WATER QUALITY

Water quality in the Upper Greenbrier Watershed is generally moderate to good, and water chemistry is adequate to support aquatic biota that range from cool water to cold water communities. Sedimentation is a problem within much of the watershed, and streams typically transport considerable fine sediment during periods of storm runoff. Otherwise streams generally run fairly clear. There are an estimated 263 miles of mapped "blue line" streams in the GIS layers for the Upper Greenbrier Watershed, although perennial and intermittent stream mileage greatly exceeds that. Designated uses of the surface waters within the watershed include propagation and maintenance of fish and other aquatic life (Category B), and water contact recreation (Category C). In addition, the WVDEP Division of Water Resources considers the public water supply designated use (Category A) as applying to all waters of the state, unless such water has had Category A specifically removed. Category A applies to all known waters within the assessment area, as well as Categories B and C.

Despite the previously discussed sediment issues within many streams, and some stream temperature issues as well (refer to the Temperature section, below), all streams within the assessment area are considered by the State of West Virginia to be meeting water quality standards. No streams within the Upper Greenbrier Watershed have been identified by the State as being acid impaired, and water chemistry generally demonstrates moderate to good conditions from the acidity standpoint. See the acidity section, following. There are no streams listed in the State's 2006 303(d) List of impaired streams. (However, the entire length of the Greenbrier River main stem, up to the confluence of the East and West Forks at Durbin, is included in the 303(d) List for reasons of fecal coliform impairment, although the cause is listed as "Unknown".) Some streams are listed as Category B2 Trout Waters in the State's Legislative Rules (47CSR2, Requirements Governing Water Quality Standards, Appendix A), and these include the West Fork, and a number of tributaries of both the East and West Forks. This is far from a complete list of streams that support trout, however. Further, in their 2001 list of High Quality Streams, the West Virginia Division of Natural Resources included both the East and West Forks and numerous of their tributaries as High Quality Streams.

West Virginia Legislative Rule 60CSR5 (Antidegradation Implementation Procedures) provides "Tier 2.5" water quality protection for "Waters of Special Concern", which are defined in 47CSR2. The Rule requires that no significant degradation of Tier 2.5 waters will be allowed. Degradation is deemed significant if it exceeds the baseline water quality plus 10 percent of available assimilative capacity (the difference between the baseline water quality and the water quality criteria), whether from a single activity or cumulatively. No streams in the Upper Greenbrier have been designated as Tier 2.5 streams by the WV Legislature, but 14 streams are included in the "presumptive list" of streams that meet the criteria for Tier 2.5 designation (Appendix C of 60CSR5). A more recent list and map of "Proposed Tier 2.5 Streams – June 7, 2007" maintained on the WVDEP website has 12 rivers and streams included, with a combined mileage of 25.4 miles in the East Fork drainage, and 33.9 miles in the West Fork drainage.

Water quality is considered adequate to meet established state standards (47CSR2), despite the recognized sedimentation problems in many of these streams. The high value that the State places on streams and water quality within the Upper Greenbrier Watershed is evident in the

several special designations assigned to many of these streams. Many other streams are not specifically included in these lists, but these omissions may be due more to incomplete stream inventories, or land use impacts that are reducing habitat and water quality (such as temperature effects from reduced shade).

Sediment

Reference Conditions

Reference conditions for water quality would have reflected the undisturbed condition of the subwatersheds. Essentially none of the present day human-caused conditions that affect water quality in these subwatersheds would have existed prior to European settlement. Sediment conditions in streams would have been controlled by natural processes, and not been influenced by the variety of land-clearing and disturbance activities that exist today. Natural processes would have included all of the types of erosion that occur today (sheet, rill, gully, slides, streambank, etc), but in different proportions and amounts. Riparian areas would have remained intact, leading to improved channel stability in areas that are now cleared. Overall, bedload sediment and fine sediment would have been at moderately to substantially lower levels, and suspended sediment during storm flow conditions would have also been lower. Aquatic habitats throughout the Upper Greenbrier Watershed would have exhibited a higher quality because of the reduced sediment conditions. The aquatic community in general would benefit, and trout reproduction would have been maintained at a higher level.

