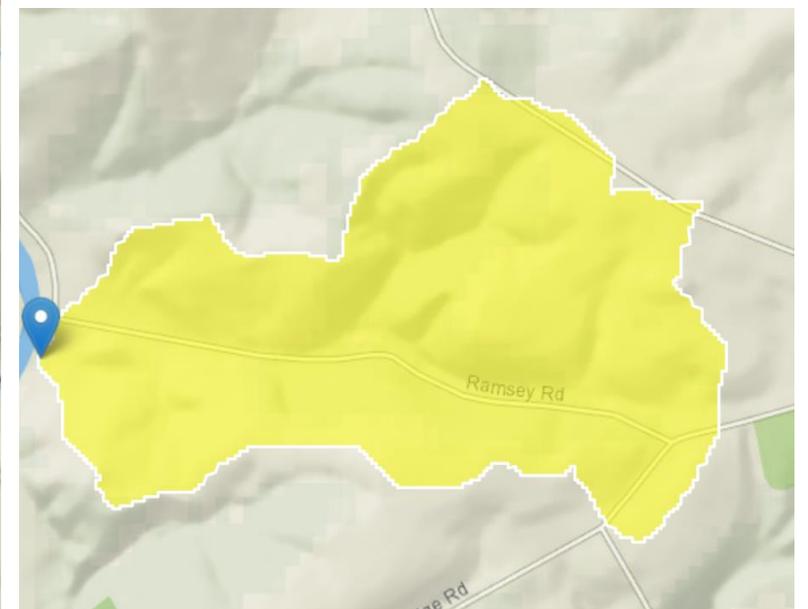
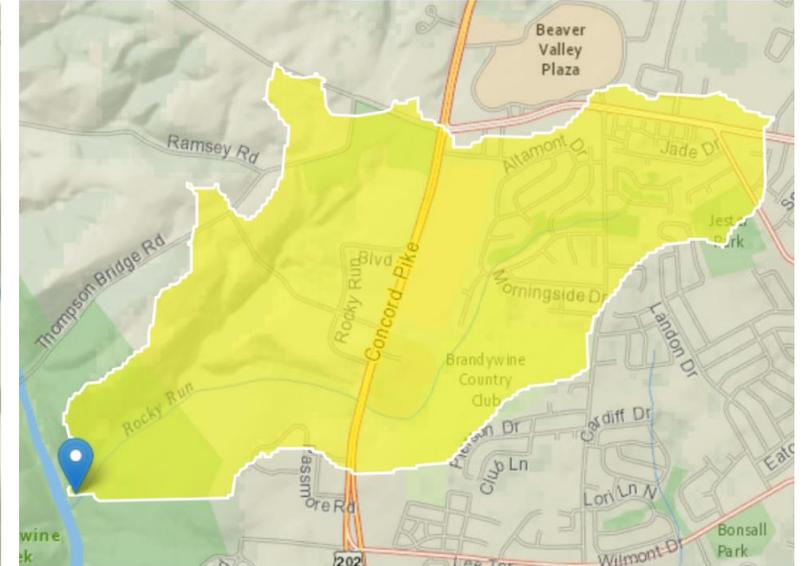


CHARACTERIZATION OF THE UPPER BRANDYWINE RIVER TRIBUTARIES

DELANEY DORAN
ENVIRONMENTAL ENGINEERING

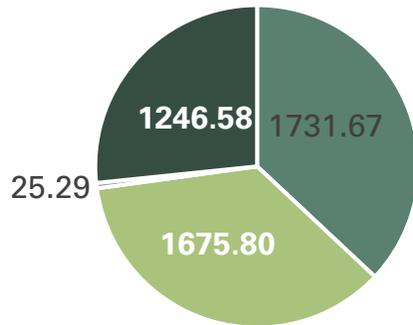
STREAMSTATS DATA

- These pictures illustrate the StreamStats output for the Upper Brandywine tributaries
- Left- 2A, Top Right- Rocky Run, Bottom Left- Ramsey Run
- StreamStats provides a map of the watershed as well as drainage characteristics for that region



