Asotin Creek Temperature Straight-to-Implementation Vegetation Study

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Cover photo: Hemispherical photo of riparian vegetation, taken along Lick Creek about 2 miles upstream of the Forest Service boundary.

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by

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Abstract

The Washington State Department of Ecology (Ecology) intends to address temperature impairments in the Asotin Creek watershed in southeastern Washington through straight-to-implementation (STI). This report supports the STI process by providing an analysis of natural vegetation and system potential shade in the Asotin Creek watershed. Natural vegetation is described in terms of two riparian vegetation categories: one for coniferous and one for deciduous vegetation.

Additionally, shade resulting from planted vegetation at several past riparian restoration project sites is analyzed and compared to system potential shade. Shade resulting from planted vegetation varies, with some sites providing system potential shade and other sites providing less than system potential shade.

As part of the Asotin Creek Temperature STI Vegetation Study, Ecology conducted reference site and past implementation site surveys during 2011. Additional field data obtained from the U.S. Forest Service were also used during this project.

Acknowledgements

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- All of the landowners who granted us permission to conduct vegetation surveys on their property.
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Background

Straight-to-Implementation

Asotin Creek and its tributaries have high water temperatures that do not support the designated beneficial uses for these water bodies. A total of 17 segments of Asotin Creek and its tributaries were listed for temperature on the 2008 303(d) list. Listed segments occur on the mainstem of Asotin Creek, North Fork (N.F.) Asotin Creek, South Fork (S.F.) Asotin Creek, Charley Creek, Lick Creek, George Creek, and Pintler Creek.

The Washington State Department of Ecology (Ecology) intends to address temperature impairments on the 303(d) list in the Asotin Creek watershed through straight-to-implementation (STI) in lieu of a Total Maximum Daily Load (TMDL) study. The STI approach minimizes the need for extensive technical study where the causes of water quality problems are well-documented and the solutions already known. STI is typically used in watersheds where either the vast majority or all of the pollution is nonpoint, with few or no point source contributions. This allows Ecology to address water quality impairments more effectively for select watersheds by focusing on implementation efforts.

Ecology's Water Quality Program will prepare an STI plan, which addresses all actions that need to be taken to improve water quality in the watershed. The STI plan also lays out a schedule for future monitoring, i.e. effectiveness monitoring. The purpose of this vegetation study report is to support the STI plan by (1) describing system potential riparian vegetation and shade, and (2) assessing the progress planted vegetation at selected restoration sites is making toward providing system potential shade.

Study Area Description

Asotin Creek and its tributaries drain the northeastern slope of the Blue Mountains in southeastern Washington, emptying into the Snake River at the town of Asotin (Figure 1). The watershed is within WRIA 35 (Middle Snake). It encompasses 326 square miles (approximately 209,000 acres). Major streams in the watershed include Asotin Creek, N.F. Asotin Creek, S.F. Asotin Creek, George Creek, Pintler Creek, Charley Creek, and Lick Creek. The watershed spans two major ecoregions, the Blue Mountains and the Columbia Plateau.

The main land uses in the watershed are forest (35%), agriculture (29%), and canyon/rangeland (36%). Urban areas cover less than 0.1% of the watershed. Land ownership within the watershed is a mix of public (50%) and private (50%). Public lands in the watershed are managed primarily by the U.S. Forest Service (USFS, 30% of watershed), Washington Department of Fish and Wildlife (WDFW, 12% of watershed), and Washington Department of Natural Resources (8% of watershed). The U.S. Bureau of Land Management and Asotin County each manage less than one square mile.

Asotin Creek and its tributaries support runs of endangered steelhead (*Oncorhynchus mykiss*) and chinook salmon (*Oncorhynchus tshawytscha*). Resident populations of rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) also are present. The Asotin Creek drainage also has also traditionally supported a large run of Pacific lamprey (*Lampetra tridentata*), which has greatly declined in recent decades.

There are no major impoundments or NPDES point sources with direct discharges to Asotin Creek or its tributaries. The Asotin Wastewater Treatment Plant is located near the mouth of Asotin Creek but discharges to the Snake River. The city of Asotin and parts of Asotin County are covered by a Municipal Phase II Eastern Washington Stormwater Permit.

