

PARADISE CREEK

MONROE COUNTY

WATER QUALITY STANDARDS REVIEW STREAM REDESIGNATION EVALUATION REPORT

**Segment: Basin, source to Lake Crawford
Stream Code: 04933
Drainage List: C**

**WATER QUALITY MONITORING SECTION (JSB)
DIVISION OF WATER QUALITY
BUREAU OF CLEAN WATER
DEPARTMENT OF ENVIRONMENTAL PROTECTION**

2018

INTRODUCTION

The Department of Environmental Protection (Department) conducted an evaluation of the Paradise Creek basin upstream of Lake Crawford in response to a petition from the Brodhead Chapter of Trout Unlimited. The petitioner requested that the Paradise Creek basin from its source to Lake Crawford be redesignated Exceptional Value (EV). The petition was received by the Department on June 25, 2014, and was accepted by the Environmental Quality Board (EQB) on August 19, 2014. In response to this petition, the Department reviewed available chemical, physical, and biological data. In addition, Department staff conducted field surveys in the basin in 2015.

The stream redesignation process begins with an evaluation of the “existing uses” and the “designated uses” of a stream. “Existing uses” are water uses actually attained in the waterbody. Existing uses are protected through permit or approval actions taken by the Department. “Designated uses” are water uses identified in regulations that protect a waterbody. Candidates for stream redesignation may be identified by the Department based on routine waterbody investigations, or based on requests initiated by other agencies or from the general public through a rulemaking petition to the EQB.

GENERAL WATERSHED DESCRIPTION

Paradise Creek is a tributary to Brodhead Creek. The upper Paradise Creek basin petition area contains streams that are relatively small freestone streams. These streams may also be described as cold and shallow and are first to third-order streams. The entire Paradise Creek basin is currently designated High Quality – Cold Water Fishes, Migratory Fishes (HQ-CWF, MF), except for Devils Hole Creek from its source to the south boundary of State Game Lands (SGL) 221, which is currently designated EV (Figure 1).

The petitioned area of the upper Paradise Creek basin contains approximately 23.6 miles of stream draining an area of 13.9 square miles. Approximately 28% of the petitioned basin is contained within SGL 221. This area is part of the greater Pocono Plateau with low to moderate topography. The current land use of the upper Paradise Creek basin consists of approximately 86% forest, 10% urban development, and about 4% as lakes, ponds, reservoirs, and wetlands. Urban development includes housing developments along State Route (SR) 196 in eastern Coolbaugh Township, Mount Pocono Borough, and development in the vicinity of the SR 390, SR 940 and SR 191 intersections. There are currently three permitted sewage discharges, one permitted sewage pump station, three pesticide application permits, and six public water supply wells throughout the Paradise Creek basin upstream of Lake Crawford.

WATER QUALITY AND USES

Water Chemistry

The Department collected in-situ field meter data from candidate and reference stations in 2013 and 2015, as well as comprehensive water chemistry samples from candidate stations in 2015 (Tables 2 & 3). In 2013, specific conductance was highest at Yankee Run (2YR) and lowest at Tank Creek (1TC).

Specific conductance on Paradise Creek at station 3PC was greater than at station 5PC in 2013, and station 3PC was greater than 6PC in 2015. This is likely due in part to the influence of Yankee Run (2YR). Alkalinity and pH results across candidate and reference stations for both 2013 and 2015 are similar (Tables 2 & 3).

Aquatic Biota

The indigenous aquatic community of a surface water is an excellent indicator of long-term conditions and is used as a measure of water quality. Department staff collected habitat and benthic macroinvertebrate data at four locations on petitioned reaches in March 2013 as well as a reference sample from an EV reach on Devils Hole Creek (DHC) and an additional EV reference sample from Dimmick Meadow Brook (DMB), Pike County. Samples from the upper Paradise Creek basin, including Devils Hole Creek as well as the EV reference samples from Dimmick Meadow Brook were collected prior to petition submission and acceptance. The Department also collected three additional stations on petitioned reaches in April and May 2015, along with an additional EV reference station on Dimmick Meadow Brook.

Habitat. Instream habitat was assessed at each station where benthic macroinvertebrates were sampled (Tables 4 & 5). The habitat evaluation consists of rating twelve parameters to derive a station habitat score. The total habitat scores ranged from 145 (6PC) to 224 (2YR) with suboptimal scores at all 2015 candidate stations (3PC, 4DHC, 6PC). Suboptimal scores were influenced by suboptimal and marginal parameters scores for channel alterations, grazing/disruptive pressures, and riparian zone width. Habitat scores generally decrease from upstream stations to downstream stations.

Benthos. Benthic macroinvertebrate samples were collected using the Department's Rapid Bioassessment Protocols (RBP) benthic sampling methodology, which is a modification of EPA's RBP (Barbour et al. 1999, Plafkin et al. 1989) (Tables 6 & 7). Macroinvertebrate samples across the upper Paradise Creek basin represent outstanding to good water quality conditions. Samples were dominated by sensitive Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa. The lowest number of sensitive EPT taxa was found at Yankee Run (2YR) in 2013 and the highest at Tank Creek (1TC). Yankee Run also had an elevated number of Chironomidae, a pollution tolerant taxa, while Tank Creek (1TC) had the lowest (Table 6). Outstanding water quality will be dominated by a high number of sensitive taxa and a low number of pollution tolerant taxa. Tank Creek and Yankee Run are two headwater tributaries that confluence to form the upper reaches of Paradise Creek (Figure 1).

