Agency of Natural Resources
Department of Environmental Conservation
Watershed Management Division
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MEMORANDUM

To: 2024 Listing File

From: Biomonitoring and Aquatic Studies Section; River Science Section, Rivers Program

Cc: Tim Clear, Chip Gianfagna (TMDLs, Assessment, Compliance and Standards Program), Jeff Crocker (River Science Section, Rivers Program)

Date: January 5, 2024

Subject: Aquatic Biota Impairment of Mud Hollow Brook (Charlotte, VT)

Background

Mud Hollow Brook is a small stream located entirely within the town of Charlotte, VT. The stream is a tributary of the LaPlatte River and generally flows from south to north (Figure 1). Mud Hollow Brook has a few small tributaries, but only one named tributary, Bingham Brook, located in its headwaters. The elevation of the brook near its confluence with the LaPlatte River is approximately 211 feet above sea level and changes very little throughout its lower reaches due to the stream's low to moderate gradient.

The brook's 20.5 km^2 watershed is dominated by agricultural land use (approximately 62%, primarily hay fields and pasture), with significant forested land cover (>25%) and smaller amounts of wetland and developed land (Table 1). Agricultural land within the 30-meter buffer of the stream network is similar to the watershed as a whole though wetlands in this buffer are found at a higher percentage (15%) with relatively less forested buffer (15%) when compared to the watershed as a whole.

Substantial water quality monitoring has been performed at three stations on Mud Hollow Brook by the LaRosa Partnership Program (LPP) between 2004 and 2023 (Figure 1). Monitoring of turbidity, chloride, total nitrogen, and dissolved and total phosphorus was performed at all three stations from 2004-2008 (Figure 2). Total nitrogen, total phosphorus and chloride samples were collected by LPP in 2021-2023, along with flow observations associated with each sampling event (Figure 3).

The Biomonitoring and Aquatic Studies Section (BASS) in the Watershed Management Division of the Department of Environmental Conservation first collected extensive water quality, habitat and biological (macroinvertebrate and fish) data at Mud Hollow Brook near its confluence with the LaPlatte River in 2009 as part of its Ambient Monitoring Network (ABN) program. This suite of data was again collected at the river mile (RM) 0.1 station in 2021. In summer 2023, BASS collected water quality data three times at RM 0.1, as well as macroinvertebrate and habitat data at the RM 0.1 and RM 0.6 stations during ABN's late summer through fall index period.

Fish communities at RM 0.1 are characterized as mixed-water and have been assessed using the mixed-water index of biotic integrity (IBI). Reaches within the stream have been characterized as either warm-water moderate gradient (WWMG) or hybrid low gradient (HLG) for macroinvertebrate assessments. Stream type designations of WWMG or HLG at Mud Hollow Brook are dependent on reach-specific slope and substrate and can change over time due to impoundments from beaver activity in wetland areas.

Water Chemistry and Habitat

The LPP turbidity, phosphorus and nitrogen data were aggregated and summarized (Figures 2 & 3). Chloride data from this period was not summarized. Chloride did not exceed 24 mg/l in 98 samples taken at the three stations and were typically much lower. These concentrations are below what might be considered to have chronic effects on macroinvertebrate and fish communities, particularly in comparison to values of other chemical parameters at these sites.

The LPP data from 2004-2008 are not associated with flow types (e.g. base vs. freshet flow), which can limit the interpretation of water chemistry data. While the inclusion of data taken during both base and freshet flows can add to data variability, concentrations of turbidity and nutrient parameters are generally high (Figure 2) and well above what would be expected under reference conditions. Turbidity values slightly decrease moving upstream while nutrient values slightly increase moving upstream. This trend was present despite less agriculture in the RM 4.8 watershed and could reflect localized changes in land use/buffer dynamics or differences in runoff or sampling conditions.

Total nitrogen and total phosphorus samples were collected by the LPP at RM 0.3 in 2021-2022, and at RM 1.1 in 2021-2023. These samples have been summarized by flow type (Figure 3). Nutrient concentrations are expected to be elevated in samples taken during freshet flows when sediment and organic matter enters the stream through surface water runoff. However, baseflow samples also show very high concentrations of both phosphorus and nitrogen, with all phosphorus samples taken during this time exceeding the Vermont Water Quality Standards (VWQS) maximum criteria of 27 µg/l for WWMG streams (applied at low median monthly flow during June through October).