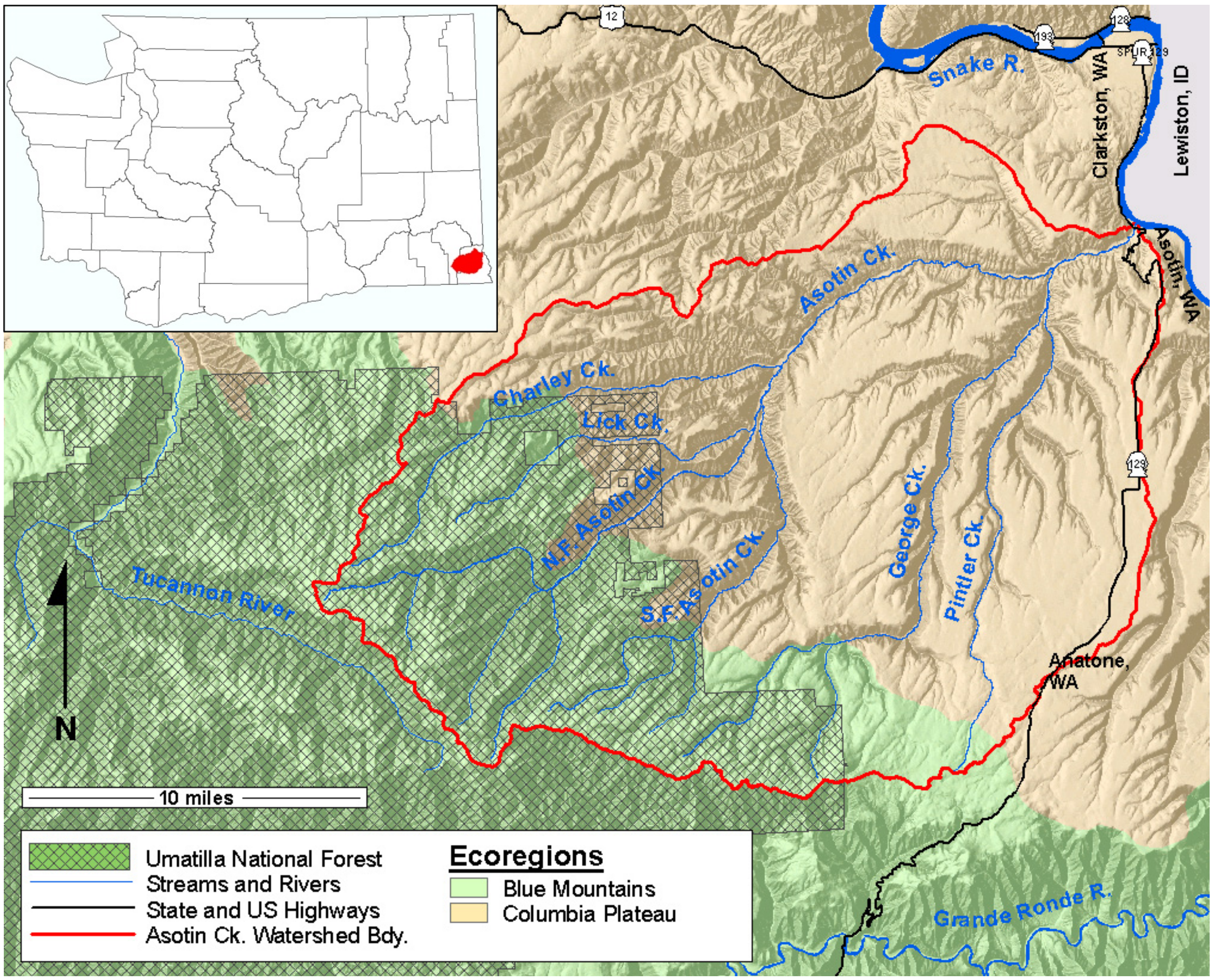

Figure 1. Location of Asotin Creek watershed in southeastern Washington.

Existing and Ongoing Studies

The Asotin Creek watershed has been heavily studied during recent decades. The Snake River Salmon Recovery Board (SRSRB) has selected the Asotin Creek basin for study as an Intensively Monitored Watershed (Bennett and Bouwes, 2009). This effort is focused on Charley Creek, Lick Creek, and the upper Asotin Creek branches, with an emphasis on salmon habitat restoration. The Intensively Monitored Watershed work includes riparian vegetation surveys and water temperature monitoring. In 2001, the SRSRB performed an Ecosystem Diagnosis and Treatment Model (EDT) habitat assessment of the Asotin Creek watershed.

Asotin Creek has also been the subject of recent ongoing work by Washington State University's Department of Natural Resource Sciences (e.g. Hardesty et al., ongoing). The Asotin Creek basin was included in the Washington State Conservation Commission's analysis of limiting factors for salmonid habitat in southeast Washington (Kuttel, 2002). The U.S. Forest Service has conducted stream vegetation surveys and water temperature monitoring (Del Groat, personal communication). The Washington Department of Fish and Wildlife has conducted additional water temperature monitoring (Steve Martin, personal communication).

Previous Restoration Work

A significant amount of riparian restoration work has already taken place in the Asotin Creek watershed. This includes riparian projects implemented by the Asotin County Conservation District, and funded by the Bonneville Power Administration, the Washington Conservation Commission, and the State of Washington. The Intensively Monitored Watershed project has also included extensive restoration work in the Charley Creek subwatershed. Overall, approximately 200,000 trees have been planted along Asotin Creek and its tributaries since 1998 (Chad Atkins, personal communication).

Goals and Objectives

The goal of the Asotin Creek Temperature STI project is to continue to address temperature problems in the Asotin Creek watershed so that water quality is improved and beneficial uses restored. More specifically, the goal is for Asotin Creek and its tributaries to meet state temperature water quality criteria. This will mean encouraging a continuation of the restoration efforts that have already been undertaken.

To support this goal, this study had the following two objectives:

- Characterize system potential vegetation throughout the Asotin Creek watershed in terms of species composition and physical attributes. Determine the amount of shade that can be provided by system potential vegetation.

- Evaluate the progress of previous riparian restoration projects in the watershed toward providing system potential shade to the stream.

Study Methods

System Potential Vegetation and Shade

Reference Sites

Reference sites were selected at 15 locations which currently represent system potential vegetation, or nearly so (Figure 2, triangles). During the summer of 2011, hemispherical vegetation photographs were taken at each of these sites to quantify effective shade. Effective shade is defined as the fraction of incoming solar shortwave radiation that is blocked from reaching the surface of the stream by vegetation and topography. Photographs were taken from the center of the stream channel and from the right and left banks. Hemispherical photographs were analyzed using HemiView canopy analysis software (University of Kansas, 1996).

In addition, a brief vegetation survey was conducted at each site. Height measurements and streambank coverage were recorded for each species of tree and shrub present. Aspect and bankfull width were also measured, since these attributes affect stream shading. Reference site data are presented in Appendix A.