Samples from 2013 and 2015 collected on the upper reaches of Paradise Creek (3PC) were evaluated and included in this report. This reach is influenced by both outstanding water quality from Tank Creek as well as good, but not great, water quality from Yankee Run. The 2013 Paradise Creek (3PC) sample had less sensitive EPT taxa than Tank Creek (1TC) and more than Yankee Run (2YR). The 2013, 3PC sample also had more pollution tolerant Chironomidae than Tank Creek (1TC) and Yankee Run (2YR), while the 2015, 3PC sample had less pollution tolerant Chironomidae than the 2013 Yankee Run (2YR) sample. The 2013 Paradise Creek (3PC) sample also had more sensitive EPT taxa than the sample collected at this site in 2015 (Tables 6 & 7). This is a very simple but useful comparison that begins to illustrate how outstanding water quality meets and mixes with water of lesser quality to influence a

downstream reach. Comparisons of the 2013 versus the 2015 3PC sample also allude to the potential for variable water quality conditions in this reach.

Additional macroinvertebrate samples were collected on downstream reaches of Paradise Creek. Station 5PC was located a considerable distance downstream of the confluence with Devils Hole Creek and downstream of an area that has more urban land use. Station 6PC was located farther downstream and just upstream of Lake Crawford (Figure 1). A sample was collected from 5PC in 2013, and a sample was collected from 6PC in 2015. The macroinvertebrate community from each station is indicative of good water quality. Both samples maintain a high number of sensitive EPT taxa, but are dominated by an increasing number of pollution tolerant individuals.

A candidate station sample was collected from the lower mainstem of Devils Hole Creek (4DHC) in 2015. This reach is currently designated HQ-CWF, MF and is located in an area with more urban land use (Figure 1). The macroinvertebrate community at 4DHC shows some changes due to increased urban influence with less sensitive EPT taxa but continues to maintain a high number of sensitive individuals across all taxa (Table 7).

BIOLOGICAL USE QUALIFICATIONS

The Department applied its integrated benthic macroinvertebrate scoring tests described at § 93.4b(b)(1)(v) to the Paradise Creek basin. Selected benthic macroinvertebrate community metrics from Paradise Creek basin were compared to reference stations from Dimmick Meadow Brook and from the reach on Devils Hole Creek that is currently designated EV. The EV reference station on Devils Hole Creek was used as a reference because the site and sample qualify as an EV reference sample (PADEP 2013), the site represents a similar drainage area to the candidate stations, and the sample was available as part of the 2013 Paradise Creek basin dataset. Dimmick Meadow Brook was used as a reference sample because it is a very high scoring reference sample for the region, the site and the sample qualify as an EV reference sample (PADEP 2013), and the site represents a similar drainage area and stream type to the candidate basins. Sampling of candidate and reference stations was conducted within a temporally narrow window to minimize seasonal variation. Comparisons with the following metrics were used as an indicator of community health: taxa richness, modified EPT index, modified Hilsenhoff Biotic Index(HBI), percent dominant taxon, and percent modified mayflies.

March 2013 candidate stations compared to the reference station on Devils Hole Creek (DHC) had Biological Conditions Scores (BCS) of 100% and 95% for Tank Creek (1TC) and Paradise Creek (3PC), while Yankee Run (2YR) and Paradise Creek (5PC) near the intersection of SR 940 and SR 941 had BCS that were 55% and 50% (Table 8). When compared to the reference station on Dimmick Meadow Brook (DMB), March 2013 candidate stations had the following BCS: Tank Creek (1TC) – 100%, Yankee Run (2YR) – 50%, Paradise Creek (3PC) – 83%, Paradise Creek (5PC) – 48% (Table 9). Three additional candidate stations collected in late-April 2015 had the following BCS when compared to an EV reference station on Dimmick Meadow Brook: Paradise Creek (3PC) – 90%, Devils Hole Creek (4DHC) – 95%, and Paradise Creek (6PC) upstream of Lake Crawford – 60% (Table 10).

March 2013 candidate stations on Tank Creek (1TC) and Paradise Creek (3PC) exceed the 92% EV qualifying criterion at § 93.4b(b)(1)(v) when compared to the Devils Hole Creek (DHC) reference sample. When compared to the Dimmick Meadow Brook (DMB) reference sample, Tank Creek (1TC) exceeds the 92% EV qualifying criteria, while Paradise Creek (3PC) does not. The April 2015 candidate station located on the lower reaches of Devils Hole Creek (4DHC) exceeds the 92% EV qualifying criterion when compared to the 2015 Dimmick Meadow Brook (DMB) reference sample. The reference stations on Devils Hole Creek (DHC) and Dimmick Meadow Brook (DMB) and the individual reference samples used for the candidate/reference evaluation are appropriate reference stations/samples (PADEP 2013). The BCS for Paradise Creek (3PC) meets the EV qualifying criterion in 2013 when compared to the Devils Hole Creek (DHC) reference.

