Bell Bend Project Site: Supplemental Field Assessments for PPL Riverlands

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I. INTRODUCTION

Additional field assessments of Walker Run and three other streams at the Bell Bend project site were completed in the fall of 2009. Prior to this additional field work, fisheries surveys, habitat assessments, and macroinvertebrate surveys had been completed on Walker Run, and were published earlier in 2009. This report will present the assessment findings for North Branch Canal Outlet Channel at the PPL Riverlands Property,

The field assessments completed in the fall of 2009 on the outlet channel for the North Branch Canal include:

- Substrate embeddedness assessments on two reaches.
- Habitat assessments on two reaches.
- Macroinvertebrate community assessments or two reaches.

The following report describes the findings of these field assessments.

II. METHODS

A. Substrate Embeddedness and Characterization. A substrate embeddedness and characterization survey was conducted on two reaches on the outlet channel of the north branch canal at Riverlands (Figure 1) in the fall of 2009.

At each stream reach, seven transects were established across the stream and perpendicular to the stream flow. The seven transects were located at 25-ft increments over the 150-ft stretch of stream reach. Up to nine survey points were located across each transect, depending on the stream width. Substrate embeddedness and substrate characterizations were made visually at each survey point across the transect. If the stream was wide enough to accommodate nine survey points per transect, then each stream reach would have 63 substrate embeddedness and 63 substrate characterization measurements.

Substrate embeddedness assessments were made visually using the protocols established in Platts, Megahan, and Minshall (1983)[1]. A 150-ft reach of stream was selected at random within each of the seven stream regions. A tape measure was used to establish the seven transects at 25-ft intervals along the 150-ft reach of stream. The survey points along each transect were selected at equal intervals across the stream at each transect. A view bucket with a 9-in diameter Plexiglas bottom was used to observe the stream substrate at survey points with sufficient water depth; otherwise, the substrate was viewed without a view bucket.

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[1] Platts, W.S., W.F. Megahan and W.G. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT-138, USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Embeddedness is defined as the degree to which sand, silt, and clay particles (collectively referred to as fines) surround or cover larger gravel, cobble, and boulder materials in the bottom of the stream. The percentage of fines surrounding these coarser particles is visually estimated as a percentage, and an embeddedness rating is derived from this percentage as follows[2]:

Rating	Description
5	< 5 percent of gravel, cobble, and boulder particles covered by fine sediments
4	5 to 25 percent of gravel, cobble, and boulder particles covered by fine sediments
3	25 to 50 percent of gravel, cobble, and boulder particles covered by fine sediments
2	50 to 75 percent of gravel, cobble, and boulder particles covered by fine sediments
1	> 75 percent of gravel, cobble, and boulder particles covered by fine sediments

We determined embeddedness ratings intermediate between these numbers based on the visually estimated percentage of fines surrounding the gravel cobble and boulder particles. A visually estimated percentage of 40 percent, for instance, would be noted with an embeddedness rating of 3.4. Substrate embeddedness is a significant predictor of wild trout abundance in streams, as streams with low embeddedness (i.e., a high embeddedness rating number) have conditions conducive to trout spawning success.

Substrate composition was determined visually by estimating the percent of the viewed area of substrate composed of each of the following substrate size classes[1,3]:

Substrate Class	Size Range
Boulder	> 12 inches
Rubble	10 to 12 inches
Cobble	2.5 to 10 inches
Gravel	3/32 to 2.5 inches
Sand	< 3/32 inches
Silt and Clay	< 0.08/32 inches (visually identified)

B. <u>Stream Habitat Assessments</u>. Visual habitat assessments were performed at two reaches of the north branch canal outlet channel at Riverlands during the fall of 2009. The low gradient habitat assessment field methodology, in the EPA's Rapid Bioassessment Protocols (RBP)[4], was utilized for these stream habitat assessments.

[2] Sylte, T. L. and J. C. Fischenich. 2002. Techniques for measuring substrate embeddedness. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-36), U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.
[3] Clean Water Services. 2000. Tualatin River Basin Rapid Stream Assessment Technique (RSAT). Watersheds 2000 Field Methods. Clean Water Services, Watershed Management Division, Hillsboro, Oregon.
[4] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

The RBP evaluates ten habitat quality parameters on a 0 to 20 scale, with scores of 16 to 20 indicating optimal habitat quality, scores of 11 to 15 indicating suboptimal habitat quality, scores of 6 to 10 indicating marginal habitat quality, and scores of 0 to 5 indicating poor habitat quality. The location of the two assessment reaches are shown in Figure 1. The ten habitat quality parameters in the RBP protocols are defined on the following page.