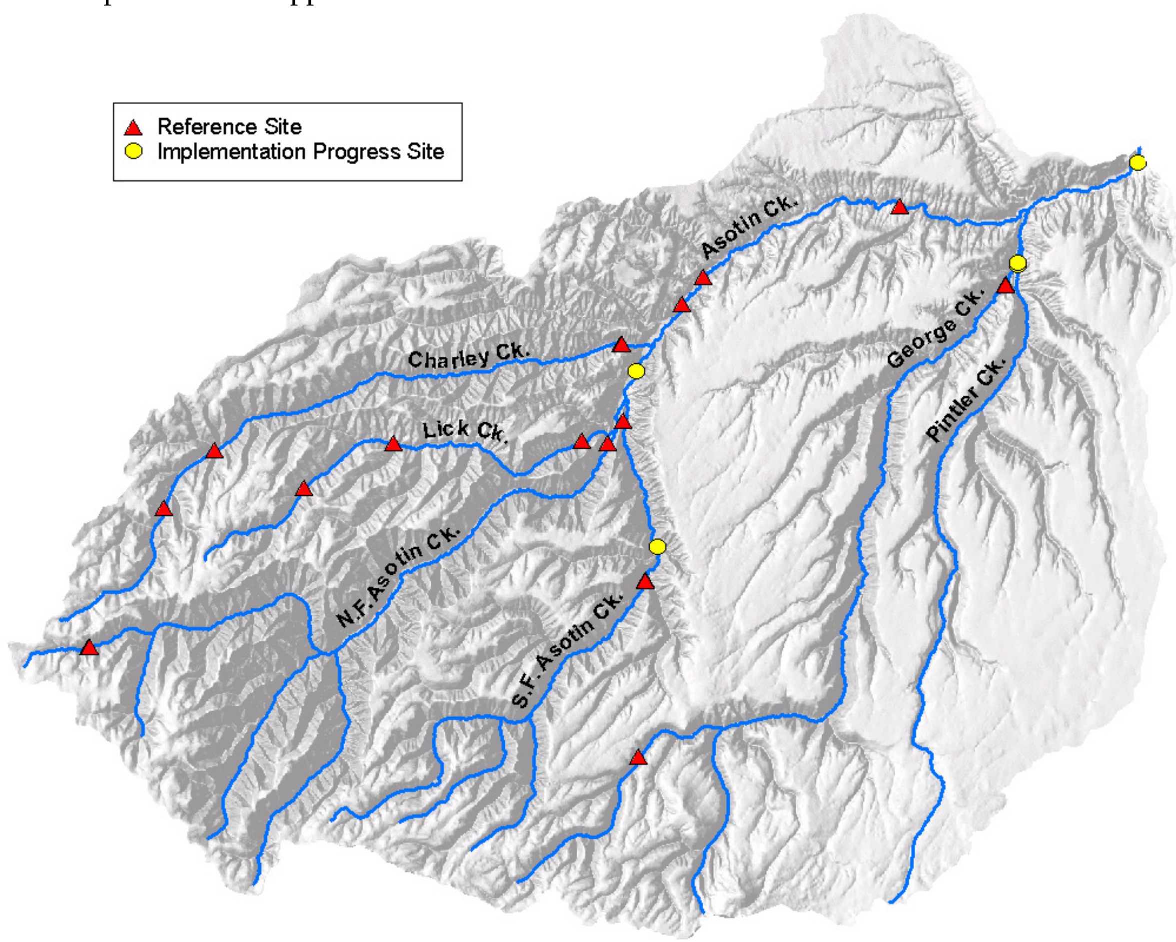

Figure 2. Reference sites and implementation progress sites visited during 2011.
The two implementation progress sites on George Creek are represented as one yellow dot.

System Potential Vegetation Analysis

System potential riparian vegetation was determined for all streams in the study area. System potential riparian vegetation is defined as that vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes. A soils-based approach similar to that used by Sullivan (2000) and Gilmore (2005) was used. First, a GIS coverage of the Asotin-Garfield U.S. Department of Agriculture (USDA)/Natural Resource Conservation Service (NRCS) soil survey was obtained. Potential vegetation was defined for each soil type based on a weight of evidence from the following sources:

- **Reference Site Vegetation Surveys –** As described in the previous section.
- **USDA Ecological Site/Plant Association data –** Each soil type in the USDA/NRCS soil survey is linked to information about the characteristic forest and/or rangeland plant coverage for that soil type.
- **USDA Forestland Productivity data –** For each soil type in the USDA/NRCS soil survey that supports forestland, a site index is provided for one or more tree species. The site index value represents the height of trees that can grow on that soil at age 50 or 100 years.
- **General Land Office surveys –** The General Land Office surveyed all township and section lines during the late 1800s. Surveyors often made notes of vegetation present along streams, and these records are now available online through the Bureau of Land Management (www.blm.gov/or/landrecords/survey/ySrvy1.php).
- **USFS Level II stream surveys –** These surveys recorded dominant and secondary tree species along several streams in the study area, as well as canopy closure measurements.

Stream reaches throughout the watershed were placed into two vegetation categories. One category represents primarily coniferous vegetation, and the other represents primarily deciduous vegetation.

System Potential Shade Analysis

For each vegetation category, representative height, canopy density, and overhang were defined. Table 1 summarizes how each of these values was derived. Ecology's Shade model (Ecology, 2003) was used to estimate the effective shade that would be produced by each vegetation category on streams with various aspects and bankfull widths. The Shade model uses mathematical simulations to generate effective shade values using an algorithm modified from Boyd (1996) using the methods of Chen et al. (1998a and 1998b).