Current Conditions

Fine sediment is high within the rivers and streams of the Upper Greenbrier Watershed. Field work conducted over the last decade has resulted in observed and measured fine sediment levels in streams that are considered to be detrimental to some fish populations, such as native brook trout. Measured fine sediment levels in sampled stream substrates ranged from moderate, and below the commonly accepted threshold of substantial adverse impact to brook trout spawning success, to high fine sediment composition and well above the threshold. Refer to the Aquatic Resource section, below.

Sediment is delivered to streams through channel bank erosion, and through sheet, rill and gully erosion of upland slopes. Some gully erosion and headcut erosion occurs below roads where flow concentration has altered drainage patterns, increasing substantially the sediment supply to channels. There is a minor amount of mass wasting within the watershed, usually associated with road cuts and fills. Mass wasting has occurred on small segments of Forest Road 44, but delivered substantial quantities of sediment to the West Fork during those events. Some land uses and facilities within riparian areas, such as roads along streams and grazing within riparian areas, contribute to de-stabilized streambanks, accelerated channel bank erosion, and channel widening. Forest Service grazing allotments and private land grazing occur in the Headwaters East Fork, Little River, and Outlet East Fork subwatersheds. Numerous sediment sources exist within these allotments.

Also, much of the present day erosion and stream channel sediment conditions are consequences of the early 1900s logging and wood processing industry. Increased stormflows resulting from such drastic land use had substantial channel stability effects, further compounded by removal of most of the riparian vegetation, riparian development, and large wood from channels. The aquatic and riparian resource condition that exists today has been and continues to be influenced by effects of the logging industry from a hundred years ago. Recovery from those impacts is a very long-term process.

Water quality and within-channel habitat conditions are impaired by the combined sediment effects of historic and more recent land uses and facilities. The Aquatic Resources section below addresses habitat aspects. Water quality sediment conditions are generally described as measures of suspended sediment and turbidity. Sediments, especially fine sediments, are mobilized in streams during periods of storm runoff, and increase suspended sediment and turbidity levels. These effects are often readily observed and recognized by the untrained observer. As stormflows fall and streams return to baseflow conditions, suspended sediment and turbidity generally fall quickly to low levels and streams appear clear again. But fine sediments stored in and on the surface of the stream substrates are readily available to be remobilized in future runoff events. Stormflow sediment characteristics of streams within the Upper Greenbrier Watershed are generally considered to be high to very high.

The effects of various roads, highways, and other land uses on hydrologic processes, erosion sources, and channel conditions indicates that accelerated channel erosion is occurring in some reaches, leading to deposition in others. Increased bedload from channel bank erosion and sediment from upland sources has led to destabilized channels, simplified habitats and higher fine sediment composition in many streams of the watershed. Impaired riparian vegetation conditions, including some on private lands, has also led to increased channel bank erosion, and increased bedload and fine sediment impairment of aquatic habitats. Early 1900s logging industry impacts are responsible for much of these current conditions, but more contemporary and present day land use and facilities also contribute to the current sediment conditions.

Sediment source areas are extensive throughout the subwatersheds, and affect many of the various tributaries and rivers within the Upper Greenbrier Watershed. Sediment sources include the range of facilities and land uses, including state, National Forest and private roads, old woods roads and railroad grades, roads and well sites associated with the Glady Gas Storage Field, some old logging skid roads, gas pipelines, and areas of grazing and agriculture. There are several Forest Service grazing allotments within three of the subwatersheds, and some private land grazing as well. Erosion and sedimentation from communities and industry along the East Fork are likely substantial, but no good information on those sources is available at this time. Finally, it is recognized that early 1900s logging throughout the Upper Greenbrier Watershed was extremely damaging and destructive to uplands, riparian areas and streams. Much of the present day erosion and sedimentation conditions and source areas are attributable to that historic logging industry, but specific source areas are sometimes hard to pinpoint because of the widespread and somewhat continuous impact on streams and riparian areas.