C. Macroinvertebrate community surveys. Macroinvertebrate community surveys were performed in two reaches on the north branch canal outlet channel at Riverlands in the fall of 2009. A 500-micron mesh D-frame net (12-inch width) was used to collect stream macroinvertebrates from four separate riffle or run locations within each sampling reach. The four sampling locations were selected to include the spectrum of habitat conditions in each reach. At each reach, the four separate location samples were composited into one sample to provide a stream reach characterization. The locations of the macroinvertebrate community sampling reaches are shown in Figure 1.

Macroinvertebrate samples from each reach were preserved in isopropyl alcohol in the field. Samples were sorted into vials in the laboratory using a 5X illuminated magnifying lamp. All samples were sorted completely. Organisms were identified to the genus level using a stereo microscope, except for midge larvae (Family Chironomidae), nematodes (Phylum Nematoda), and segmented worms (Class Oligochaeta).

Each taxonomic group of macroinvertebrate organisms (typically at the genus level) has a pollution tolerance value published in the scientific literature. Tolerance values range from 0 (no tolerance to pollution) to 10 (high tolerance to pollution). Tolerance values in this study were averaged across those published in three literature sources.[5] Pollution tolerance values were utilized to calculate the Hilsenhof Biotic Index[6], which provides a single index of the water quality of a stream reach based on the pollution tolerance of the macroinvertebrates collected there. Hilsenhof Biotic Index scores of 0 to 4.5 indicate good water quality, while scores of 8.5 to 10 indicate very poor water quality and intermediate scores indicate fair to poor water quality.

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[5] (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

[6] Hilsenhof, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist, vol. 20: 31-39.

Table 1. Habitat Quality Parameters used in the North Branch Canal Outlet Channel Stream Habitat Assessment

Habitat Quality Parameter	Definition[7]
Epifaunal Substrate and Available Cover	Includes the relative quantity and variety of natural structures in the stream, such as cobble, large rocks, fallen trees, logs and branches, and undercut banks that are available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
Pool Substrate Characterization	Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom.
Pool Variability	Rates the overall mixture of pool types found in streams: large-shallow, large-deep, small shallow, and small-deep. Streams with the majority of pools being either small-shallow or absent have poor habitat quality.
Sediment Deposition	Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of sediment deposition. Streams with heavy deposits of sediments with pools almost absent have poor habitat quality.
Channel Flow Status	The degree to which the stream channel is filled with water. Streambeds with very little water and present mostly as standing water have poor channel flow status.
Channel Alteration	The degree to which the stream has been channelized, dredged, or stabilized with shoring structures.
Channel Sinuosity	The degree of sinuosity evaluates the meandering of the stream, with high sinuosity indicative of optimal habitat quality.
Bank Stability	An evaluation of whether the streambanks are eroded. Signs of erosion include crumbling, unvegetated banks with exposed tree roots and exposed soil.
Vegetative Protection of Streambanks	Measures the amount of vegetative protection for the streambanks and immediate riparian zone.
Riparian Vegetation Zone Width	Measures the width of natural vegetation from the edge of the streambank out through the riparian zone.

[7] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Figure 1. Habitat assessment, sediment embeddedness, and macroinvertebrate sampling locations on the outlet channel of the north branch canal.

III. FINDINGS

A. Substrate Embeddedness and Characterization – Outlet Channel of the North Branch Canal. Two reaches of stream of the north branch canal outlet channel at Riverlands were surveyed for substrate embeddedness and composition (Table 2). The lower (downstream reach nearer the Susquehanna River) had low stream embeddedness, with an embeddedness rating of 3.2. The stream substrate was dominated by gravel and cobble, which comprised an average of 57 percent of the bottom. The lower reach was a combination of run and riffle habitats, and had an average stream width of 2.3 ft and an average water depth of 0.2 ft.