The difference in the BCS for Paradise Creek (3PC) in 2013, which straddle the 92% EV qualifying criteria, highlights that the metric scores for 3PC are representative of slightly lesser water quality than Tank Creek (1TC), for example. While 3PC has a higher taxa richness (30 vs. 27), 1TC has a higher modified EPT index (18 vs. 20), a lower modified HBI (2.85 vs. 2.20), a lower percent dominant taxa (28.0 vs. 24.5), and a higher percent modified mayflies metric score (18.8 vs. 31.4) (Table 8). These differences in metric scores for these two 2013 stations (3PC & 1TC) are primarily driven by higher abundances of pollutant tolerant Chironomidae (Tables 6, 8 & 9).

The confluence of Tank Creek and Yankee Run begins the farthest upstream reach of Paradise Creek proper. As described previously, this reach of Paradise Creek (3PC) is influenced by both outstanding water quality from Tank Creek (1TC) as well as good, but not great, water quality from Yankee Run (1YR). Yankee Run does not meet the 92% EV qualifying criteria (BCS = 55% and 50%). Tank Creek meets the 92% EV qualifying criteria (BCS = 100% and 100%) (Tables 8 & 9). Station 3PC is located approximately one mile downstream of both Tank Creek (1TC) and Yankee Run (1YR) (Figure 1). The outstanding water quality from Tank Creek mixes with Yankee Run and begins to dilute and assimilate pollutants from the urbanized influence of Mount Pocono Borough located in the headwaters of Yankee Run. The Tank Creek basin is primarily forested and flows out of SGL 221. As a result, the BCS for Paradise Creek (3PC) are variable, indicative of slightly lesser water quality than Tank Creek, better water quality than Yankee Run, and demonstrates that Paradise Creek (3PC) meets the EV qualifying criterion in 2013.

The farthest upstream reaches of Paradise Creek (3PC), Tank Creek, and Devils Hole Creek have demonstrated, via the Department's integrated benthic macroinvertebrate scoring tests described at § 93.4b(b)(1)(v), an existing use of EV. Subsequent candidate/reference evaluations do not supersede prior demonstrations of meeting the EV use, and any additional biological measures of water quality would be used to measure changes in water quality from the benchmark biological characterization. The benchmark for water quality is that use attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (25 Pa. Code §93.1).

ADDITIONAL EXCEPTIONAL VALUE WATERS QUALIFYING CRITERIA

Due to SGL 221 encompassing approximately 28% of the upper Paradise Creek basin the Department evaluated additional antidegradation criteria listed in § 93.4b(b). These additional criteria include:

- A. The water is an outstanding National, State, regional or local resource water [§ 93.4b(b)(1)(iii) – see Appendix A¹];
- B. The water is a surface water of exceptional ecological significance [§ 93.4b(b)(2) – see Appendix A²].

Areas of Paradise Creek that satisfy these EV qualifying criteria are discussed below:

A. Waters qualifying as EV as outstanding National, State, regional or local resource waters under § 93.4b(b)(1)(iii):

The “outstanding resource waters” EV criterion described at 25 Pa. Code § 93.4b(b)(1)(iii) may be applied to the petitioned waters since they are currently designated High Quality. The definition of “outstanding National, State, regional or local resource waters” in § 93.1 requires adoption of “water quality protective measures”. “Coordinated water quality protective measures”, also defined at § 93.1, are required for regional or local governments (See Appendix A). Such water quality protective measures have been applied through management activities implemented on lands that are situated along watershed corridors in a manner that provides protection to substantial reaches of the corridor within the Paradise Creek basin as described below:

Outstanding State Resource Waters

The Department evaluated water quality protective measures developed by the Pennsylvania Game Commission (PGC) to protect aquatic and adjacent riparian areas as important habitats on state game lands. The PGC has issued aquatic habitat buffer guidelines with inner buffer zones of 100 feet for EV and 50 feet for HQ streams and with outer buffer zones of 50 and 100 feet, respectively, for a total of 150 feet of protection. The management plans allow limited activities within the buffered areas, recommend elimination or minimization of existing roads or parking areas, and encourage restoration of riparian areas.

The water quality protective measures described in PGC resource management plans meet the “outstanding National, State, regional or local resource waters” definition and apply to stream segments where SGL 221 lands are situated along watershed corridors in a manner that provides protection to substantial reaches of the corridor within the Paradise Creek basin. These stream segments include portions of the Devils Hole Creek basin, Tank Creek, and Unnamed Tributary (UNT) 04977 to Paradise Creek located entirely within SGL 221.

A total of 7.7 stream miles qualify as EV Waters under this criterion.

Outstanding Local Resource Waters

The Department typically evaluates “outstanding local resource waters” by identifying and reviewing “coordinated water quality protective measures”, which require legally binding measures coupled with

a real estate interest. Typically, these measures are presented in conservation easements that are held in perpetuity by or that benefit certain governmental entities. Local conservation easements must be situated along the watershed corridor in a manner that provide protective measures to substantial reaches of the corridor, and also require that such measures be “coupled with” an interest in real estate, as described at § 93.1. Definitions - “*Coordinated water quality protective measures*”. The Department was unable to identify such protective measures within the petitioned basin.