Table 1. Source of values used for height, canopy density, and overhang for vegetation categories used in Asotin Creek watershed.

Attribute	Conifer vegetation category	Deciduous vegetation category
Height	Measured heights from reference sites (USDA site index values were lower than reference sites, probably because they often reflect only 50 years of growth, and/or upland rather than riparian conditions)	Measured heights from reference sites and USDA site index values. (USDA site index values agreed well with measurements at reference sites)
Density	Calibrated to correctly predict effective shade observed at reference sites	
Overhang	Estimated as 10% of height	Compromise between measured value and value required to correctly predict effective shade at reference sites

Implementation Progress

Five sites were selected throughout the study area where riparian restoration projects have already been completed (Figure 2, circles). At each of these sites, hemispherical vegetation photographs were taken. Aspect, bankfull width, and vegetation heights were also measured. Effective shade measurements resulting from hemispherical photo analysis were compared to the shade that would be expected from the system potential vegetation. This provided a way to assess the progress of the re-established vegetation at each of these sites toward providing system potential shade to the stream channel.

Study Quality Assurance Evaluation

Study data were collected as described in the Quality Assurance Project Plan for the Asotin Creek Temperature STI Vegetation Study (Stuart, 2011). Center-channel hemispherical photos were duplicated upstream or downstream at five of the 15 reference sites in order to assess the natural heterogeneity in effective shade along the course of a stream. The average difference between a pair of nearby center-channel effective shade results was eight percentage points. Considering the natural variation in riparian vegetation as well as the fact that not all duplicate photos were necessarily taken at places with equal stream aspects or bankfull widths, this result suggests that HemiView results do provide a representative estimate of effective shade.

Results and Discussion

System Potential Vegetation and Shade

Natural riparian vegetation in the Asotin Creek watershed falls into two major categories, representing primarily coniferous and primarily deciduous vegetation. Within each vegetation category, a few subcategories are defined. The subcategories within a single vegetation category have very similar shade characteristics, and do not need separate shade curves. However, the differences in species composition and/or layout may be of interest to those undertaking riparian restoration projects.

These system potential vegetation categories are mapped in Figure 3. Subcategories are indicated generally, but it is beyond the scope of this study to define the exact boundaries between subcategories. This is partly because there are no exact boundaries between subcategories or even categories. Vegetation tends to transition gradually from one type to the next.

Representative height, canopy density, and overhang distances for each vegetation category, along with the species makeup for the various subcategories, are presented in Table 2. Effective shade provided by each of the two categories is presented in Figures 4-5 and Tables 3-4.

One surprising feature of mature, natural riparian vegetation observed at reference sites in the Asotin Creek watershed is the remarkable lack of willows (*Salix sp.*). Although not entirely absent, they are typically small and sparse, contributing very little to stream shade. The vast majority of stream shade in the Deciduous zone is provided by white alder (*Alnus rhombifolia*) and water birch (*Betula occidentalis*). Black cottonwood (*Populus trichocarpa*) is also widespread but usually grows a bit further back from the immediate edge of the creek. One exception to this is the “shrub thicket” subcategory, in which a great variety of shrub and small tree species, including willows, combine to form a very diverse and thick cover over a narrow stream. This may always have been the case. General Land Office survey comments from the 1870s about stream-side vegetation mostly fail to mention willows except in the very upper reaches of George and Pintler Creeks, and one instance on S.F. Asotin Creek. Instead, the comments consistently refer to alder, birch, and cottonwood along the banks of the creeks.

Table 2. System potential riparian vegetation categories for the Asotin Creek watershed.

Riparian Vegetation Category	Height	Density	Overhang
Conifer	**40 m**	**37%**	**4.0 m**

Subcategory	Overstory species	Understory species
Englemann Spruce/Subalpine Fir	Douglas-fir western larch Englemann spruce grand fir subalpine fir	Sitka alder prickly currant threeleaf foamflower
Grand Fir	grand fir Douglas-fir Englemann spruce	Pacific yew alder (Sitka?) thimbleberry Rocky Mtn. maple Woods' rose prickly currant
Transitional	Douglas-fir ponderosa pine	mixed alders black hawthorn Rocky Mtn. maple Lewis mock orange common snowberry mallow-leafed ninebark

Note: The "transitional" subcategory occurs at the downstream end of the Conifer Forest zone, as the conifers begin to transition into deciduous vegetation. The shade characteristics of this subcategory may be intermediate between those of Conifer and Deciduous categories.

Riparian Vegetation Category	Height	Density	Overhang
Deciduous	**25 m**	**55%**	**3.5 m**

Subcategory	Overstory species	Understory species
Mixed Riparian Forest	water birch white alder black cottonwood ponderosa pine Douglas-fir	red osier dogwood common snowberry black hawthorn blue elderberry nootka rose Lewis mock orange
Alder Riparian Forest	white alder black cottonwood	Lewis mock orange nootka rose blue elderberry red osier dogwood

Note: In both the "mixed riparian forest" and the "alder riparian forest" subcategories, there is a distinct pattern of species placement. The white alder and/or water birch form the overstory band closest to the stream edge, while the cottonwoods (and conifers, where present) grow a little further back from the stream.

Subcategory	Overstory species	Understory species
Shrub Thicket	Douglas fir (very sparse) ponderosa pine (very sparse)	alder (various?) black hawthorn Rocky Mtn. maple peachleaf willow coyote willow oceanspray common snowberry

Note: The "shrub thicket" subcategory tends to occur where there is not enough year-round streamflow to support larger deciduous trees. In reality the height for this subcategory is lower and the density (e.g., on Lick Creek) is higher than for the other two subcategories. The overall shade ends up being about the same.

