality and aesthetics
Endangered species habitat

Multiple site visits were necessary to accurately identify the functions and values performed within the BBNPP project boundary. Prior to field work, LandStudies reviewed existing information about the wetlands within the project area. Documents reviewed included the BBNPP Combined Operating License Application (COLA) - Revision 1 (Unistar, 2008), the "Wetlands Delineation Report and Exceptional Value Wetlands Analysis" (Normandeau, 2010), and other ecological reports written by Normandeau Associates and LandStudies, Inc. All reports are listed in the references section. After the review of existing information the first round of field visits was performed in November and December 2009. The second round of field visits was performed in July and September 2010. The purpose of the summer 2010 field work was to understand seasonal wetland characteristics, revisit areas affected by beaver dam removal, as well as evaluate newly delineated wetlands resulting from changes to the BBNPP project boundary. "Wetland Function-Value Evaluation Forms" provided in The Highway Methodology were completed for wetland areas or group of similar wetlands during the 2009 field investigations. Completed function and value evaluation forms are provided in Appendix B. The evaluation forms include general wetland characteristics, document whether each function and value was suitable or not suitable, and reference numbers associated with the list of qualifying criteria in Appendix A.

Wetlands were grouped for evaluation based on similar characteristics including location, hydrology, and vegetation type. In most cases, the numbers used identify each wetland area correspond to the numbering system used in the US Army Corps of Engineers Second Preliminary Jurisdictional Determination Request (Normandeau, November 2010). However, in some situations, the labeling of wetland areas was modified specifically for this report by LandStudies to better represent areas exhibiting similar functions and values.