B. Waters Qualifying as EV as Surface Waters of Exceptional Ecological Significance under § 93.4b (b)(2):

Information gathered for the Pennsylvania Natural Heritage Program and reported in County Natural Areas Inventory for Monroe County (1999) identified Seven Pines Mountain as a good quality Ridgetop Dwarf-tree Forest Natural Community located within SGL 221 and Devils Hole Creek as an EV/HQ-CWF stream with excellent water quality. However, the Department was unable to identify any important, unique or ecologically sensitive surface waters that would satisfy the exceptional ecological significance criterion at § 93.4b(b)(2) within the petitioned area.

PUBLIC RESPONSE AND PARTICIPATION SUMMARY

The Department provided public notice of this redesignation evaluation and requested any technical data from the general public through publication in the Pennsylvania Bulletin on August 29, 2014 (44 Pa.B. 6148). Barrett, Coolbaugh, and Paradise townships, Mount Pocono Borough, and the PGC were notified of the redesignation evaluation in a letter dated September 2, 2014. In addition, a notification was posted on the Department’s website. No data were received resulting from the public notice. However, data was offered by the Brodhead Chapter of Trout Unlimited as part of the petition on June 25, 2014.

RECOMMENDATION

Based on applicable regulatory definitions and requirements of § 93.4b(b)(1)(v) (the Department’s integrated benthic macroinvertebrate scoring test), the Department recommends that the entire Tank Creek basin, the Paradise Creek mainstem from the confluence of Tank Creek and Yankee Run to Devils Hole Creek, and the Devils Hole Creek basin from the southern border of SGL 221 to the confluence with Paradise be redesignated Exceptional Value, Migratory Fishes based on § 93.4b(b)(1)(v). In addition, those portions of Devils Hole Creek basin, Tank Creek, and UNT 04977 to Paradise Creek located entirely within SGL 221 also satisfy EV criteria and are being recommended for redesignation to EV based on § 93.4b(b)(1)(iii) (outstanding state resource waters). The Department recommends that the entire Yankee Run basin and those portions of the Paradise Creek downstream from the confluence of Devils Hole Creek, with the exception of the portion of UNT 04977 within SGL 221, maintain the current High Quality – Cold Water Fishes, Migratory Fishes designated use. This recommendation adds approximately 9.4 stream miles of EV waters to Chapter 93 and partially satisfies the EV designation sought in the petition.

APPENDIX A

¹Definition at 25 Pa. Code § 93.1: *Outstanding National, State, regional or local resource water*—A surface water for which a National or State government Agency has adopted water quality protective measures in a resource management plan, or regional or local governments have adopted coordinated water quality protective measures³ along a watershed corridor.

²Definition at 25 Pa. Code § 93.1: *Surface water of exceptional ecological significance*—A surface water which is important, unique or sensitive ecologically, but whose water quality as measured by traditional parameters (for example, chemical, physical or biological) may not be particularly high, or whose character cannot be adequately described by these parameters. These waters include:

- (i) Thermal springs.
- (ii) Wetlands which are exceptional value wetlands under § 105.17(1) (relating to wetlands).

³Definition at 25 Pa. Code § 93.1: *Coordinated water quality protective measures*—

- (i) Legally binding sound land use water quality protective measures coupled with an interest in real estate which expressly provide long-term water quality protection of a watershed corridor.
- (ii) Sound land use water quality protective measure include: surface or ground water protection zones, enhanced stormwater management measures, wetland protection zones or other measures which provide extraordinary water quality protection.
- (iii) Real estate interests include:
 - (A) Fee interests.
 - (B) Conservation easements.
 - (C) Government owned riparian parks or natural areas
 - (D) Other interests in land which enhance water quality in a watershed corridor area.

REFERENCES

Barbour, M.T., Gerritsen, J., Snyder, B.D., Stribling, J.B. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. United States Environmental Protection Agency. EPA 841-B-99-002.

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Plafkin, J.L., Barbour, M.T., Porter, K.D, Gross, S.K., Hughes, R.M. 1989. Rapid Bioassessment Protocols for use in streams and rivers: Benthic Macroinvertebrates and Fish. United States Environmental Protection Agency. EPA/444/4-89-001.

The Nature Conservancy (Pennsylvania Science Office). 1991, (updated 1999). A Natural Areas Inventory of Monroe County, Pennsylvania. The Monroe County Planning Commission.