Species are listed in approximate observed order of abundance. Species lists are by no means exhaustive.

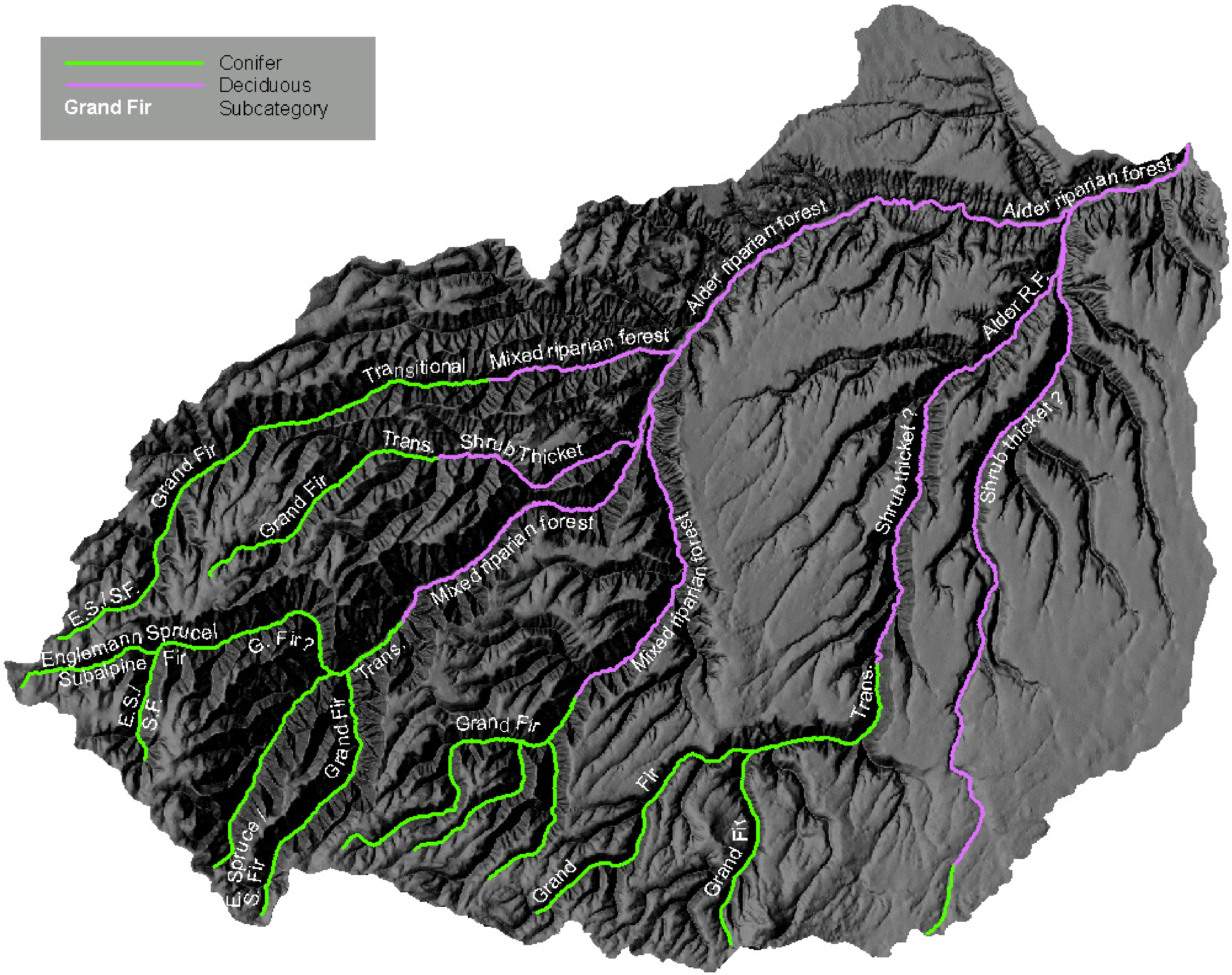

Figure 3. Map of the Asotin Creek watershed showing system potential riparian vegetation categories and subcategories.