STREAMSTATS ANALYSIS

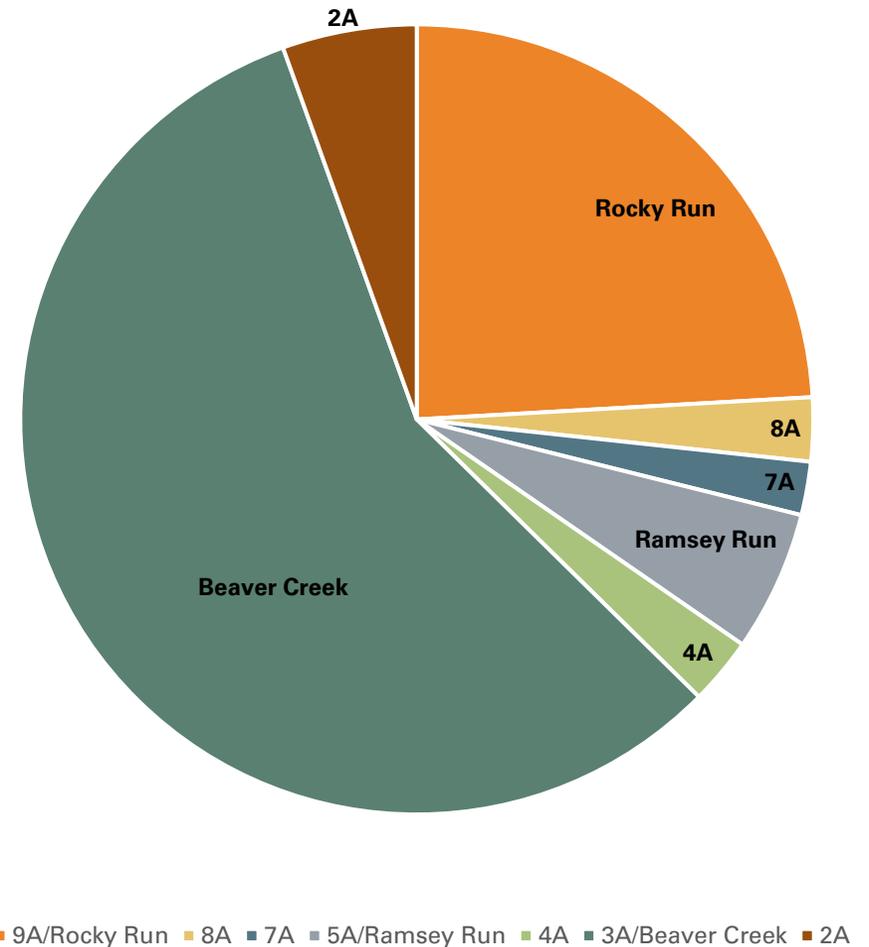
Distribution of Land Uses (in acres) of Tributary Watersheds in Upper Brandywine



- Forest (acres)
- Developed Land (acres)
- Storage Wetlands (acres)
- Other (acres)

Stream Name/Number	Total Drainage Area (acres)	Forest (acres)	Developed Land (acres)	Storage Wetlands (acres)	Other (acres)
9A/Rocky Run	1126	318.7	663.2	2.3	141.9
8A	122	74.7	16.6	0.0	30.7
7A	102	70.5	0.0	0.9	37.9
5A/Ramsey Run	269	97.9	22.9	0.0	148.2
4A	128	67.7	2.3	0.0	58.0
3A/Beaver Creek	2669	1056.9	942.2	21.4	648.6
2A	256	45.3	28.7	0.8	181.2
Total	4672	1731.7	1675.8	25.3	1246.6

Drainage Area of Upper Brandywine Tributaries (acres)



- 9A/Rocky Run
- 8A
- 7A
- 5A/Ramsey Run
- 4A
- 3A/Beaver Creek
- 2A

WATER QUALITY DATA

TOP: MARCH 6-7, 2021, BOTTOM: APRIL 18, 2021

Stream Name/Number	Depth (ft)	Width (ft)	Area (ft ²)	V (ft/sec)	Q (ft ³ /sec)	Turbidity	Nitrogen (mg/L)	Conductivity (μS)
9A/Rocky Run	5.42	32.6	88.2	0.03	2.69	0.0	3.7	578
8A	0.50	4.8	1.2	0.05	0.05	0.0	1.4	30
7A	0.46	0.3	0.1	0.24	0.02	17.1	5.5	131
5A/Ramsey Run	0.25	4.1	0.5	0.08	0.04	0.3	4	132
4A	0.66	27.9	9.2	0.05	0.51	0.5	2.3	433
3A/Beaver Creek	0.53	0.4	0.1	0.07	0.01	0.7	5.2	232
2A	0.42	5.0	1.0	0.03	0.03	3.3	2.1	183