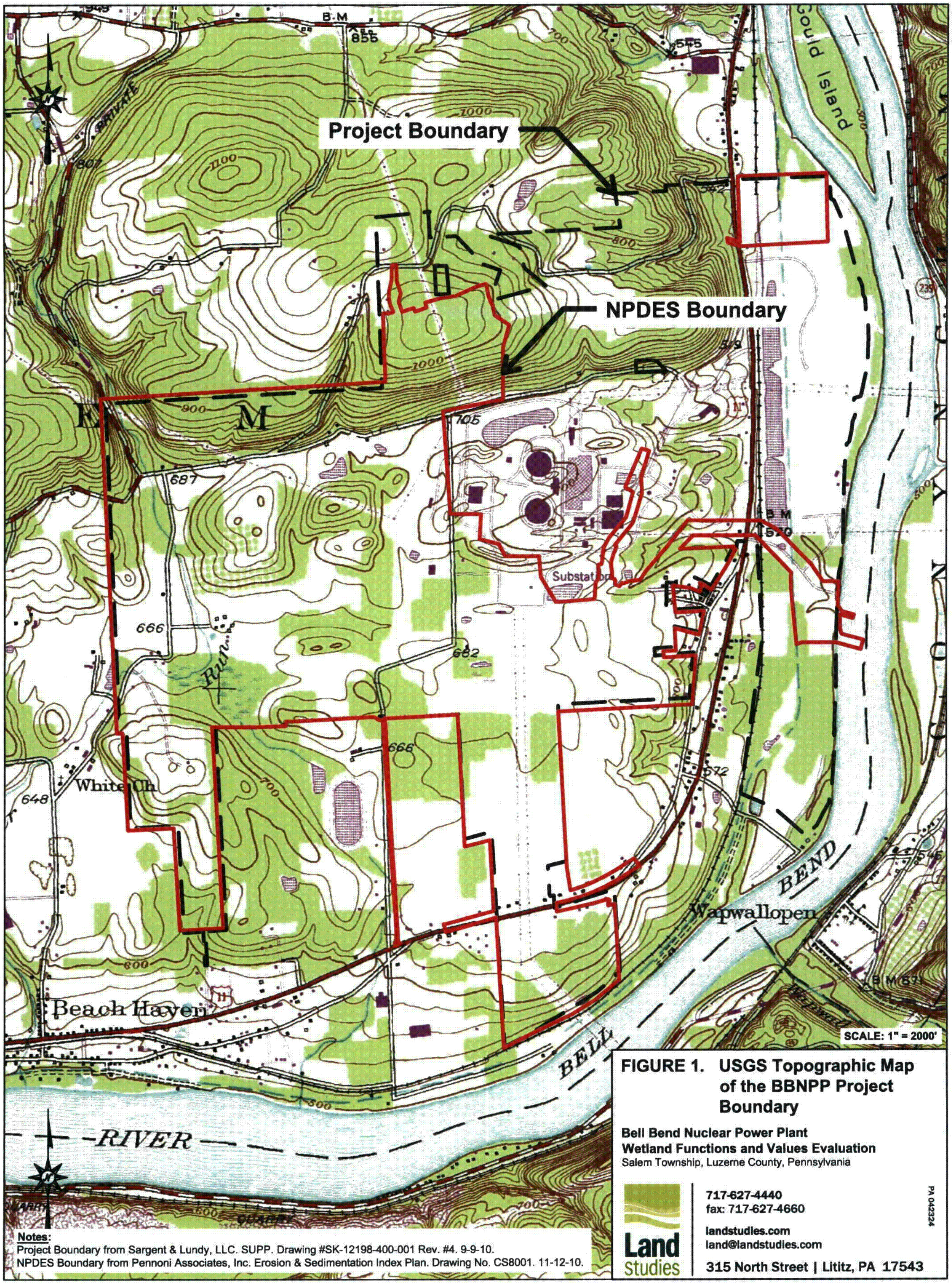

FIGURE 1. USGS Topographic Map of the BBNPP Project Boundary

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Notes:
Project Boundary from Sargent & Lundy, LLC. SUPP. Drawing #SK-12198-400-001 Rev. #4. 9-9-10.
NPDES Boundary from Pennoni Associates, Inc. Erosion & Sedimentation Index Plan. Drawing No. CS8001. 11-12-10.

Study Area Description

Geology

The BBNPP study area is part of the Appalachian Mountain section of the Valley and Ridge physiographic province, which is characterized by a distinctive series of linear ridges and valleys that are the result of differential erosion of folded sedimentary rocks with varying degrees of resistance to weathering and erosion. Valleys are composed of less resistant rocks such as limestone and shales, whereas ridges and uplands are composed of more resistant rocks, particularly sandstone. The Susquehanna River has incised into and crosses these ridges as it flows generally from north to south, and its numerous tributaries form a trellis drainage network pattern as they flow along the valleys with less resistant rocks.

The underlying bedrock consists of layered sedimentary rocks that are Devonian in age (~416 to 359 million years old). The vast majority of the BBNPP project boundary is underlain by dark-gray silty claystone of the Mahantango Formation (Dmh). Some of the northern-most portions of the BBNPP project boundary are underlain by dark-gray to grayish-black clay shale of the Harrel Formation (Dh) and dark-gray sandstone, siltstone, and shale of the Trimmers Rock Formation (Dtr). Source materials within Walker Run may includes any of these formations as well as gray and bluish-gray sandstone, greenish-gray and grayish-red siltstone, grayish-red claystone, and greenish-gray shale from the Irish Valley Member (Dci) of the Catskill Formation.

During the past 2 million years (approximate), the landscape has been modified by cyclical erosion and deposition associated with advancing and retreating ice sheets, up to several kilometers thick in places, that flowed southward from the northern polar regions. The most recent ice advance, known as the Wisconsinan, occurred about 45,000 to 15,000 years ago. The most recent part of this advance is referred to in this region as the Woodfordian, which is responsible for creating the most prominent glacial features in the BBNPP study area and the surrounding region. These features include a northwest-southeast trending Woodfordian terminal moraine complex that consists of boulder, poorly sorted sediment, and Woodfordian glaciofluvial (including kame) terraces along the Susquehanna River that consist of stratified sands and gravels. "Kame terraces are frequently found along the side of a glacial valley and are the deposits of meltwater streams flowing between the ice and the adjacent valley side. These kame terraces tend to look like long flat benches, with a lot of pits on the surface made by kettles. They tend to slope downvalley with gradients similar to the glacier surface along which they formed, and can sometimes be found paired on opposite sides of a valley" (definition provided by www.wikipedia.org). The terminal (end) and ground moraines deposited at the front of and beneath the ice sheet, respectively, are much coarser than the outwash sediments, and also are marked by kettles. Kettles are depressions on the ground surface that resulted from melting of ice blocks within the glacial deposits during deglaciation. After deglaciation, which ended approximately 10,000 yrs ago, the landscape of the BBNPP project boundary was mantled with fresh glacial and near-glacial deposits, which consisted of kame terrace sediments that were deposited along the sides of river valleys adjacent to ice margins, and of various types of till

and outwash that formed at the leading edge of the Woodfordian ice sheet. Drainage was poor as a result of the near-glacial and glacial deposits, which typically consist of sediment that ranges from clay- to boulder-size, and resulted in widespread swampy conditions as streams adjusted to deglacial conditions.