The ABN water quality data collected in 2009, 2021 and 2023 under baseflow conditions show similar patterns (Table 2). Chloride concentrations are low, while alkalinity and pH are elevated above expected background levels. Turbidity is below the VWQS limit of 25 NTU, but notably higher than the near-zero expected turbidity for an undisturbed stream at baseflow. Conductivity, total aluminum and total iron are also elevated, likely due to the transport of fine sediments and suspended solids reflected by the elevated turbidity values. Iron and aluminum have been used to illustrate this pattern, though other earth metal parameters were similarly elevated. Total nitrogen, total phosphorus and dissolved phosphorus are all very high at baseflow, with phosphorus values significantly exceeding the 27 µg/l limit for WWMG streams. Due to a recently established beaver impoundment, the RM 0.2 station was characterized as an HLG stream type in 2023. The reach has been assessed as RM 0.1 in the past using WWMG. Ammonia and nitrate/nitrite concentrations were also sampled during this period but were found to be at or below the 0.05 mg/l detection limit.

Recent ABN riffle habitat and substrate observations in 2021 (RM 0.1) and 2023 (RM 0.6) show low embeddedness, but very high silt ratings (5 out of 5) and substantial fine sediments (11-12%). Gravel percentages were also high (16-21%), though this may be naturally elevated by the moderate gradient and presence of significant riparian wetlands. Filamentous algae productivity also appears to be

elevated based on pebble count data, likely a result of naturally partially open canopy and high nutrient concentrations.

Biological Assessments

Macroinvertebrate assessments in 2009, 2021 and 2023 are shown in Table 3. The community at RM 0.1 in 2009 received an assessment of 'Good'. While this community met B(2) VWQS criteria, the biotic index score was notably elevated and both total and EPT richness values were low. The biotic index score at this site was significantly higher in 2021, which caused the community to receive an assessment of 'Fair', failing to meet VWQS minimum B(2) criteria. EPT richness met minimum criteria but was just above the B(2) threshold. A similar pattern was found at RM 0.6 in 2023, with the community failing to meet minimum biological criteria due to an elevated biotic index score. Biotic index is a measure of the community's tolerance to nutrient enrichment and organic pollution and can also be correlated with thermal stress in some taxa. In each of these biological samples, moderately to highly tolerant taxa (biotic index value = 5-8) comprised over 85% of the total community and most of the species found.

The low gradient macroinvertebrate sample collected at RM 0.2 in 2023 showed a similar community fingerprint. The community failed to meet minimum standards for an HLG stream, receiving an IBI score of 28 and an assessment of 'Fair' (Table 3). Five of 10 metrics failed to meet individual B(2) thresholds. The richness of sensitive taxa was very low, while the relative abundance of tolerant taxa was very high (reflected in the elevated biotic index score and low sensitive COTE% value). The proportion of the community comprised of pollution tolerant midge larvae (Diptera: Chironomidae) was also high, leading to a very low EOT/EOT+C score. Midge larvae comprised five of the 10 most common taxa, and nine of the 10 most common taxa in the community were tolerant of enrichment (biotic index value = 6-8).

The fish community at RM 0.1 was assessed using the mixed-water IBI in 2009 and 2021, barely meeting the minimum VWQS B(2) criteria both times. Individual metrics from both sample events show an absence of intolerant fish species and a dominance of pollution-tolerant, generalist feeders. Instances of the anomalies parasitic yellow grub and black spot disease were elevated, suggesting a fish community stressed by pollution. Overall, the fish community appears to be stressed by elevated nutrients and water temperature, reflected by the very high overall densities and abundance of eurythermal and warmwater species respectively.