The upper reach of the stream was just below the weir of the discharge canal. This reach was typically run habitat, with an average stream width of 4.3 ft and an average water depth of 0.3 ft. This reach had high substrate embeddedness, with an average embeddedness rating of 1.6 (Table 2). The stream substrate was dominated by a combination of silt and gravel, with sand and clay also present. Gravel and cobble comprised an average of 24.2 percent of the stream bottom.

Table 2. Substrate embeddedness and stream morphometric and substrate characteristics for the North Branch Canal Outlet Channel at Riverlands.

Stream Station	Transect No.	Stream Width (ft)	Average Water Depth (ft)	Habitat Type	Dominant Substrate Type	Median Embeddedness (%)	Transect Embeddedness Rating	Percent Fines*	Median Percent Silt and Clay	Median Percent Sand (< 3/32")	Median Percent Gravel (3/32" to 2.5")	Median Percent Cobble (2.5" to 10")	Median Percent Rubble (10" to 12")	Median Percent Boulder (> 12")
Stream from Discharge Canal - Lower Reach														
DCS-L	TA	2.5	0.14	Run	gravel/cobble	42.5	3.3	26.3%	5.0%	42.5%	35.0%	17.5%	0.0%	0.0%
DCS-L	TB	1.9	0.24	Riffle	gravel/cobble	30.0	3.7	18.8%	5.0%	27.5%	45.0%	22.5%	0.0%	0.0%
DCS-L	TC	1.8	0.24	Run	cobble/gravel	52.5	2.8	26.3%	10.0%	32.5%	32.5%	25.0%	0.0%	0.0%
DCS-L	TD	2.1	0.17	Riffle	gravel/cobble	32.5	3.6	17.5%	5.0%	25.0%	35.0%	30.0%	0.0%	0.0%
DCS-L	TE	2.6	0.20	Riffle	gravel	37.5	3.5	17.5%	5.0%	25.0%	52.5%	15.0%	0.0%	0.0%
DCS-L	TF	2.4	0.28	Run	cobble/sand	45.0	3.2	22.5%	7.5%	30.0%	20.0%	37.5%	0.0%	5.0%
DCS-L	TG	2.7	0.29	Run	sand/gravel	72.5	2.1	40.0%	12.5%	55.0%	20.0%	12.5%	0.0%	0.0%
DCS-L	**7**	**2.3**	**0.22**	**Run/Riffle**	**gravel/cobble**	**44.6**	**3.2**	**24.1%**	**7.1%**	**33.9%**	**34.3%**	**22.9%**	**0.0%**	**0.7%**
Stream from Discharge Canal - Upper Reach														
DCS-U	TA	5.2	0.42	Run	silt	100.0	1.0	92.5%	85.0%	15.0%	0.0%	0.0%	0.0%	0.0%
DCS-U	TB	3.1	0.20	Run	sand	100.0	1.0	56.3%	22.5%	67.5%	7.5%	0.0%	0.0%	0.0%
DCS-U	TC	3.7	0.50	Run	silt/clay	100.0	1.0	96.3%	92.5%	7.5%	0.0%	0.0%	0.0%	0.0%
DCS-U	TD	4.8	0.55	Run	silt	100.0	1.0	93.8%	87.5%	12.5%	0.0%	0.0%	0.0%	0.0%
DCS-U	TE	2.9	0.04	Riffle	gravel	15.0	4.5	6.3%	0.0%	12.5%	65.0%	22.5%	0.0%	0.0%
DCS-U	TF	6.5	0.36	Run	gravel	90.0	1.4	18.8%	10.0%	17.5%	65.0%	10.0%	0.0%	0.0%
DCS-U	TG	3.6	0.19	Run	silt	100.0	1.0	90.0%	80.0%	20.0%	0.0%	0.0%	0.0%	0.0%
DCS-U	**7**	**4.3**	**0.32**	**Run**	**silt/gravel**	**86.4**	**1.6**	**64.8%**	**53.9%**	**21.8%**	**19.6%**	**4.6%**	**0.0%**	**0.0%**

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

B. Habitat Assessments – Outlet Channel for the North Branch Canal. Two stream reaches in the outlet channel of the north branch canal at Riverlands were assessed for habitat quality using the EPA RBP methods. The habitat assessment scores for these reaches were 7.5 and 6.3, both in the marginal habitat quality category (Table 3). Habitat quality in the lower reach was rated slightly higher, but still in the marginal habitat quality category.