Table WQ-1. Partial List of Known Sediment Sources in the Upper Greenbrier Watershed

Sediment Source	Subwatershed	Description of Work Needed	Miles
FR97, FR756 in May/Little R. EA	Little River	Road maintenance, drainage improvement, etc.	3.5
FR179 in May/ Little River EA	West Fork	Road maintenance, drainage improvement, grading, etc.	4.3
Woods Rds in May/Little River EA/DN	West Fork and Little River	Abandon Woods Roads 00, 1, 18, 19, 20, 21, 22, 23, 108, 109, 111, 112, 113, 114, 115, 116, 117. Block access, remove drainage structures, restore drainage, revegetate soils.	8.1
FR242, 428, & 451 in May/ Little River EA	West Fork and Little River	Abandon Forest Roads. Block access, remove drainage structures, restore drainage, revegetate soils.	3.8
Other woods roads throughout subwatersheds	All 4 subwatersheds	Numerous other woods roads and old railroad grades exist throughout the 4 subwatersheds. Sediment reduction work is needed, but no inventories exist. Block access, remove structures, restore drainage, outslope, revegetate soil, etc.	??
Forest Roads	All 4 subwatersheds	All Forest Roads need routine maintenance, grading, drainage improvement, ditchline repair, spot surfacing, etc on recurring basis.	??
Bennett Run un-named road	Headwaters East Fork	Drainage improvement and sediment reduction, revegetate bare soil.	0.4 est.
Forest Road 51	Headwaters East Fork	Block access past East Fork crossing at end of Abes Run Road; other drainage improvements.	
Forest Road 804	Headwaters East Fork	Isolated drainage/erosion problems near East Fork Greenbrier and Bearwallow Run. Restore drainage and revegetate eroding soil.	0.5 est.
Townsend Hollow unnamed rd.	Outlet East Fork	Road in un-named hollow (Townsend Hollow) north of Forest Road 54 near Buffalo Lake. Major road erosion, stream running in road. Restore flow to stream, obliterate road, revegetate soil.	1.0 est.
Forest Road 286	Headwaters East Fork	FR286 up along Poca Run north of Hwy 28. Major erosion, rutting, gullies. Restore drainage, stabilize rutting and gullies, stabilize soil.	1.3 est.
Forest Road 57	Headwaters East Fork	Gullies near Long Run. Stabilize gullies and soil.	??
Forest Roads 222 and 248	Little River	In addition to Forest Road 242 (Clubhouse Run), Forest Road 222 (Elklick Run) and Forest Road 248 (Hinkle Run) have serious drainage and erosion occurring. Restore drainage, obliteration if possible, erosion/gully stabilization.	??
Trail 367	Little River	Trail near Hinkle Run has drainage and stream crossing problems. Restore drainage and stabilize stream crossings.	??
USFS grazing allotments	Little River, Headwaters & Outlet East Fork	Riparian area treatments are needed to restore riparian conditions and reduce sedimentation. Fencing and riparian planting are likely options.	??

The above list of sediment sources and needed improvements to reduce erosion and sediment is an incomplete list. Other sediment source areas are known or believed to exist within the various subwatersheds, but specific sites have not been identified or inventoried. Some of the woods road project work included in the May/Little River EA and Decision Notice may no longer be needed, while many other woods roads have not been inventoried. Specific improvements needed on state roads have not been identified. Sediment reduction projects on Forest Service grazing allotments and on private land grazing have likely not all been identified, although

improvements in riparian management are needed. Roads in the Glady Gas Storage Field may need additional improvements for sediment reduction. Numerous opportunities for stream bank stabilization exist, resulting largely from the early 1900s logging industry impacts.

Despite current high sediment conditions in these streams, none are listed on the State's 2006 303(d) List for reasons of sediment impairment. In terms of sediment, all streams within the Upper Greenbrier River assessment area are considered by the WVDEP to be meeting their designated uses. However, this does not mean that they are in a satisfactory condition in terms of fine sediment and habitat relations, bank stability, nor even stormflow-related suspended sediment levels.