Stream Name/Number	Depth (ft)	Length (ft)	Area (ft ²)	V (ft/sec)	Q (ft ³ /sec)	Turbidity	Nitrogen (mg/L)	Conductivity (μS)
9A/Rocky Run	5.50	32.8	90.2	0.06	15153.6-		7.8	388
8A	0.60	4.9	1.5-	-	-		5.4	232
7A	0.30	0.31	0.0	0.08	10.943-		5.4	127.8
5A/Ramsey Run	0.30	4.1	0.6	0.07	138.17-		5.4	220
4A	0.85	8.2	3.5-	-	-		0.3	140.4
3A/Beaver Creek	0.80	27.9	11.2	0.05	1361.52-		10.9	365
2A	0.53	4.75	1.3-	-	-		3.2	203

WATER QUALITY TESTING

PARAMETERS TESTED
FOR SAMPLES FROM
APRIL 18, 2021

Parameter	Unit	Water Quality Standard
Temperature	°C	No more than 27.7°C
pH	pH unit	6.5-8.5
Turbidity	NTU	Cannot exceed 10 NTUs
Dissolved Oxygen (DO)	mg/L	Cannot be <5.5 average
Electrical Conductivity (EC)	µS	Should be between 150-500µS
Enterococci Bacteria	#/100mL	925/100mL
Aluminum (Al)	mg/L	0.75 mg/L acute 0.087 mg/L chronic
Boron (B)	mg/L	0.75 mg/L
Calcium (Ca)	mg/L	*
Copper (Cu)	mg/L	0.0134 mg/L
Iron (Fe)	mg/L	1 mg/L
Potassium (K)	mg/L	*
Magnesium (Mg)	mg/L	*
Manganese (Mn)	mg/L	0.5 mg/L
Sodium (Na)	mg/L	*
Phosphorus (P)	mg/L	0.2 mg/L
Sulfur (S)	mg/L	250 mg/L
Zinc (Zn)	mg/L	0.117 mg/L acute 0.118 mg/L chronic
NH4-N (Ammonia-Nitrate)	mg/L	Usually does not exceed 0.2 mg/L
NO3 (Nitrate)	mg/L	10 mg/L

EPA BIOASSESSMENT METHODOLOGY

- These charts display the characteristics used to assess the habitat of each of the Upper Brandywine Tributaries

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloping; 60-100% of bank has erosional scars.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to <5 centimeters or less in average stubble height.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION # _____ RIVERMILE _____	STREAM CLASS _____	
LAT _____ LONG _____	RIVER BASIN _____	
STORET # _____	AGENCY _____	
INVESTIGATORS _____	REASON FOR SURVEY _____	
FORM COMPLETED BY _____	DATE _____ TIME _____ AM PM	

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are egg new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by the sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material; increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or >25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in sampling reach

EPA ASSESSMENT RESULTS

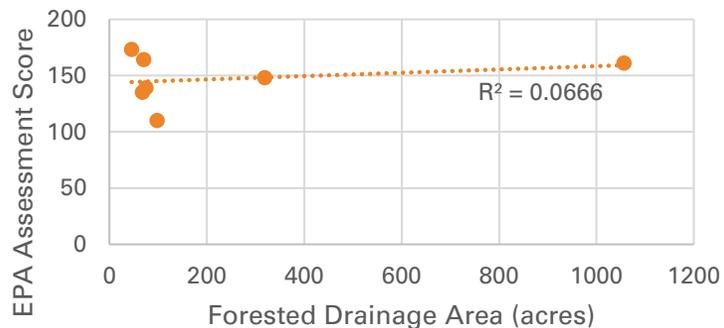
Stream Name/Number	Epifaunal Substrate/Available Cover	Embeddedness	Velocity/Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles (or Bends)	Bank Stability (LB)	Bank Stability (RB)	Vegetative Protection (LB)	Vegetative Protection (RB)	Riparian Vegetative Zone Width (LB)	Riparian Vegetative Zone Width (RB)	Score	Condition
9A/Rocky Run	13	20	20	17	18	15	12	3	3	7	4	8	8	148	Suboptimal
8A	11	19	9	13	8	20	18	10	4	10	10	4	3	139	Suboptimal
7A	20	14	10	20	17	20	20	8	8	8	8	3	8	164	Optimal
5A/Ramsey Run	11	3	9	20	15	7	15	4	3	7	4	10	2	110	Suboptimal
4A	12	8	6	14	16	13	17	6	4	10	9	10	10	135	Suboptimal
3A/Beaver Creek	13	20	18	19	14	18	17	10	1	8	6	10	7	161	Optimal
2A	16	20	15	18	19	20	18	10	10	10	5	10	2	173	Optimal