Soils

The following soil description is an excerpt from the "Wetland Delineation and Exceptional Value Wetland Analysis" (Normandeau, 2010). It provides a summary of the soils found within the BBNPP project boundary. Detailed soil descriptions and soil maps are also provided in this report.

> "The Natural Resources Conservation Service (NRCS) mapped the majority of the site as upland soils encompassing Chenango gravelly loam, Arnot-Rock outcrop complex, Braceville gravelly loam, Morris very stony silt loam, Oquaga and Lordstown loams, Pope soils, Wayland silt loam, Weikert and Klinesville channery silt loam, Wellsboro very stony silt loam and Wyoming gravelly loam. These soils are classified as somewhat poorly drained to excessively drained and have seasonal high water tables ranging from 6 inches in depth to greater than 72 inches in depth. NRCS information indicates that Chenango and Wyoming soils are unlikely to have inclusions of hydric soil. However, the other six upland soils may potentially have inclusions of hydric soil in areas such as depressions, drainageways and bottomlands.
>
> Hydric soils mapped onsite consist of Atherton silt loam, Holly silt loam, Rexford loam and Wayland silt loam which are classified as somewhat poorly drained to very poorly drained. Consequently, the range for seasonal high water tables in these soils extends from the soil surface to a depth of 18-inches. Atherton and Rexford soils were largely mapped in association with Walker Run and its network of small tributaries in the western section of the site. Rexford soil is also mapped in association with a small stream in the eastern section of the site and in headwaters areas in the southern end of the site. Holly and Wayland soil is mapped exclusively in the Riverlands along the Susquehanna River floodplain."

Atherton soils have a seasonally high water table near or at the soil surface. These nearly level soils are found primarily in depression in glacial outwash terraces, older stream terraces, and kame-kettle land formations. Atherton soils are poorly or very poorly drained with low runoff potential and ponding water (Soil Survey of Luzerne County, 1981).

Rexford soils are deep, somewhat poorly drained and poorly drained soils located in smooth low-lying concave depressions on glacial outwash terraces. This soil commonly has a fragipan at 15 to 24 inches which slows the downward movement of water. The seasonal high water table is 6 inches to 1 foot (Soil Survey of Luzerne County, 1981).

Holly soils consist of deep very poorly and poorly drained soils formed in the loamy alluvium on floodplains. Permeability is moderate or moderately slow. The seasonal high water table is within a depth of 6 inches of the soil surface (Soil Survey of Luzerne County, 1981).

Wayland soils consist of poorly drained and very poorly drained nearly level soils formed in recent alluvium and located in low areas or slackwater areas on floodplains. The water table is often within 6 inches of the surface and sometimes causes ponding (Soil Survey of Luzerne County, 1981).

Wetlands and Surface Water Bodies

Wetlands within the BBNPP project boundary are associated with two distinct watersheds; Walker Run and the North Branch of the Susquehanna River (NBSR). Confers Lane serves as the divide between the two watersheds within the site.

The majority of wetlands delineated within the Walker Run watershed are contiguous to Walker Run or one of its tributaries. Wetlands are also located adjacent to tributaries to the Susquehanna River. Isolated wetlands, not hydrologically connected to a surface water body are present in both watersheds. These wetlands are primarily topographic depressions. Some wetlands that are contiguous with other wetlands or water bodies may appear isolated on the map because the wetland delineation ended at the BBNPP project boundary. A summary of surface water features (watercourses and ponds) is provided below. Multiple studies were completed by LandStudies and Normandeau to evaluate these surface water bodies. These studies were intended to assess baseline conditions within the surface water bodies of the site and included fish and macroinvertebrate surveys, habitat assessment, geomorphic assessment, substrate embeddedness, water quality testing, and pressure transducer measurements. These studies are listed in the reference section. Surface water features are shown on Figure 3 – Wetland Identification Map.