Summary

The watershed of Mud Hollow Brook is dominated by agricultural land use. Dozens of water quality samples collected by the ABN and LPP over the last 20 years at multiple stations have shown highly elevated nutrient concentrations with total phosphorus exceeding the WWMG nutrient criteria of 27 µg/l in every instance. Riparian encroachment and surface water runoff are likely exacerbating nutrient pollution by increasing water temperature and turbidity/sediment stress.

All three macroinvertebrate samples collected at two sites in 2021 and 2023 failed to meet minimum WWMG and HLG biological criteria. Individual metrics directly point to organic matter pollution and nutrient enrichment as the primary cause of biological degradation. While fish assessments meet B(2) standards, fingerprints in that community also suggest notable stress on the community due to upstream land use, elevated temperature, and nutrient pollution.

Based on the results of these extensive monitoring efforts, BASS is recommending that Mud Hollow Brook be placed on the State's 303(d) List of Impaired Waters due to the aquatic biota use impairment. The primary pollutant is believed to be nutrients, with the listed problem described as runoff from agricultural lands. Based on the non-point source nature of the pollutants, and upstream monitoring results and land use patterns, we recommend listing the entire stream (and its tributaries) from its confluence with the LaPlatte River.

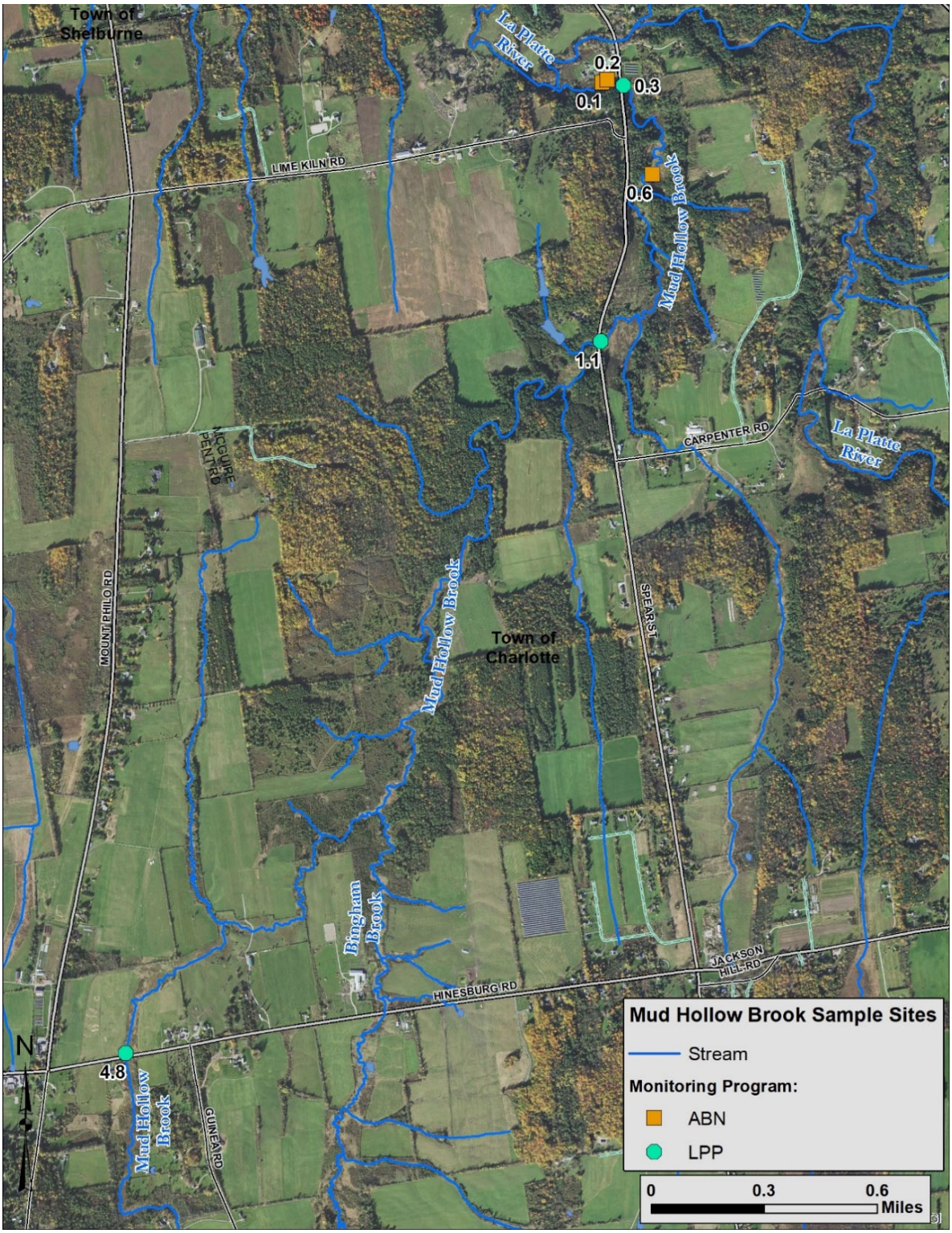

Figure 1. Map of the lower portion of the Mud Hollow Brook watershed. Numbers associated with monitoring stations are river miles (RM) measured from the confluence with the LaPlatte River. The RM 0.1 and RM 0.2 sites overlap spatially, designating different macroinvertebrate collections methods due to a beaver impoundment in 2023.

Table 1. Geographic and watershed land use information for each station on Mud Hollow Brook. The RM 0.1 and 0.2 stations effectively overlap but were given separate stream type designations due to a beaver impoundment created between 2021 and 2023.

River Mile	Stream Type	Latitude	Longitude	Drainage Area (km^2)	% Agriculture	% Developed	% Wetland	% Forest
0.1	WWMG	44.35363	-73.19455	20.4	61.7	5.1	5.5	27.0
0.2	HLG	44.35373	-73.19427	20.4	61.7	5.1	5.5	27.0
0.3	-	44.35353	-73.19340	20.4	61.7	5.1	5.5	27.0
0.6	WWMG	44.35014	-73.19181	20.2	61.9	5.1	5.4	26.9
1.1	-	44.34373	-73.19449	17.2	63.4	4.4	6.0	25.4
4.8	-	44.31632	-73.21956	3.7	44.1	5.4	11.2	38.5