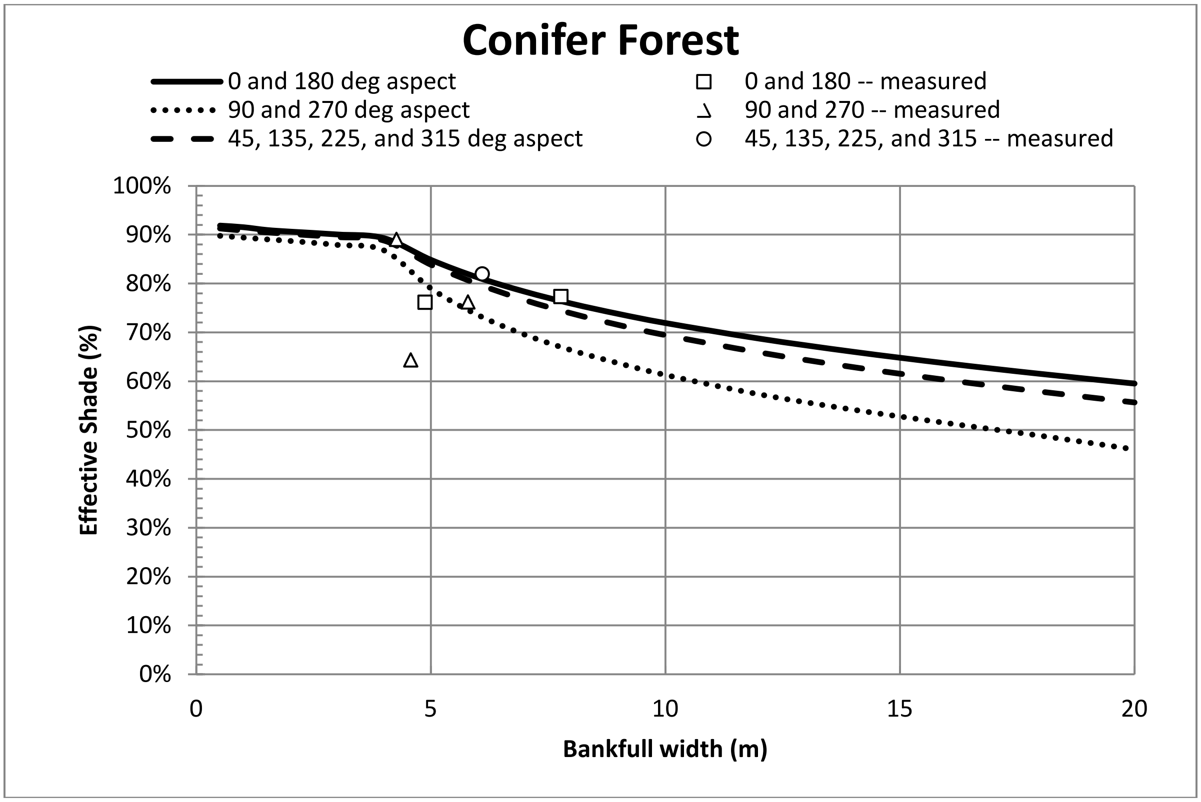

Figure 4. Potential effective shade curve for the Conifer Forest vegetation category, showing measured shade at reference sites for comparison.

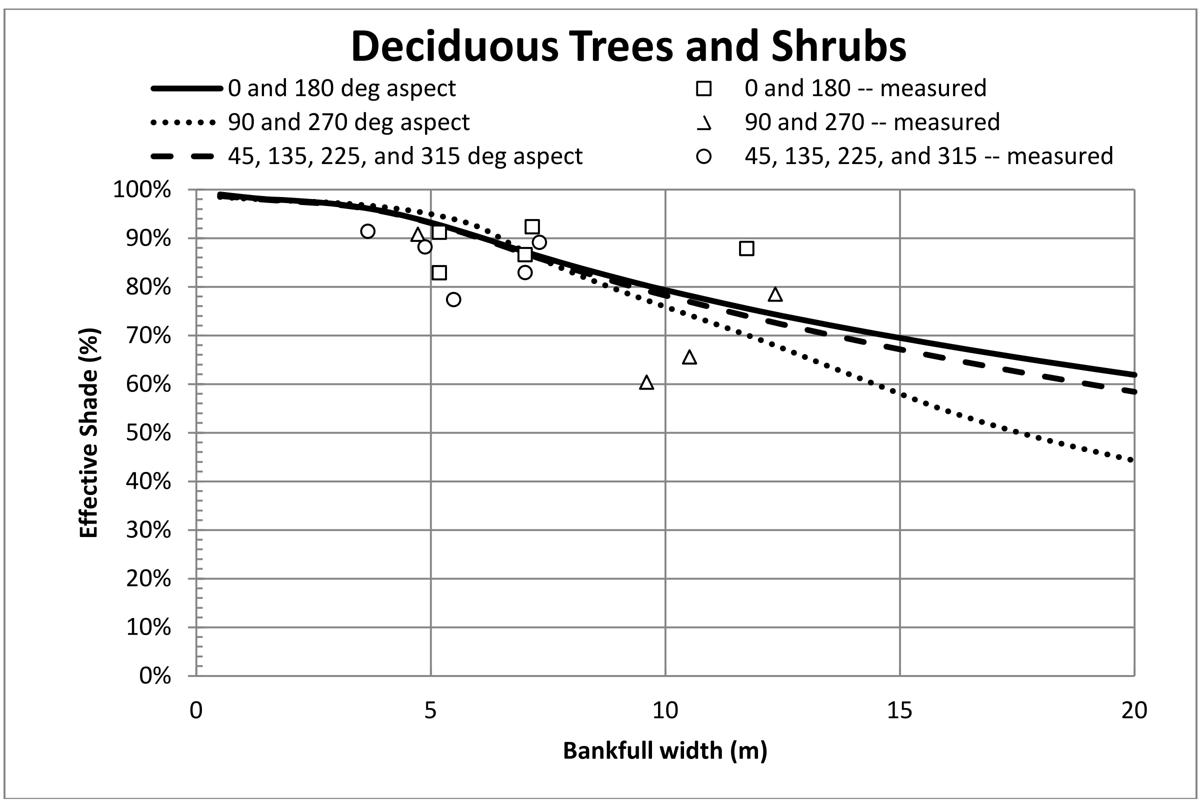

Figure 5. Potential effective shade curve for the Deciduous Trees and Shrubs vegetation category, showing measured shade at reference sites for comparison.

Table 3. Potential effective shade for streams in the Conifer Forest vegetation category, based on bankfull width and stream aspect.