> Walker Run (8, 8A, 8B) is a perennial stream that is listed as a Cold Water Fishery (CWF) by PADEP Chapter 93 Water Quality Standards. It flows southward toward NBSR and west of the BBNPP footprint. Walker Run supports reproducing brown trout populations and has been designated as a wild trout stream by the PFBC; therefore all wetlands in or along the floodplain of Walker Run are exceptional value wetlands (25 Pa. Code § 105.17). Multiple springs, rainfall, and snowmelt influence the stream flow. Walker Run has a drainage area of about 4.1 mi^2 to the Susquehanna River.
>
> The Eastern Tributary to Walker Run (9, 9A), also referred to as the Unnamed Tributary, flows along the eastern and southern site boundaries of the proposed BBNPP footprint and discharges into Walker Run on the southwest side of the site. The unnamed tributary has a drainage area of about 0.68 mi^2 and an approximate length of 2.1 miles.
>
> Tributary 2 to Walker Run originates in Wetland 11 or the "teardrop wetland" and flows south into the Unnamed Tributary to Walker Run. It is piped beneath agricultural fields for approximately 560 feet between Wetland 11 and Wetland 12.3.

The Unnamed Tributary to Lake Took-A-While (30) is located south of the BBNPP site; it flows into the NBSR via Lake Took-A-While and the North Branch Canal (NBC). Its drainage area is not part of the Walker Run watershed.

Six ponds exist within the BBNPP project boundary. Johnson's Pond (12A) and the Farm Pond (10A) are spring fed. The Farm Pond outlets into Walker Run and Johnson's Pond outlets to the Eastern Tributary to Walker Run. The Beaver Pond (12B) is on the Eastern Tributary to Walker Run and was created by a beaver dam along an access road. Unnamed Pond 1 (18A) and Unnamed Pond 2 (17A) are isolated ponds east of Confers Lane. The southern end of Lake Took-A-While (35C) is located within the project boundary at the Riverlands and outlets into the NBC at its northern end. A few other surface water features that were delineated as palustrine open water (POW) areas exist within wetlands throughout the project area and are described in the Functions and Values Assessment section of this report.

The NBSR flows from north to south past the Susquehanna Steam Electric Station (SSES), makes a broad 90 degree turn to the west, and flows to the south of the BBNPP site before reaching Berwick, PA. The proposed BBNPP CWS Makeup Water Intake Structure site is approximately 22 miles downstream of Wilkes-Barre, PA and 5 miles upstream of Berwick, PA. The NBSR ultimately receives all surface water and groundwater that drains from the BBNPP site.

The NBC (39, 39B, and 39C) is located within the BBNPP project boundary at Susquehanna Riverlands, east of Route 11. The NBC was historically used within the region for transportation. Two unnamed tributaries feed the canal. One enters at the northern end of the reconstructed section of the NBC and the other flows into Lake Took-A-While which also provides flow to the canal. The Canal Outfall Channel (39A) is a manmade channel formed by overflow and seepage from the canal that discharges into the NBSR.

An ephemeral swale (35A) begins at a pipe culvert under the railroad tracks at the Riverlands. It receives flow draining from Wetland 34 and empties into Wetland 35, which surrounds Lake Took-A-While.

Approximately 630 linear feet of an Unnamed Tributary to the NBC (26) exists within the project boundary. This ephermeral watercourse is a man-made ditch/swale that was likely created in the past to drain existing wetlands for farming. Currently, this watercourse serves as an outlet to Wetland 25. Beyond the project boundary, it ultimately empties into a vast wetland area along the NBC at the Riverlands.

Land Use

The following primary land uses are present within the BBNPP/SSES project boundary include forest (36.7%), agriculture or old field/former agriculture (28.2%), developed (18.6%), wetlands (8.3%), upland scrub/shrub (5.3%), and water (3.0%) (Normandeau, 2010). A significant change of cropland

to fallow fields occurred between the 2009 and 2010 growing season. This land use change affected the suitability of multiple wetlands to perform the sediment/toxicant retention and nutrient removal and retention functions. The conversion to fallow land decreases the potential sources of nutrient and sediments within the wetland's watershed.

Susquehanna Riverlands

Susquehanna Riverlands is a recreational and educational facility owned and operated by PPL located east of Route 11. It encompasses 1,200 acres on both the east and west sides of the Susquehanna River. In addition to diverse ecological habitats, an important historical site is located within the Susquehanna Riverlands. A portion of the Riverlands property is located within the BBNPP project boundary.