Habitat quality in the Riverlands stream from the discharge canal was rated marginal because of poor epifaunal substrate, pool substrate, pool variability, channel alteration, vegetative protection, riparian vegetation zone width, and channel sinuosity. Additionally, habitat quality was marginal in the lower reach because of bank stability, and marginal in the upper reach because of sediment deposition and channel flow status.

Table 3. Habitat assessment scores for the two reaches on the outlet channel of the north branch canal at Riverlands

Habitat Category	DC-Main Lower	DC-Main Upper	Scoring Descriptions
Epifaunal substrate / available cover	9	2	
Pool substrate characterization	6	7	
Pool variability	4	6	Optimal: 20 to 16
Sediment deposition	15	3	Suboptimal:15 to 11
Channel flow status	13	10	Marginal: 10 to 6
Channel alteration	6	6	Poor: 5 to 0
Channel sinuosity	5	5	
Bank stability	4	12	
Vegetative protection	4	6	
Riparian vegetation zone width	9	6	
Average Score:	**7.5**	**6.3**	

C. Macroinvertebrate Community Surveys – Outlet Channel for the North Branch Canal. The macroinvertebrate community was surveyed at two reaches or the north branch canal outlet channel (Figure 1). A total of 28 macroinvertebrate taxa were collected from the Riverlands stream (Table 4) comprised of 1,322 individuals. The macroinvertebrate community was dominated by sow bugs (*Caecidotea*, 25 %), moths (*Neocataclysta*, 21 %), midges (Chironomidae, 15 %), and flatworms (*Phagocata*, 10 %). These four taxonomic groups constituted about 71 % of the macroinvertebrate community in the Riverlands stream. This type of dominance typically indicates fair to poor water quality conditions.

The macroinvertebrate community metrics also indicate that the Riverlands stream has fair to poor water quality (Table 5). The two reaches are similar in their macroinvertebrate community metrics, with Hilsenhof Biotic Index values of 6.3 and 6.5 for the upper and lower reaches respectively.

Table 4. Macroinvertebrates collected from the North Branch Canal Outlet Channel, with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	DC Stream-Upper	DC Stream-Lower	Tolerance Value
Acariformes					6.0
Hoplonemertea	Tetrastemmatidae	*Prostoma*		3	7.7
Tricladida	Planariidae	*Dugesia*	16		7.4
Tricladida	Planariidae	*Phagocata*	4	128	7.2
Hirudinida	Erpobdellidae		3		10.0
Hirudinida	Glossiphoniidae	*Helobdella*	4		6.0
Oligochaeta			9	11	8.3
Amphipoda	Hyalellidae	*Hyalella*			4.7
Amphipoda	Gammaridae	*Crangonyx*	53	32	5.6
Amphipoda	Gammaridae	*Gammarus*	3	80	6.2
Isopoda	Asellidae	*Caecidotea*	176	156	6.2
Bivalvia	Sphaeridae	*Pisidium*	11	9	6.6
Gastropoda	Physidae	*Physa*	52	6	7.7
Gastropoda	Lymnaeidae	*Fossaria*			7.0
Gastropoda	Hydrobidae	*Amnicola*			7.0
Gastropoda	Planorbidae	*Helisoma*			6.5
Megaloptera	Sialidae	*Sialis*			3.3
Lepidoptera	Pyraulidae	*Neocataclysta*	196	88	5.5
Odonata	Aeshnidae	*Aeshna*			5.5
Odonata	Aeshnidae	*Boyeria*			3.4
Odonata	Calopterygidae	*Calopteryx*			6.8
Odonata	Coenagrionidae	*Enallagma*	18		8.3
Odonata	Cordulegastridae	*Cordulegaster*			2.8
Odonata	Gomphidae	*Gomphus*			4.1
Coleoptera	Elmidae	*Dubiraphia*	1		5.9
Coleoptera	Elmidae	*Optioservus*			4.5
Coleoptera	Elmidae	*Stenelmis*			6.0
Coleoptera	Dryopidae	*Helichus*			5.5
Coleoptera	Hydrophilidae	*Hydrobius*			4.7
Coleoptera	Dytiscidae	*Agabus*			5.1
Coleoptera	Dytiscidae	*Hydroporus*	1		4.9
Diptera	Ceratopogonidae	*Bezzia*			5.1
Diptera	Ceratopogonidae	*Ceratopogon*		1	4.9
Diptera	Ceratopogonidae	*Culicoides*	2		8.6
Diptera	Ceratopogonidae	*Palpomyia*	1		6.0
Diptera	Ceratopogonidae	*Probezzia*			5.0