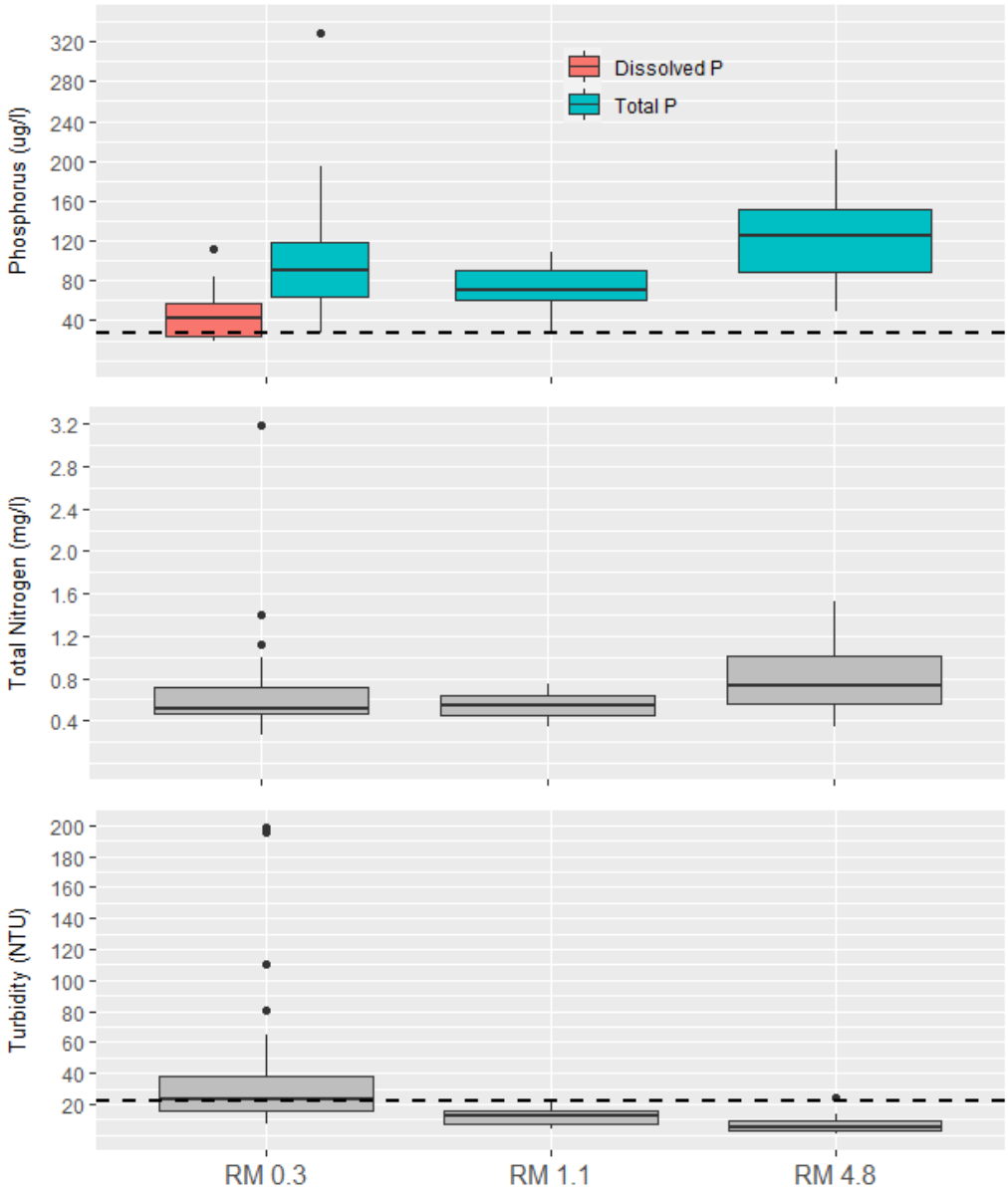

Figure 2. LaRosa Partnership Program water quality data collected from 2004-2008 at three sites on Mud Hollow Brook. Plots represent an aggregation of base and freshet flow data. Dashed lines represent maximum baseflow criteria in the Vermont Water Quality Standards.