Restored and unimproved sections of the historical NBC are located within the BBNPP project boundary. According to the PPL Corporation website, the NBC stretched from Pittston to Northumberland, a distance of 72.5 miles. In use during the period from 1830 to 1900, the canal was 40 feet wide at the top and 4-6 feet deep. The canal boats were 80 feet long and could haul up to 120 tons of cargo, which might include coal, flour, grain or lumber. These were drawn by teams of mules which traveled the tow paths that now form a portion of a walking trail.

The Susquehanna Riverlands has also been identified as an Important Bird Area (IBA) by the Pennsylvania Audubon Society. The IBA program was developed to locate important bird habitat using objective scientific criteria. The IBA designation can then be used by residents, planners, and state and local officials when making land planning and use decisions.

"A Guide to Critical Bird Habitat in Pennsylvania" provides the following information about the 2,500 acre IBA. The Susquehanna Riverlands has many diverse habitat types including cultivated fields, lawns, picnic and other outdoor recreation area, wetlands including marshes, riparian forests and swamps. The NBC provides excellent waterfowl habitat. Densities of some forest-interior or canopy species are fairly high due to extensive forested areas. Oak/hickory forests support good populations of scarlet tanager, ovenbird, worm eating warbler, pin warbler, red eyed vireo, and rose breasted grosbeak. Riparian forests support yellow throated vireo, warbling vireo, and American redstart. Thicket species include golden winged warbler, yellow breasted chat, blue winged warbler and brown thrasher. A total of 217 Bird species have been reported on site and 126 Species have been documented as breeding at the site (A Guide to Critical Bird Habitat in Pennsylvania, Crossley 1999).

The majority of wetlands supporting the values described in the functions and values assessment are located within the Riverlands. The remainder of the BBNPP site has restricted access and therefore the wetlands support few values.

Walker Run Watershed

Reproducing Brown Trout Populations and Exceptional Value Wetlands

Brown trout populations exist within Walker Run. Numerous fish sampling studies (Normandeau 2010, LandStudies 2009, PFBC 2009) revealed that these trout populations are reproducing and therefore Walker Run meets the criteria identified as a wild trout stream in 25 Pa. Code § 57.119(b). Unnamed tributaries to Walker Run are also included in the wild trout stream classification. According to 25 Pa. Code § 105.17, wetlands located in or along the floodplain of a wild trout stream are considered exceptional value wetlands (EV). Therefore most of the wetlands within the Walker Run watershed are considered exceptional value (isolated wetlands are exempt from EV status). Stream habitat evaluations were also performed on Walker Run and its unnamed tributaries. In general, upstream of Beach Grove Road, stream habitat is optimal to near optimal due to adequate shade, low substrate embeddedness, and sufficient riffle areas. The reach downstream of Beach Grove Road has marginal habitat quality attributed to greater substrate embeddedness, greater sediment deposition, fewer riffle areas, channelization, poor bank stability and vegetative protection. Many of these streams and wetland areas were altered by historical land use practices including farming and logging. In addition, topographic alterations due to infrastructure construction altered surface water flow paths and divided wetlands. These land use practices caused stream channelization, stream erosion, and sediment deposition in the stream valleys creating some of the poor habitat characteristics and substrate embeddedness problems documented in the aquatic studies. A 1939 aerial photograph of the BBNPP project boundary is shown in Figure 2.

Beaver Dam Removal

Significant beaver activity was occurring near the confluence of Walker Run and the Eastern Tributary to Walker Run within the BBNPP project boundary. A beaver dam was located immediately downstream of the confluence. The beaver dam caused significant backwater in both Walker Run and the Eastern Tributary contributing to inundation of some of the wetlands. Inundation increased with closer proximity to the beaver dam. These inundated conditions and increased groundwater levels were evident during the November 2009 field investigations. The beavers were relocated in spring 2010 and in April 2010 the beaver dam was removed. The dam removal significantly affected the hydrologic conditions in wetlands 10.1, 10.2, and 10.3. The area was re-assessed during the July 2010 field investigations to account for any functions and values changes resulting from the beaver dam removal. The functions and values described in the report are based on the current condition, with no dam present.

Another beaver dam was located along an existing access road, which created an open water area described in this report as the "Beaver Pond" (12B) within Wetland 12.2. In September 2010, this beaver dam was removed and the pond was drained in order to replace the culvert pipe under the access road. A weir structure will be installed to re-establish the open-water that had existed behind the beaver dam.