Desired Conditions

Wetlands and floodplains function as detention/retention storage areas for floodwaters, sources of organic matter, and habitat for aquatic and riparian species. Improving watershed conditions contribute to the de-listing of water quality limited water bodies to meet Clean Water Act requirements and state water quality management rules. Streams are in dynamic equilibrium; that is, stream systems normally function within natural ranges of flow, sediment movement, temperature, and other variables that provide for healthy aquatic systems. Streamside vegetation contributes to the protection and maintenance of water quality, water quantity, nutrient inputs, and physical channel integrity to support channel function, aquatic biota, aquatic and wildlife habitat, floodplain function, aesthetic values and designated uses (Forest Plan, p. II-9).

Acidity (pH)

Reference Conditions

Stream acidity under reference conditions would have been governed by the natural buffering capacity of the soils and bedrock, and by the natural acidity of precipitation and the influence of vegetation. In general, most streams probably had slightly higher average pH values. And during summer storms and snowmelt runoff, acid shock events were not a problem. The effect on the aquatic community in most of the subwatershed streams may not be great, because most maintain some buffering capacity.

Current Conditions

Water chemistry in the streams of the Upper Greenbrier River watershed is moderately good to very good. Water samples taken by the Forest Service between fall 2001 and spring 2007 from a sample of streams indicates generally good chemistry in terms of acidity relations. Refer to Table WQ-2 for selected water quality results in these streams. Water quality data collected by the West Virginia Department of Environmental Protection (WVDEP) since 1999 is presented in Table WQ-3. The "alkalinity" metric used by WVDEP is replaced by the "ANC" or acid neutralizing capacity metric in the USFS data. Alkalinity is measured in milligrams of calcium carbonate per liter ($CaCO^3$/L), while ANC is Acid Neutralizing Capacity, measured in micro-equivalents per liter (ueq/L). Also, "conductivity" is measured in micro Siemens per centimeter in the USFS data, but in micro ohms per centimeter in the WVDEP data.

Table WQ-2. USFS Water Quality Summary for Upper Greenbrier Watershed Streams

Site (Stream Name)	pH	Conductivity	Calcium	ANC
West Fork Greenbrier River	6.9 - 7.5	28 - ?	1.9 - 8.1	108.7 - 525.7
Snorting Lick Run	6.6	22	1.8	74.4
Mikes Run	6.3 - 7.0	18 - ?	0.6 - 1.6	20.1 - 122.8
Gertrude Run	6.5	22	1.5	60.3
Fox Run	6.6	19	1.3	48.2
Iron Bridge Run	6.4	21	1.4	43.5
Old Road Run	7.1	48	7.4	324.2
Little River (West Fork)	6.8 - 7.1	23 - 33	2.0 - 3.8	78.0 - 208.4
Span Oak Run	6.5	23	1.6	44.0
Clubhouse Run	6.4	20	1.5	34.0
Hinkle Run	6.2 - 7.0	15 - ?	1.0 - 2.0	12.6 - 98.9
Mountain Lick Creek	6.6	22	1.6	58.3
East Fork Greenbrier River	6.7 - 7.3	23 - ?	2.0 - 3.5	76.9 - 172.7
Poca Run	6.5 - 7.0	22 - 62	1.4 - 4.5	44.6 - 334.0
Long Run	6.6 - 7.1	24 - ?	1.6 - 3.7	69.1 - 190.5
Mullenax Run	7.0 - 7.3	25 - ?	3.2 - 3.9	114.9 - 254.3
Abes Run	6.4	30	1.8	69.0
Bennett Run	6.4	20	1.7	49.2
Fivemile Hollow	6.6	25	2.4	85.3
Lick Run	6.5	24	1.6	72.9
Buffalo Fork	6.5	24	1.7	83.5
Little River (East Fork)	6.8	41	3.2	142.9
Old House Run	6.6	25	1.9	77.6

Notes: Calcium is total calcium measured in milligrams per liter (mg/L)