Stream Name/Number	Score	Condition
9A/Rocky Run	148	Suboptimal
8A	139	Suboptimal
7A	164	Optimal
5A/Ramsey Run	110	Suboptimal
4A	135	Suboptimal
3A/Beaver Creek	161	Optimal
2A	173	Optimal

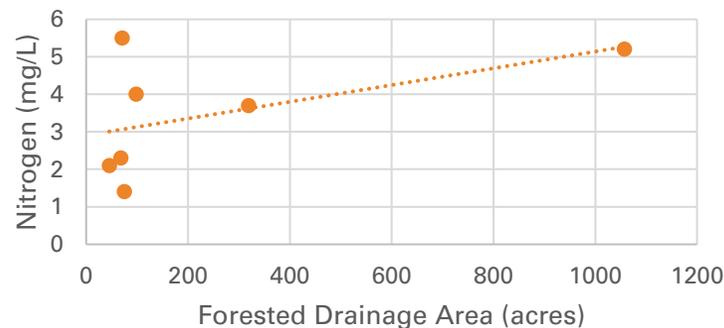
SUMMARY AND ANALYSIS

Stream Name/Number	Total Drainage Area (acres)	Forest (acres)	Developed Land (acres)	Storage Wetlands (acres)	Other (acres)	Q (ft3/sec)	Turbidity	Nitrogen (mg/L)	Conductivity (µS)	Score	Condition
9A/Rocky Run	1126	318.7	663.21	2.25	141.88	2.69	0.0	3.7	578	148	Suboptimal
8A	122	74.7	16.59	0.00	30.74	0.05	0.0	1.4	30	139	Suboptimal
7A	102	70.5	0.00	0.92	37.94	0.02	17.1	5.5	130.9	164	Optimal
5A/Ramsey Run	269	97.9	22.87	0.00	148.22	0.04	0.3	4	131.9	110	Suboptimal
4A	128	67.7	2.30	0.00	57.98	0.51	0.5	2.3	433	135	Suboptimal
3A/Beaver Creek	2669	1056.9	942.16	21.35	648.57	0.01	0.7	5.2	232	161	Optimal
2A	256	45.3	28.67	0.77	181.25	0.03	3.3	2.1	183.3	173	Optimal

Forested Drainage Area vs. EPA Assessment



Forested Drainage Area vs. Nitrogen Content



Multiple analyses were done to consider the relationship between forested area, considered healthier for streams and very present in the Upper Brandywine tributaries, and other parameters of stream health. The scatter plots to the right show minimal correlation, however there are some limitations in the data set that would affect this.

CONCLUSIONS

StreamStats: the % forested area of the Upper Brandywine tributaries ranges from 17.7-61.9% with the average being 42.6%, the drainage area of the watersheds ranges from 102-2669 acres, with the average being 667 acres

Velocity and Discharge: the velocity (in ft/sec) ranges from 0.03-0.24, and the discharge ranges from 0.01-2.69 cubic feet/second

Water Quality: measures of conductivity range from 30 to 578 μ S, nitrogen ranges from 1.4-5.5 mg/L, and turbidity ranges from 0-17.1 NTU

- **Conductivity**- be between 150-500 μ S; at the time of collection, streams 8A, 7A, and Ramsey run were below this range while Rocky Run exceeded it
- **Nitrogen**- should be less than 1 mg/L; at the time of collection, all streams exceeded this metric
- **Turbidity**- should not exceed 10 NTU; at the time of collection, stream 7A had 17.1 NTU

EPA Assessment: 4 streams were in suboptimal condition while 3 streams were in optimal condition

Analysis: the data suggest that there is some relationship between land use and stream health; further analysis should be done to consider the presence of agricultural lands in tributary watersheds and how this relates to stream health and water quality parameters

Generally: the health of the tributaries of the Upper Brandywine River is between suboptimal-optimal range; the nitrogen measurements are high in all tributaries, while conductivity and turbidity are generally within accepted values