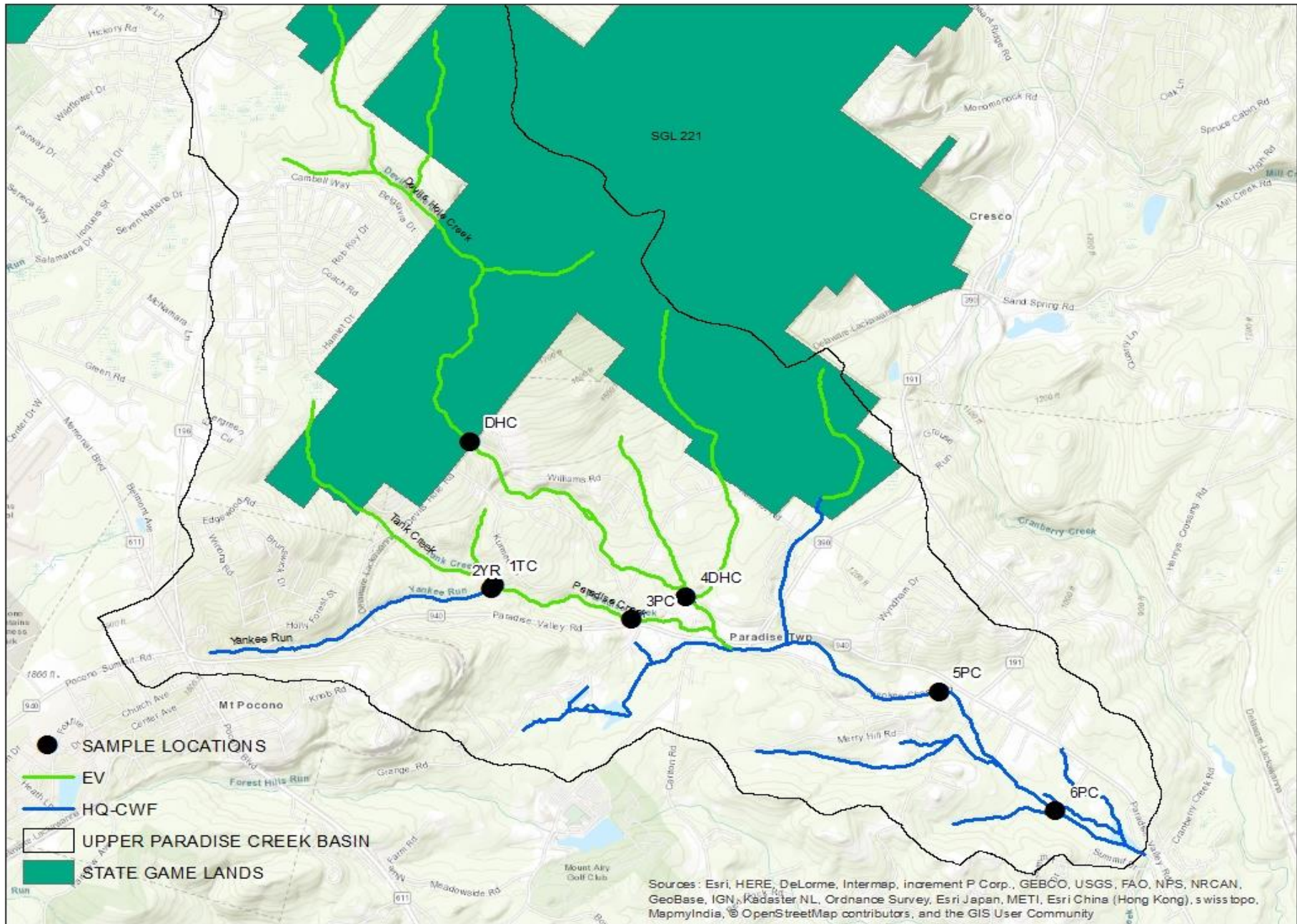


Figure 1. Paradise Creek station locations

Table 1. Paradise Creek station locations

STATION	LOCATION
1TC	Tank Creek (04990) near confluence with Paradise Creek. Paradise Township, Monroe County Lat: 41.131566 Long: -75.329607
2YR	Yankee Run (04989) near confluence with Paradise Creek. Paradise Township, Monroe County Lat: 41.131231 Long: -75.329896
3PC	Paradise Creek (04933) upstream Devil's Hole Rd. Paradise Township, Monroe County Lat: 41.128836 Long: -75.316158
4DHC	Devils Hole Creek (04983) near confluence with Paradise Creek. Paradise Township, Monroe County Lat: 41.130622 Long: -75.310876
5PC	Paradise Creek (04933) near Keokee Chapel Ln. and intersection of SR 940 & SR 191 Paradise Township, Monroe County Lat: 41.123114 Long: -75.286200
6PC	Paradise Creek (04933) upstream of Lake Crawford. Paradise Township, Monroe County Lat: 41.113717 Long: -75.274884
DHC (Ref)	Devils Hole Creek (04983) upstream of SGL 221 southern boundary Paradise Township, Monroe County Lat: 41.142827 Long: -75.331901
DMB (Ref)	Dimmick Meadow Brook (04954) upstream of Schocopee Rd. Milford Township, Pike County Lat: 41.349329 Long: -74.836024

Table 2. Water chemistry results – Paradise Creek 2013

PARAMETER	UNITS	STATIONS¹				REFERENCE²	
		1TC	2YR	3PC	5PC	DHC	DMB
TEMPERATURE	°C	4.4	3.4	4.9	6.2	4.5	11.1
SPECIFIC CONDUCTANCE	uS/cm ²	73.7	205	161	94.7	43.1	27.9
pH		6.82	7.02	7.18	7.07	6.32 ³	6.78
DISSOLVED OXYGEN	mg/L	10.9	11.5	11.2	10.7	10.8	9.68
ALKALINITY	mg/L	12	20	16	16	12	8