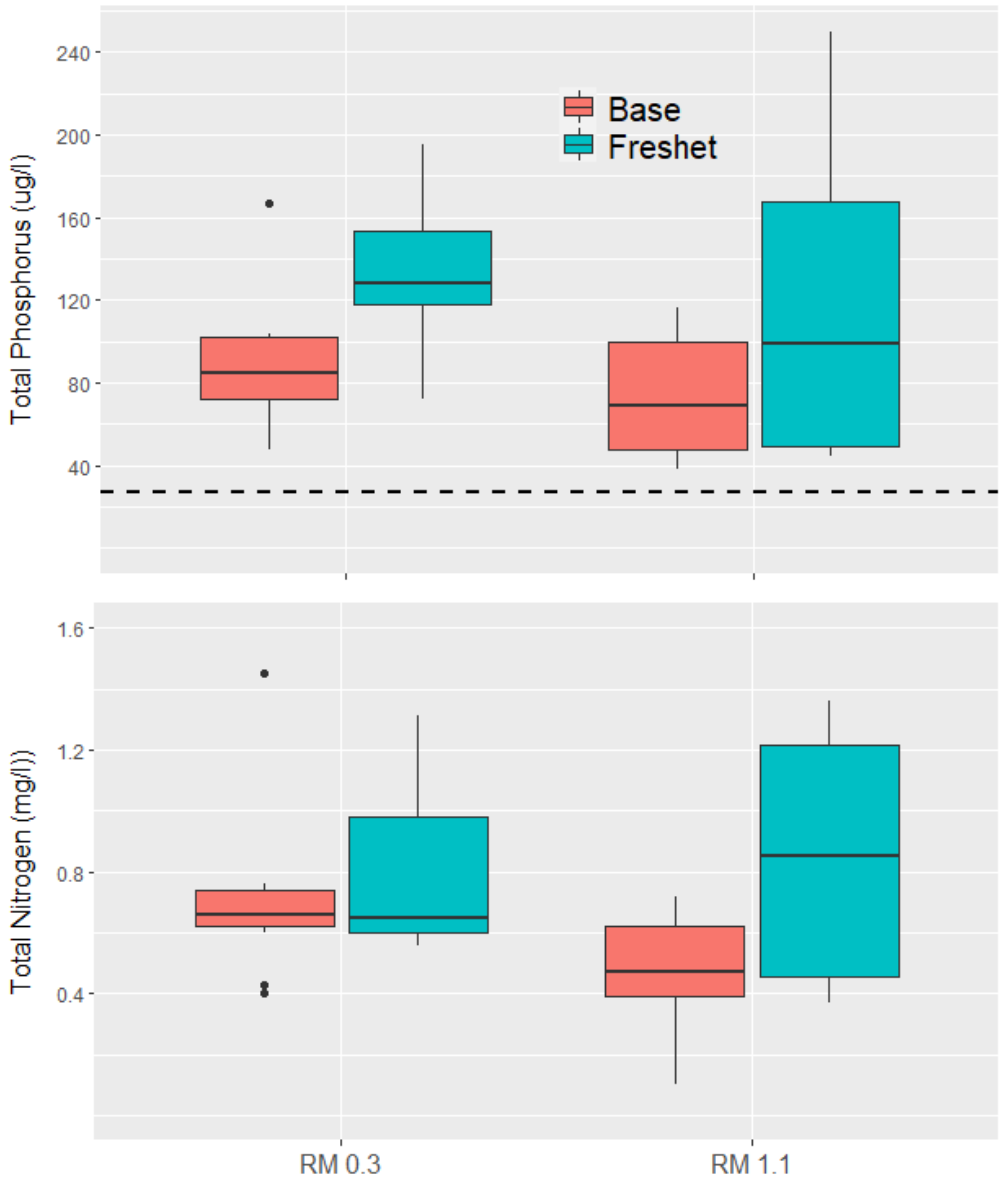

Figure 3. LaRosa Partnership Program water quality data collected from 2021-2023 at two sites on Mud Hollow Brook. Plots are separated by data collected under baseflow and freshet flow conditions. The dashed line represents baseflow nutrient criteria for warm-water moderate gradient streams in the Vermont Water Quality Standards.

Table 2. Relevant water quality data collected by the Biomonitoring and Aquatic Studies Section of DEC. Additional water quality data for these sites can be found in the Vermont Integrated Watershed Information System (IWIS; anrweb.vt.gov/DEC/IWIS). The RM 0.1 and RM 0.2 sites overlap spatially, but were named separately to designate different macroinvertebrate collections methods due to a beaver impoundment in 2023.

River Mile	Date	Flow Level	Flow Type	Dissolved Oxygen (mg/l)	Dissolved Oxygen Saturation (%)	Alkalinity (mg/l)	pH (None)	Conductivity (umho/cm)	Chloride (mg/l)	Dissolved Phosphorus (ug/l)	Total Phosphorus (ug/l)	Total Nitrogen (mg/l)	Total Aluminum (ug/l)	Total Iron (ug/l)	Turbidity (NTU)
0.1	2009-09-23	Moderate	Base			254	7.85	557	9.78	44.1	88.2	0.41	239	961	17.9
	2021-09-02	Moderate	Base	6.17	69.7	190	7.82	404.8		63.6	112	0.84	192	558	6.9
0.2	2023-07-20	Moderate	Base	8.29	92.7	172	7.22	358.4	9.9	110	138	0.76	410	802	13.7
	2023-08-24	Low	Base	7.92	89.9	230	7.72	464.7	11.4	73.6	84.8	0.67	166	523	6.1
	2023-09-07	Low	Base	6.79	82.6	261	7.84	557.9	14.1	70.9	69.3	0.59	281	556	7.8
0.6	2023.09-07	Low	Base	7.38	88.5	266	7.92	557.5	12	42.4	75.2	0.69	280	603	7.7

Table 3. Macroinvertebrate community assessments for biological sampling events at Mud Hollow Brook. Individual metric values are colored to correspond to biological criteria thresholds in the Vermont Water Quality Standards (VWQS). For more information on the calculation of individual metrics and how assessments are determined, please refer to Appendix G of the VWQS (dec.vermont.gov/watershed/map/assessment/waterqualitystandards).