Table WQ-3. WVDEP Water Quality Summary for Upper Greenbrier Watershed Streams

Site (Stream Name)	pH	Conductivity	Calcium	Alkalinity
West Fork Greenbrier River	6.4-8.0	29-77	3.7-10.4	6.9-31.1
Snorting Lick Run	6.1	25	2.2	5.0
Mikes Run	5.9-6.5	21-22	1.8	5.0
Old Road Run	7.6	121	20.5	56.2
Braucher Run	7.2	122	18.1	49.4
Little River (West Fork)	5.5-7.6	23-59	7.6	22.9
Clubhouse Run	5.8-6.7	21-23	1.7-1.9	4.9-5.0
Mountain Lick Creek	7.2	54	5.3	12.7
East Fork Greenbrier River	6.7-7.9	21-43	2.4-4.7	5.0-15.5
Poca Run	6.9	36	3.4	8.2
Long Run	6.5-7.3	29-31	2.4-2.8	6.1-9.1
Grassy Run	6.3	33		
Mullenax Run	7.5	38	4.7	16.4
Little River (East Fork)	6.6-7.7	35-65	3.7-6.1	7.4-23.8

Although streams in the area are considered to be meeting water quality standards for acidity, acid deposition is likely having some effect on water chemistry in all these streams. Water chemistry is generally adequate in terms of acidity relations, and the streams are relatively not susceptible to being acid deposition impaired. Limited portions of the watershed have some acid sensitive geologic types, primarily along the top of Shavers Mountain in the West Fork subwatershed (about 3100 acres), with another 2210 acid sensitive acres in the upper portions of the Headwaters East Fork and Little River subwatersheds. However, perennial streams in these areas gain better chemistry water as they flow through less sensitive strata immediately downstream. The poorest chemistry streams are mostly in the headwaters of Little River (Hinkle and Clubhouse Runs), and their pH stayed above 6.0 with ANC generally above 20. (WVDEP data documented several streams with pH below 6.0, but these were isolated instances, and otherwise pH remained above 6.0). Streams are otherwise adequate to good in their acid buffering condition, not considered to be acid impaired, and should currently sustain their aquatic communities. Several streams originating on the east flank of Shavers Mountain (including Old Road, Fill, and Braucher Runs) flow through Greenbrier Limestone strata, gaining considerable buffering capacity and have high ANC/alkalinity values.

Desired Conditions

Improving watershed conditions contribute to the de-listing of water quality limited water bodies to meet Clean Water Act requirements and state water quality management rules. Streams are in dynamic equilibrium; that is, stream systems normally function within natural ranges of flow, sediment movement, temperature, and other variables that provide for healthy aquatic systems (Forest Plan, p. II-9).

Stream Temperature

Stream temperature is one environmental factor that can influence the species composition of aquatic communities and the relative health of individual populations that inhabit aquatic ecosystems. Stream temperature affects various bio-physical and physicochemical properties associated with aquatic environments (such as respiration rates and dissolved oxygen capacity), which can place physiological constraints on the type and abundance of aquatic organisms that could otherwise be supported by aquatic habitats.

Aquatic ecosystems typically exhibit signature stream temperature patterns or temperature regimes that develop in response to prominent and persistent associations between land form, climate patterns, watershed hydrologic properties, and other watershed characteristics. Aquatic inhabitants frequently exhibit life history strategies that are adapted to specific temperature regimes and the associated environmental cues that function to initiate behavior critical to sustaining population viability for aquatic species over the long term. Changes to temperature regimes can result in modifications to aquatic species composition as well as population vigor.

Reference Conditions

Reference stream temperature regimes for the upper Greenbrier River system are unknown and cannot be quantified. However, reference conditions may be qualitatively assessed upon

consideration of correlations that typically exist between stream temperature regimes, watershed conditions, and dependent aquatic communities. Insight to reference stream temperatures can also be gained by comparing watershed conditions and aquatic communities in the upper Greenbrier River system today with conditions that likely existed prior to European settlement. Discussion that follows for the conditions of current stream temperatures supports a contention that reference conditions in the Upper Greenbrier Watershed likely exhibited more stable ranges for daily stream temperatures and more moderate extremes for seasonal stream temperatures (*i.e.* cooler summer maximum stream temperatures and warmer winter minimum stream temperatures) when compared to general stream temperature characteristics exhibited today.