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

³ 2015 data

Table 3. Water chemistry results – Paradise Creek 2015

PARAMETER	UNITS	STATIONS ¹			REFERENCE ²
		3PC	4DHC	6PC	DMB
TEMPERATURE	°C	6.7	6.99	7.79	11.3
SPECIFIC CONDUCTANCE	µS/cm ²	270.1	91.1	172.9	27.6
pH		7.18	6.78	7.15	7.18
DISSOLVED OXYGEN	mg/L	11.63	11.62	11.6	16
ALKALINITY	mg/L	12	8	12	-
HARDNESS T	mg/L	42	15	28	-
AMMONIA D	mg/L	<0.011	<0.011	<0.011	-
AMMONIA T	mg/L	<0.011	<0.011	0.017	-
NITROGEN D	mg/L	0.572	0.486	0.473	-
NITROGEN T	mg/L	0.556	0.488	0.477	-
NITRATE & NITRITE D	mg/L	0.494	0.375	0.377	-
NITRATE & NITRITE T	mg/L	0.478	0.378	0.369	-
PHOSPHORUS D	mg/L	0.001	0.001	0.001	-
PHOSPHORUS T	mg/L	0.002	0.002	0.003	-
ORTHO PHOSPHORUS D	mg/L	0.004	0.004	0.005	-
ORTHO PHOSPHORUS T	mg/L	0.004	0.004	0.005	-
OSMOTIC PRESSURE	MOSM	4	2	3	-
TOTAL ORGANIC CARBON	mg/L	1.087	1.833	1.639	-
TOTAL DISSOLVED SOLIDS	mg/L	354	64	118	-
TOTAL SUSPENDED SOLIDS	mg/L	<5	<5	8	-
ALUMINUM T	µg/L	17	42	37	-
BARIUM T	µg/L	26	10	14	-
BORON T	µg/L	<19.105	<19.105	<19.105	-
BROMIDE T	µg/L	21.17	<8.041	<8.041	-
CALCIUM T	mg/L	12.4	4.252	7.98	-
COPPER T	µg/L	0.664	0.548	0.711	-
IRON T	µg/L	25	19	49	-
LEAD T	µg/L	<0.101	<0.101	0.286	-
MAGNESIUM T	mg/L	2.752	1.091	1.881	-
MANGANESE T	µg/L	6	<3	11	-
NICKEL T	µg/L	<12	<12	<12	-
SELENIUM T	µg/L	<0.763	<763	<0.763	-
SODIUM T	mg/L	32.74	10.01	19.69	-
STRONTIUM T	µg/L	40	10	27	-
CHLORIDE T	mg/L	64.92	19.48	40.78	-
SULFATE T	mg/L	6.44	4	5.98	-
ZINC T	µg/L	<5	<5	<5	-

"<" indicate concentrations below the reporting limit

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

Table 4. Habitat assessment results – Paradise Creek 2013

PARAMETER	STATIONS ¹				REFERENCE ²	
	1TC	2YR	3PC	5PC	DHC	DMB
1. instream cover	15	18	15	15	19	18
2. epifaunal substrate	16	19	17	18	18	19
3. embeddedness	18	18	18	17	18	17
4. velocity/depth	15	16	13	15	18	14
5. channel alterations	20	20	16	18	19	18
6. sediment deposition	17	17	16	18	16	18
7. riffle frequency	19	19	19	19	20	19
8. channel flow status	18	19	14	17	15	16
9. bank condition	17	18	16	18	19	18
10. bank vegetative protection	20	20	18	18	19	19
11. grazing/disruptive pressures	20	20	16	15	18	20
12. riparian zone width	20	20	15	15	17	20
Total Score	215	224	193	203	216	216
Rating ³	OPT	OPT	OPT	OPT	OPT	OPT

Table 5. Habitat assessment results – Paradise Creek 2015

PARAMETER	STATIONS ¹			REFERENCE ²
	3PC	4DHC	6PC	DMB
1. instream cover	20	15	10	19
2. epifaunal substrate	20	20	13	19
3. embeddedness	15	16	11	16
4. velocity/depth	16	15	10	15
5. channel alterations	12	6	6	16
6. sediment deposition	16	16	13	18
7. riffle frequency	20	20	15	20
8. channel flow status	20	20	16	19
9. bank condition	11	13	15	17
10. bank vegetative protection	15	13	15	18
11. grazing/disruptive pressures	10	10	11	20
12. riparian zone width	11	6	10	20
Total Score	186	170	145	217
Rating ³	SUB	SUB	SUB	OPT

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

³ OPT=Optimal (≥192); SUB=Suboptimal (132-191)