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 4 (continued). Macroinvertebrates collected from the North Branch Canal Outlet Cl with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	DC Stream-Upper	DC Stream-Lower	Tolerance Value
Diptera	Chironomidae		57	140	7.3
Diptera	Empididae	*Hemerodromia*			6.6
Diptera	Culicidae	*Anopheles*			8.0
Diptera	Culicidae	*Psorphora*			8.0
Diptera	Ephydridae				6.0
Diptera	Psychodidae	*Pericoma*			4.0
Diptera	Ptychopteridae	*Ptychoptera*			4.0
Diptera	Simuliidae	*Prosimulium*			3.8
Diptera	Simuliidae	*Simulium*		1	6.2
Diptera	Tipulidae	*Dicranota*			2.7
Diptera	Tipulidae	*Hexatoma*		1	2.5
Diptera	Tipulidae	*Limnophila*			3.9
Diptera	Tipulidae	*Pedicia*			4.4
Diptera	Tipulidae	*Pseudolimnophila*		2	2.3
Diptera	Tipulidae	*Tipula*		3	5.6
Diptera	Stratiomyidae	*Allognasta*			7.0
Diptera	Stratiomyidae	*Odontimyia*	1		7.0
Diptera	Tabanidae	*Chrysops*			5.0
Diptera	Tabanidae	*Tabanus*		1	4.3
Ephemeroptera	Caenidae	*Caenis*			5.4
Ephemeroptera	Heptageniidae	*Maccaffertium*			4.0
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*			1.7
Ephemeroptera	Leptophlebiidae	*Leptophlebia*			3.3
Plecoptera	Chloroperlidae	*Haploperla*			1.3
Plecoptera	Capniidae	*Allocapnia*			3.4
Plecoptera	Nemouridae	*Soyedina*			2.5
Trichoptera	Dipseudopsidae	*Phylocentropus*			5.0
Trichoptera	Hydropsychidae	*Cheumatopsyche*		40	5.5
Trichoptera	Hydropsychidae	*Hydropsyche*			5.8
Trichoptera	Hydropsychidae	*Diplectrona*			3.2
Trichoptera	Limnephilidae	*Hydatophylax*			2.5
Trichoptera	Limnephilidae	*Pycnopsyche*			3.7
Trichoptera	Molannidae	*Molanna*			6.0
Trichoptera	Philopotamidae	*Chimarra*		8	4.1
Trichoptera	Philopotamidae	*Dolophilodes*			0.6
Trichoptera	Phryganeidae	*Ptilostomis*	4		4.8
Trichoptera	Psychomyiidae	*Lype*			2.9
Total Organisms per Sample:			612	710	= 8,264

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 5. Macroinvertebrate community metrics for the North Branch Canal Outlet Channel, including the Hilsenhof biotic index.

Benthic Community Metric	DC Stream-Upper	DC Stream-Lower
Hilsenhof Biotic Index (scores defined below)	6.3	6.5
Number of Intolerent Taxa (tolerance values < 3.0)	0	2
Number of EPT Taxa	1	2
EPT Ratio	0.7%	6.8%
Percent Ephemeroptera Taxa	0.0%	0.0%
Percent Plecoptera Taxa	0.0%	0.0%
Percent Trichoptera Taxa	0.7%	6.8%
EPT to Diptera Ratio	0.07	0.32

Hilsenhof Biotic Index Score Definitons for Water Quality:
Scores of 0 to 4.5 are rated good
Scores of 4.51 to 6.5 are rated fair
Scores of 6.51 to 8.5 are rated poor
Scores of 8.51 to 10.0 are rated very poor

IV. SUMMARY – NORTH BRANCH CANAL OUTLET CHANNEL

The outlet channel originates from regulated flow out of the north branch canal weir. Seepage and overflow from the north branch canal just downstream of the weir also contribute flow to the outlet channel. The channel flows through a relatively flat area, where stream banks are low to moderate in height. Further downstream, however, the channel is entrenched with high and eroding stream banks that have developed from a headcut. Photographs of the Riverlands stream are provided in the Appendix.