Bankfull width (m)	Effective shade from vegetation (%) at the stream center at various stream aspects (degrees from N)			Daily average global solar short-wave radiation (W/m^2) at the stream center at various stream aspects (degrees from N)		
	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect
0.5	92%	91%	90%	25	27	32
1	92%	91%	89%	26	28	33
1.5	91%	90%	89%	28	29	34
2	91%	90%	89%	29	31	35
3	90%	89%	88%	31	32	37
4	89%	89%	87%	33	35	41
5	85%	84%	79%	47	50	65
6	81%	80%	74%	58	62	82
7	78%	77%	69%	67	72	94
8	76%	74%	66%	75	81	104
9	74%	71%	64%	81	88	112
10	72%	69%	61%	87	94	120
12	69%	66%	57%	97	105	132
14	66%	63%	54%	105	115	142
16	64%	60%	51%	112	123	150
18	61%	58%	49%	119	130	158
20	60%	56%	46%	125	137	167

Table 4. Potential effective shade for streams in the Deciduous Trees and Shrubs vegetation category, based on bankfull width and stream aspect.

Bankfull width (m)	Effective shade from vegetation (%) at the stream center at various stream aspects (degrees from N)			Daily average global solar short-wave radiation (W/m^2) at the stream center at various stream aspects (degrees from N)		
	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect
0.5	99%	99%	99%	3	3	4
1	99%	99%	99%	3	4	4
1.5	98%	98%	98%	5	5	5
2	98%	98%	98%	6	6	6
3	98%	98%	98%	7	7	7
4	96%	96%	97%	11	11	9
5	94%	94%	96%	17	18	13
6	92%	92%	94%	24	24	17
7	90%	90%	93%	31	31	22
8	88%	87%	90%	39	39	30
9	85%	85%	86%	46	47	42
10	83%	82%	83%	53	55	54
12	79%	78%	75%	66	69	76
14	75%	73%	67%	78	83	101
16	71%	69%	59%	89	95	126
18	68%	66%	53%	99	106	145
20	65%	62%	48%	108	117	160

Implementation Progress

The progress of planted vegetation toward providing potential shade was assessed at five sites where restoration work had previously been done. All five sites are located in the Deciduous vegetation category. The results of this analysis are presented in Table 5.

Table 5. Comparison of potential and actual shade at sites where riparian restoration has been previously implemented.

Site	Location	Bankfull Width	Aspect	Year Planted[1]	Height of planted veg.	Effective Shade	
						Potential[2]	Actual
S.F. Asotin meander reconstruction	46.22507 -117.28033	4.0 m	300°	1998	6-11 m	96%	83%
Asotin Ck. at Koch property	46.28032 -117.28690	9.4 m	2°	1998-1999	6-11 m	84%	19%
George Ck. meander recon. (younger age class)	46.30930 -117.11233	5.5 m	54°	2007	8 m	93%	55%
George Ck. meander recon. (older age class)	46.30859 -117.11240	5.5 m	80°	2006	5-8 m	95%	92%
Asotin Ck. at Asotin City Park revegetation	46.33875 -117.05636	9.1 m	2°	1997-1998	3 m	85%	67%

[1]Brad Johnson, personal communication.
[2]Potential effective shade is calculated for each site using Table 4.

All of these restoration sites except the Asotin City Park site are meander reconstruction projects. At these sites, the stream channel was widened, and the existing vegetation destroyed, by flooding in the winter/spring of 1997. Subsequently, at each site a meandering single stream channel was engineered and built, and vegetation was planted along the banks of the new channel.

The planted riparian vegetation at the George Creek and S.F. Asotin Creek meander reconstruction projects is, 4-13 years after establishment, quite effective at blocking solar radiation from the stream (Figure 6). At the George Creek older age class site, current effective shade essentially matches potential shade. Given a few more years of growth it is likely that the George Creek younger age class and S.F. Asotin Creek sites will also reach this point.

The restored vegetation at the two sites on Asotin Creek does not yet provide potential shade. At the City Park site this may be because restoration only occurred on one side of the creek due to residential use on the other side. Much of the vegetation at this site regenerated naturally, in addition to the planted vegetation. At the Koch site, vegetation has not yet reached the height that would be necessary to adequately shade the 9.4 m-wide channel. It is not known if more work or simply more time is necessary for this to occur.

Figure 6. Hemispherical photo of restored vegetation along George Creek, looking skyward from the stream channel.

The white line shows the solar path on August 1st. The vegetation blocks the vast majority of solar radiation through the course of the day.

Conclusions and Recommendations

As a result of this study, the following conclusions and recommendations are made.

- Diverse types of natural riparian vegetation occur in the Asotin Creek watershed, with conifer-dominated communities occurring in the upper stream reaches and deciduous-dominated communities occurring in the middle and lower stream reaches.

- Potential riparian vegetation provides a strong shading effect to stream channels, with system potential effective shade generally ranging from 50-100% for bankfull widths that occur in the Asotin Creek watershed.

- Past restoration projects have increased effective shade to the stream channel. Some restored sites now provide close to system potential shade, though others sites do not yet.

- It is recommended that future restoration projects make heavy use of the riparian plant species that naturally occur in a given stream reach. For much of the middle and lower drainage, this particularly means white alder, water birch, and/or black cottonwood. These species can grow to a height of 25 m or more, which is particularly necessary to shade wider stream channels such as the mainstem of Asotin Creek.

- It is recommended that HemiView surveys be repeated at past restoration project sites several years in the future to assess effective shade as this planted vegetation matures. Additional sites may be added.

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Appendices

Appendix A. Reference Sites Survey Summary

Table A-1. Summary of data collected at reference sites in the Asotin Creek watershed.