Table 6. Semi-quantitative benthic macroinvertebrate data – Paradise Creek 2013

TAXA		STATIONS ¹				REFERENCE ²	
		1TC	2YR	3PC	5PC	DHC	DMB
EPHEMEROPTERA (MAYFLIES)							
Ameletidae	<i>Ameletus</i>					1	
Baetidae	<i>Baetis</i>	23		5	44	28	6
	<i>Diphedor</i>			1			
Ephemerellidae	<i>Drunella</i>	6	6	7	1	28	
	<i>Ephemerella</i>	5	1	2	3	10	30
	<i>Eurylophella</i>			1	1		
Heptageniidae	<i>Cinygmula</i>	3				3	18
	<i>Epeorus</i>	54	1	29	7	35	32
	<i>Leucrocuta</i>						1
	<i>Maccaffertium</i>			1	4		
Leptophlebiidae	<i>Paraleptophlebia</i>	1		1	7	8	5
PLECOPTERA (STONEFLIES)							
Capnidae	<i>Paracapnia</i>						6
Chloroperlidae		1				1	
	<i>Alloperla</i>					1	
	<i>Sweltsa</i>	3		9	3	3	2
Leuctridae	<i>Leuctra</i>	5	1	3	3	18	3
Nemouridae	<i>Amphinemura</i>	6	6	5	1	4	1
	<i>Ostrocerca</i>		1				
	<i>Prostoia</i>		4	2	1		
	<i>Soyedina</i>	1					
Peltoperlidae	<i>Tallaperla</i>	6	5	7	1	6	3
Perlidae	<i>Acroneuria</i>						6
	<i>Paragnetina</i>				3		
Perlodidae	<i>Isoperla</i>	5		7	5	9	4
	<i>Malirekus</i>	2				2	
Pteronarcyidae	<i>Pteronarcys</i>	2	2	5		6	5
Taeniopterygidae	<i>Taenionema</i>	3	1	5	4	2	
TRICHOPTERA (CADDISFLIES)							
Hydropsychidae	<i>Ceratopsyche</i>		1	3	7	2	5
	<i>Cheumatopsyche</i>			1	2		
	<i>Diplectrona</i>	13	1	11	1	8	7
	<i>Hydropsyche</i>						
	<i>Parapsyche</i>	1					
Lepidostomatidae	<i>Lepidostoma</i>	3		3	4	1	2
Limnephilidae	<i>Pycnopsyche</i>						
Philopotamidae	<i>Dolophilodes</i>	1	2		1	3	1
Polycentropodidae	<i>Polycentropus</i>			2	2	1	
Rhyacophilidae	<i>Rhyacophila</i>	17	13	12	3	9	8
Uenoidae	<i>Neophylax</i>						1

Table 6 (cont.). Semi-quantitative benthic macroinvertebrate data – Paradise Creek 2013

TAXA		STATIONS ¹				REFERENCE ²	
		1TC	2YR	3PC	5PC	DHC	DMB
ODONATA (DRAGONFLIES)							
Gomphidae	<i>Lanthus</i>		2		1		
DIPTERA (TRUE FLIES)							
Blephariceridae	<i>Blepharicera</i>						
Ceratopogonidae	<i>Probezzia</i>		1				
Chironomidae		34	48	61	93	42	28
Dolichopodidae			1				
Empididae	<i>Clinocera</i>	1			1		
	<i>Neoplasta</i>		1	2			
Psychodidae	<i>Pericoma</i>						
Simuliidae	<i>Prosimulium</i>	19	115	23	4	5	34
	<i>Simulium</i>						
	<i>Stegoptema</i>		4	1			
Tipulidae	<i>Antocha</i>	1			1		1
	<i>Dicranota</i>					1	
	<i>Hexatoma</i>	2			4	1	2
COLEOPTERA (BEETLES)							
Elmidae	<i>Optioservus</i>		1				
	<i>Oulimnius</i>		2	4	2	1	1
	<i>Promoresia</i>			1	1		7
Psephenidae	<i>Psephenus</i>						2
NON-INSECT TAXA							
Gammaridae	<i>Gammarus</i>			3			
Nematoda				1	1		
Oligochaeta							1
Hydracarina		2			1		
Total number of taxa		27	23	30	32	28	28
Total number of individuals		220	220	218	217	239	222

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

Table 7. Semi-quantitative benthic macroinvertebrate data – Paradise Creek 2015

TAXA		STATIONS ¹			REFERENCE ²
		3PC	4DHC	6PC	DMB
EPHEMEROPTERA (MAYFLIES)					
Ameletidae	<i>Ameletus</i>				1
Baetidae	<i>Baetis</i>	21	24	12	18
	<i>Dipheter</i>	3			2
Ephemerellidae	<i>Drunella</i>	6	3	4	
	<i>Ephemerella</i>	2	29	17	12
	<i>Eurylophella</i>			9	
	<i>Teleganopsis</i>			7	
Heptageniidae	<i>Cinygmula</i>		5		3
	<i>Epeorus</i>	73	33	9	24
	<i>Leucocuta</i>				1
	<i>Maccaffertium</i>			4	
Leptophlebiidae	<i>Paraleptophlebia</i>		6	5	3
PLECOPTERA (STONEFLIES)					
Chloroperlidae	<i>Alloperla</i>	1			
	<i>Sweltsa</i>	2	6		2
Leuctridae	<i>Leuctra</i>		5	2	13
Nemouridae	<i>Amphinemura</i>	4	1		9
Peltoperlidae	<i>Tallaperla</i>	3			
Perlidae	<i>Acroneuria</i>		1	1	3
	<i>Paragnetina</i>			1	
Perlodidae	<i>Isoperla</i>	7	5	4	3
	<i>Malirekus</i>	3			
Pteronarcyidae	<i>Pteronarcys</i>	7		1	15
TRICHOPTERA (CADDISFLIES)					
Brachycentridae	<i>Micrasema</i>				1
Hydropsychidae	<i>Cheumatopsyche</i>	1	8		
	<i>Diplectrona</i>	4	3		11
	<i>Hydropsyche</i>	1	20	8	8
Lepidostomatidae	<i>Lepidostoma</i>			4	1
Philopotamidae	<i>Dolophilodes</i>		5		2
Polycentropodidae	<i>Polycentropus</i>		1	1	
Rhyacophilidae	<i>Rhyacophila</i>	6	10	4	16
Uenoidae	<i>Neophylax</i>			4	2

Table 7 (cont.). Semi-quantitative benthic macroinvertebrate data – Paradise Creek 2015