The substrate embeddedness and composition survey found fair to poor habitat conditions (high substrate embeddedness, gravel and cobble substrate about 24 percent) in the upper reach of the north branch canal outlet channel stream. The downstream (lower) reach, however, had good substrate conditions, with the substrate dominated by cobble and gravel (57 percent) and with substrate embeddedness relatively low.

The habitat quality was found to be marginal in the habitat assessment surveys of the upper and lower reaches of the outlet channel. Macroinvertebrate community surveys showed fair to poor water quality in both reaches, as determined using the macroinvertebrate biotic index. Even though substrate embeddedness was low and gravel/cobble substrate composition was high in the lower reach, the macroinvertebrate community was fair to poor across all the community metrics. This may be caused by poor water quality in the stream.

These surveys collectively indicate marginal habitat conditions in the Unnamed Tributary.

V. REFERENCES

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APPENDIX

Photographs of the North Branch Canal Outlet Channel

Habitat Assessments, Macroinvertebrate Sampling, and Substrate Embeddedness Surveys

Outlet Channel of the North Branch Canal

Stream facing downstream towards the Susquehanna River (left)
and upstream towards the North Branch Canal (right).

Outlet Channel of the North Branch Canal

Facing upstream.

Substrate in riffle.

Outlet Channel of the North Branch Canal

Substrate downstream in the outlet channel.

Substrate in riffle.

Outlet Channel of the North Branch Canal

Stream facing upstream (left) and downstream (right). A tributary joins the main channel in the photo on the right. This water is seeping through the earthen dam at the North Branch Canal.

Outlet Channel of the North Branch Canal

Substrate characteristic of the upstream section of the outlet channel.

Silt causes turbid water in the upstream section of the outlet channel.

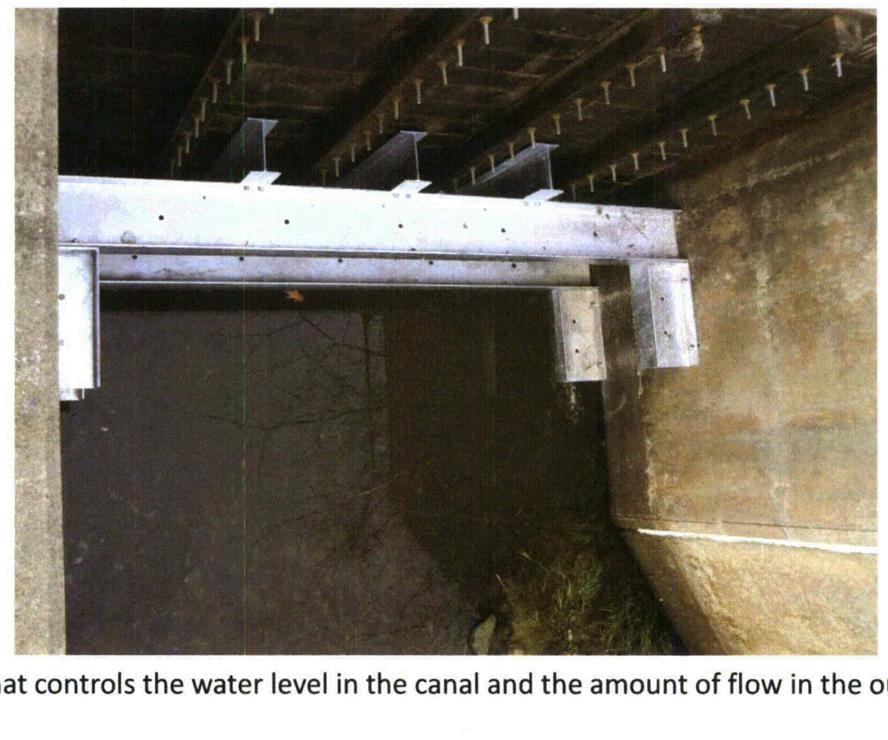
Outlet Channel of the North Branch Canal

Substrate characteristic of the upstream section of the outlet channel.

Silt causes turbid water in the upstream section of the outlet channel.

Outlet Channel of the North Branch Canal

Stream channel just below weir.



Weir that controls the water level in the canal and the amount of flow in the outlet channel.