Stream Type: Warm-water Moderate Gradient

River Mile	Date	Density	Richness	EPT Richness	PMA-O	B.I.	Oligo.	EPT/EPT + Chiro	PPCS-F	Community Assessment
0.1	**9/23/2009**	2232	30.0	19.0	65.8	5.25	0.00	0.99	0.41	**Good**
	9/2/2021	4548	50.5	16.5	68.3	5.83	0.33	0.75	0.53	**Fair**
0.6	**9/7/2023**	7648	53.0	22.0	80.4	5.67	0.00	0.83	0.43	**Fair**
	Full Support	≥ 300	≥ 30	≥ 16	≥ 45	≤ 5.4	≤ 12	≥ 0.45	≥ 0.4	
	Indeterminate	≥ 250	≥ 28	≥ 15	≥ 40	≤ 5.65	≤ 14.5	≥ 0.43	≥ 0.35	
	Non-Support	< 250	< 28	< 15	< 40	> 5.65	> 14.5	< 0.43	< 0.35	

Stream Type: Hybrid Low Gradient

River Mile	Date	Density	EOT Richness	BCG Intolerant Richness	PMA-O	B.I.	Amphipod + Isopod - Hyallela	EOT/EOT+C	PPCS-F	Sensitive COTE%	Shredders / Collector	IBI Score	Community Assessment
0.2	**9/7/2023**	737	16.0	3.0	71.1	6.08	0.9	0.114	0.433	10.930	0.030	**28**	**Fair**
	IBI 5	≥ 500	≥ 15	≥ 14	≥ 75	≤ 4	0	≥ 0.5	≥ 0.57	≥ 28	≥ 0.5		
	IBI 4	≥ 400	≥ 13	≥ 11	≥ 65	≤ 5	≤ 1	≥ 0.38	≥ 0.49	≥ 20	≥ 0.35		
	IBI 3	≥ 300	≥ 11	≥ 9	≥ 55	≤ 6	≤ 5	≥ 0.26	≥ 0.41	≥ 13	≥ 0.2		
	IBI 2	≥ 200	≥ 7	≥ 5	≥ 45	≤ 6.5	≤ 25	≥ 0.13	≥ 0.36	≥ 5	≥ 0.1		
	IBI 1	≥ 0	≥ 0	≥ 0	≥ 0	>6.5	>25	≥ 0	≥ 0	≥ 0	≥ 0		

Table 4. Fish community assessments for surveys conducted at Mud Hollow Brook RM 0.1. Individual metric values are colored to correspond to biological criteria thresholds in the Vermont Water Quality Standards (VWQS). For more information on the calculation of individual metrics and how assessments are determined, please refer to Appendix G of the VWQS (dec.vermont.gov/watershed/map/assessment/waterqualitystandards).

Date	Density (#/100m2)	Native Species Richness	Intolerant Species Richness	Benthic Insectivore Richness	% White Sucker & Creek Chub	% Generalist Feeders	% Insectivores	% Top Carnivores	% Anomalies	IBI Score	Community Assessment
2009-09-24	**120.5**	**8**	**0**	**2**	**14.6**	**50.9**	**48.4**	**0.6**	**0.0**	**35**	**Good**
2021-10-13	**204.2**	**12**	**0**	**2**	**5.3**	**70.1**	**20.9**	**9.0**	**14.6**	**30**	**Good**
IBI 5	> 20	> 9	1	> 1	< 11	< 30	> 55	warm-water population with <25km^2 drainage = 5	< 1		
IBI 4		8 - 9			11 - < 18	30 - < 40	44 - 55		1 - < 2		
IBI 3	10 - 20	5 - 7		1	18 - < 26	40 - < 50	32 - < 44		2 - < 3		
IBI 2		3 - 4			26 - 33	50 - 60	20 - < 32		3 - 4		
IBI 1	< 10	0 - 2	0	0	> 33	> 60	< 20		> 4		