Current Conditions

Stream temperatures can be influence by many factors. Various watershed and stream conditions that can influence stream temperatures have been considerably altered from their reference conditions in the Upper Greenbrier Watershed. Although timbering activities and other types of disturbance continue today, the most pronounced changes to the Upper Greenbrier Watershed arguably occurred as a result of timbering activities during the early 1900s. Results from the timbering activities and subsequent fires effectively eliminated forest cover, increased road densities, accelerated erosion and stream sedimentation rates, reduced natural stream channel integrity, and degraded aquatic habitat composition and quality. Changes to any one of these conditions could trigger alterations to stream temperatures. The dramatic changes that occurred to watershed and stream conditions in the Upper Greenbrier Watershed suggest stream temperature regimes likely experienced substantial alterations. Changes to stream temperature regimes likely included increased daily temperature fluctuations as well as increased extent and duration of summer maximum temperatures and winter minimum temperatures.

The greatest deviations from reference stream temperature conditions likely occurred toward the mid-1900s following widespread deforestation and recurring wildfires. As early as 1935, streams in the Upper Greenbrier Watershed were generally described as once being excellent trout streams which had become poorly shaded, spread to several times their original width, and possessed stream flows so low (or dry) and warm that they were no longer suitable for trout during the summer months (McGavock and Davis 1935).

As forested areas gradually recovered in the Upper Greenbrier Watershed, particularly in riparian areas where the effects of stream shading could be realized, stream temperature regimes likely began to experience a recovery trend toward reference conditions. Although the majority of the of the Upper Greenbrier Watershed is now in a forested condition, many other vital stream channel processes and watershed hydrologic properties remain impaired and are in various stages of recovery from the cumulative effects associated with historic and present day disturbances.

Recent monitoring of stream temperatures has been conducted in the Upper Greenbrier Watershed. Stream temperature data were recorded at 15 minute intervals from June to October, 2005 at 13 sites located in 11 different streams in the Upper Greenbrier Watershed. Figure WQ-3 shows a graphical example of the dataset from one monitoring site. Since native brook trout (*Salvelinus fontinalis*) are identified as the aquatic Management Indicator Species in the Land and Resource Management Plan for the Monongahela National Forest (Forest Plan), stream

temperature data are summarized in Table WQ-4 for optimal, tolerable, and lethal temperature ranges described for brook trout (Raleigh 1982).

Figure WQ-3. Stream Temperature Data for West Fork Greenbrier River, Summer, 2005
(2,800' above sea level).

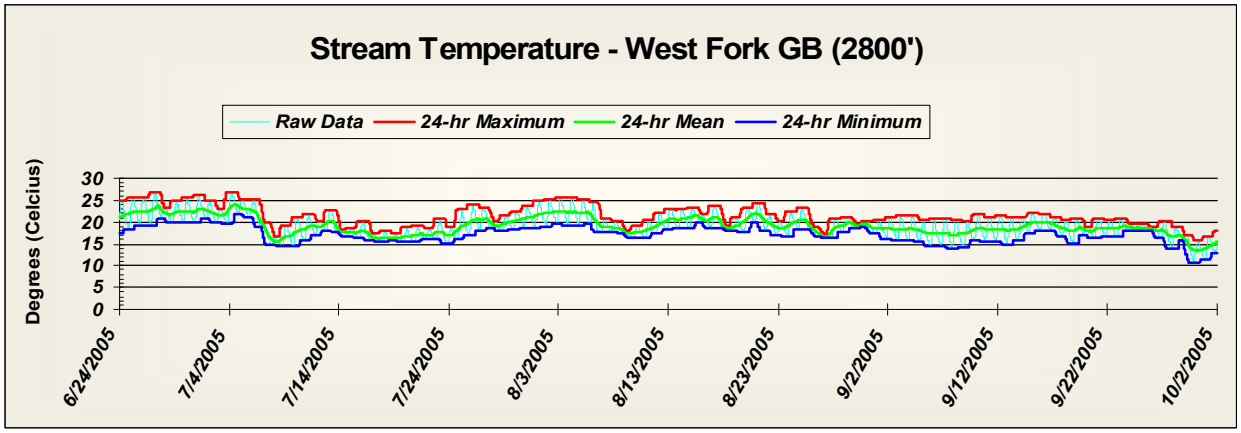

Table WQ-4. Stream Temperature Data (Degrees Celsius) from June – September, 2005
(Optimal, tolerable, and lethal stream temperature data are summarized for brook trout)