TAXA		STATIONS ¹			REFERENCE ²
		3PC	4DHC	6PC	DMB
ODONATA (DRAGONFLIES)					
Gomphidae	<i>Lanthus</i>			1	
DIPTERA (TRUE FLIES)					
Blephariceridae	<i>Blepharicera</i>	1			
Ceratopogonidae	<i>Probezzia</i>			3	
Chironomidae		40	28	94	32
Empididae	<i>Clinocera</i>			19	
	<i>Hemerodromia</i>			1	
	<i>Neoplasta</i>			2	
Simuliidae	<i>Prosimulium</i>	5	2	1	23
	<i>Simulium</i>	1		1	
Tipulidae	<i>Antocha</i>	2	1	1	3
	<i>Hexatoma</i>	2	7	5	
	<i>Tipula</i>				1
MEGALOPTERA (DOBSON-, FISHFLIES)					
Corydalidae	<i>Nigronia</i>			2	
COLEOPTERA (BEETLES)					
Elmidae	<i>Oulimnius</i>	7	8		
	<i>Promoresia</i>	1	8		6
	<i>Stenelmis</i>			1	
Psephenidae	<i>Ectopria</i>				1
	<i>Psephenus</i>				5
NON-INSECT TAXA					
Gammaridae	<i>Gammarus</i>	1			
Oligochaeta		1		1	
Total number of taxa		26	23	31	28
Total number of individuals		205	219	229	221

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

Table 8. Upper Paradise Creek Basin – March 2013 RBP Metric Comparison to Devils Hole Creek

METRIC	STATIONS ¹				REFERENCE ²
	1TC	2YR	3PC	5PC	DHC
1. TAXA RICHNESS	27	23	30	32	28
Cand/Ref (%)	96	82	107	114	
Biol. Cond. Score	8	8	8	8	8
2. MOD. EPT INDEX	20	13	17	18	20
Cand/Ref (%)	100	65	85	90	
Biol. Cond. Score	8	4	8	8	8
3. MOD. HBI	2.20	2.90	2.85	4.62	2.32
Cand-Ref	-0.12	0.58	0.53	2.30	
Biol. Cond. Score	8	8	8	0	8
4. % DOMINANT TAXA	24.5	52.3	28	42.9	17.6
Cand-Ref	6.9	34.7	10.4	25.3	
Biol. Cond. Score	8	0	8	0	8
5. % MOD. MAYFLIES	31.4	3.6	18.8	10.6	35.6
Ref-Cand	4.2	32	16.8	25	
Biol. Cond. Score	8	2	6	4	8
TOTAL BIOLOGICAL CONDITION SCORE	40	22	38	20	40
% COMPARABILITY TO REFERENCE	100	55	95	50	

Table 9. Upper Paradise Creek Basin – March 2013 RBP Metric Comparison to Dimmick Meadow Brook

METRIC	STATIONS ¹				REFERENCE ²
	1TC	2YR	3PC	5PC	DMB
1. TAXA RICHNESS	27	23	30	32	28
Cand/Ref (%)	96	82	107	114	
Biol. Cond. Score	8	8	8	8	8
2. MOD. EPT INDEX	20	13	17	18	18
Cand/Ref (%)	111	72	94	100	
Biol. Cond. Score	8	6	8	8	8
3. MOD. HBI	2.20	2.90	2.85	4.62	1.91
Cand-Ref	0.29	0.99	0.94	2.71	
Biol. Cond. Score	8	4	5	0	8
4. % DOMINANT TAXA	24.5	52.3	28	42.9	15.3
Cand-Ref	9.2	37	12.7	27.6	
Biol. Cond. Score	8	0	6	0	8
5. % MOD. MAYFLIES	31.4	3.6	18.8	10.6	38.7
Ref-Cand	7.3	35.1	19.9	28.1	
Biol. Cond. Score	8	2	6	3	8
TOTAL BIOLOGICAL CONDITION SCORE	40	20	33	19	40
% COMPARABILITY TO REFERENCE	100	50	83	48	

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

Table 10. Upper Paradise Creek Basin – May 2015 RBP Metric Comparison to Dimmick Meadow Brook

METRIC	STATIONS ¹			REFERENCE ²
	3PC	4DHC	6PC	DMB
1. TAXA RICHNESS	26	23	31	28
Cand/Ref (%)	93	82	111	
Biol. Cond. Score	8	8	8	8
2. MOD. EPT INDEX	12	13	15	18
Cand/Ref (%)	67	72	83	
Biol. Cond. Score	4	6	8	8
3. MOD. HBI	2.53	2.78	4.34	2.38
Cand-Ref	0.15	0.40	1.96	
Biol. Cond. Score	8	8	0	8
4. % DOMINANT TAXA	35.6	15.1	41	14.5
Cand-Ref	21.1	0.6	26.5	
Biol. Cond. Score	8 ³	8	0	8
5. % MOD. MAYFLIES	39.5	34.7	24	19.9
Ref-Cand	-19.6	-14.8	-4.1	
Biol. Cond. Score	8	8	8	8
TOTAL BIOLOGICAL CONDITION SCORE	36	38	24	40
% COMPARABILITY TO REFERENCE	90	95	60	

¹ Refer to Figure 1, Table 1 for station locations

² Reference Stations– Refer to Table 1 for locations

³ Dominant Taxa with HBI < 3