Stream Name	Elevation (feet)	Acres	Maximum 24-hr Minimum Temp.	Maximum 24-hr Mean Temp.	Maximum 24-hr Maximum Temp.	Days with Averages Exceeding Optimal Temp.	Days with Maximum Approaching Tolerable Temperature	Days with Maximum Exceeding Lethal
East Fork GB	2798	38448	22.15	23.07	23.74	70	21	0
West Fork GB	2800	33294	21.89	24.06	26.87	76	35	13
Mountain Lick Ck	2840	2467	19.46	20.92	22.97	40	6	0
Little River (WF GB)	2920	12459	18.63	21.41	27.51	26	15	6
Old Road Run	2950	2585	16.11	17.61	20.13	0	0	0
Little River (EF GB)	2995	5737	18.53	19.37	20.84	26	0	0
East Fork GB	3000	15702	18.65	19.47	21.20	27	0	0
Long Run	3005	1497	17.70	17.99	18.37	0	0	0
Mikes Run	3030	1019	18.99	19.66	20.94	26	0	0
Buffalo Fork	3120	2642	18.11	19.45	21.63	22	0	0
Hinkle Branch	3200	1966	16.77	17.49	18.53	0	0	0
Mullenax	3280	2217	17.44	18.19	19.75	3	0	0
East Fork GB	3535	4324	17.94	19.71	22.71	18	3	0

It is important to note that although stream temperature monitoring devices can accurately capture stream temperature measurements where the device is placed, it is possible for streams to possess micro-habitats associated with areas of up-wellings or springs where temperatures may

deviate from those recorded. In this way, aquatic biota may be able to seek micro-habitats within stream segments that would otherwise appear to be intolerable.

Stream temperature data show that eight of 13 stream sites monitored in the Upper Greenbrier Watershed clearly possess summer stream temperatures that would support brook trout populations. The lower reaches of the West Fork Greenbrier River and its largest tributary, the Little River, possess stream temperatures during the summer that are lethal to brook trout. The East Fork Greenbrier River and lower reaches of Mountain Lick Creek exhibit maximum stream temperatures that approach lethal levels during the summer. Summer stream temperatures remained within the optimal range for brook trout in only two of the 13 stream sites monitored - Long Run and Hinkle Branch. No streams within the Upper Greenbrier Watershed are listed in the State 303(d) List as temperature impaired.

Stream temperature data and other information (see Aquatic Habitat and Populations discussion) available for streams in the Upper Greenbrier Watershed indicate portions of this stream system possess temperature regimes capable of supporting cold-water biota typically associated with native brook trout communities. Some stream reaches, particularly in larger streams such as the East Fork and West Fork Greenbrier River, are currently transitional areas better suited for cool-water aquatic communities characteristic of smallmouth and rock bass communities. Water temperatures in these cool-water transitional areas generally become too warm and stressful to sustain viable populations of cold-water biota during the summer but these areas can still provide critical seasonal habitat (*e.g.* over-wintering habitats) for cold-water biota during other times of the year.

Assessment of watershed characteristics may help explain variation in stream temperature data collected from different streams. Preliminary assessment of data from streams in the Upper Greenbrier Watershed indicate watershed area and stream length exhibit the greatest influence on variation in the stream temperature dataset. However, this result may be more a function of a relatively limited range of variation in other watershed characteristics being assessed for the dataset than a true lack of correlation with these other seemingly less influential watershed variables. Identical assessments of stream temperature datasets from other watersheds across the Forest suggest significant correlations also exist between stream temperature and watershed characteristics of stream elevation, percent forested area (for both riparian area and watershed area), percent wetlands, road density (for both riparian area and watershed area), and stream crossing density. Understanding relationships between stream temperatures and influential watershed characteristics can help identify opportunities to manage watersheds for desired conditions.

Desired Conditions

Streams are in dynamic equilibrium; that is, stream systems normally function within natural ranges of flow, sediment movement, temperature, and other variables that provide for healthy aquatic systems (Forest Plan, p. II-9). Restoration activities have resulted in maintaining necessary water temperatures to sustain viable populations of native and desired non-native aquatic species (Forest Plan, p. II-29).