Site	Location	Aspect	Bankfull Width	Effective Shade[1]	Tree Species	Measured Heights	Shrub/Tall Forb Species
Charley Ck. on FS Land – upper site	N 46.24345 W 117.50179	19°	16 ft	C: 76% L: 80% R: 78%	grand fir Douglas-fir Rocky Mtn. maple Pacific yew	110-118 ft 73-118 ft 23 ft 6 ft	thimbleberry prickly currant white spiraea threeleaf foamflower common snowberry
Charley Ck. on FS Land – lower site	N 46.26085 W 117.47780	96°	19 ft	C: 76% L: 58% R: 83%	grand fir Englemann spruce ponderosa pine Rocky Mtn. maple	106-117 ft 81 ft 110 ft 19 ft	alder[2] Woods' rose white spiraea threeleaf foamflower common snowberry thimbleberry
Charley Ck. near Mouth	N 46.28910 W 117.29279	112°	15.5 ft	C: 91% L: 96% R: 99%	white alder water birch black cottonwood black hawthorn	54 ft 46 ft 70 ft 26 ft	Lewis mock orange nootka rose red raspberry (unidentified) currant
(duplicate)	N 46.2891 W 117.29241	151°	16 ft	C: 88%			
Lick Ck. upper site	N 46.24805 W 117.43819	70°	14 ft	C: 89% L: 95% R: 81%	grand fir Douglas-fir Pacific yew Englemann spruce	75-107 ft 121 ft 12-22 ft 69 ft	prickly currant thimbleberry Woods' rose threeleaf foamflower
Lick Ck. below Moonshine Spring	N 46.26070 W 117.39716	118°	12 ft	C: 91% L: 95% R: 84%	Douglas-fir white alder Rocky Mtn. maple black hawthorn	99-114 ft 48 ft 34 ft 14 ft	common snowberry mallow-leafed ninebark cow parsnip Lewis mock orange Woods' rose oceanspray red raspberry red osier dogwood
Lick Ck. near Mouth	N 46.25960 W 117.31200	17°	17 ft	C: 91% L: 88% R: 94%	alder Rock Mtn. maple black hawthorn Douglas-fir	41 ft 29-30 ft 19 ft 98-112 ft	oceanspray common snowberry rose[3,4] Canadian gooseberry
N.F. Asotin Ck. near Headwaters	N 46.20074 W 117.53813	99°	15 ft	C: 64% L: 48% R: 68%	Douglas-fir western larch Englemann spruce subalpine fir	81-96 ft 44-53 ft 84 ft 104 ft	alder[2] prickly currant threeleaf foamflower
(duplicate)	N 46.20084 W 117.53746	57°	20 ft	C: 82%			
NF Asotin Ck. above Lick Ck.	N 46.25804 W 117.30044	351°	23 ft	C: 87% L: 78% R: 95%	water birch white alder Douglas-fir black hawthorn	47-60 ft 59-64 ft 77 ft 22 ft	red osier dogwood common snowberry rose[3] thimbleberry red raspberry Lewis mock orange

Site	Location	Aspect	Bankfull Width	Effective Shade[1]	Tree Species	Measured Heights	Shrub/Tall Forb Species
SF Asotin Ck. above Warner Gulch	N 46.21493 W 117.28571	341°	17 ft	C: 83% L: 94% R: 83%	water birch black cottonwood white alder	10-19 ft 17 ft 46 ft	oceanspray red osier dogwood
(duplicate)	N 46.21469 W 117.28585	44°	18 ft	C: 77%			
SF Asotin Ck. near Campbell Grade Rd.	N 46.26479 W 117.89303	302°	24 ft	C: 89% L: 94% R: 90%	white alder black cottonwood	50-57 ft 70-88 ft	red osier dogwood Lewis mock orange
George Ck. near Little Butte[5]	N 46.15955 W 117.29205	6°	25.5 ft	C: 77% L: 76% R: 75%	grand fir Rocky Mtn. maple Englemann spruce Pacific yew	98-110 ft 35 ft 142 ft 38 ft	mallow-leafed ninebark threeleaf foamflower
George Ck. above Pintler Ck.[5]	N 46.30262 W 117.11745	27°	23 ft	C: 83% L: 91% R: 85%	white alder	50-87 ft	
(duplicate)	N 46.30242 W 117.11754	347°	23.5 ft	C: 92%			
Asotin Ck. at WDFW access	N 46.30081 W 117.26418	26°	38.5 ft	C: 88% L: 92% R: 85%	white alder black cottonwood	57-61 ft 84 ft	Lewis mock orange nootka rose rose[4]
Asotin Ck. above Palmer Gulch	N 46.30906 W 117.25422	72°	40.5 ft	C: 79% L: 85% R: 77%	white alder black cottonwood	60-62 ft 112 ft	Lewis mock orange nootka rose
Asotin Ck. above Kearny Gulch	N 46.32849 W 117.16380	100°	31.5 ft	C: 60% L: 40% R: 79%	white alder boxelder blue elderberry	75-97 ft 60 ft 14 ft	nootka rose Lewis mock orange common snowberry red osier dogwood
(duplicate)	N 46.32855 W 117.16415	108°	34.5 ft	C: 66%			

[1]Effective Shade at: C = center of stream channel; L = left bank; R = right bank. Calculated as the percentage of direct solar radiation blocked from reaching the stream through the course of the day on August 1st.
[2]Most likely Sitka alder.
[3]Possibly nootka rose.
[4]Possibly baldhip rose.
[5]These sites show evidence of impacts to the understory by animal grazing, although the overstory is intact.

Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of the stream by vegetation and topography.

Forb: Herbaceous plant; a non-woody plant that is not a grass, sedge, or a rush.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Riparian: Relating to the banks along a natural course of water.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Straight-to-Implementation (STI): A simple approach to a water cleanup plan that does not require extensive scientific analysis. Typically used when causes of water quality problems are well-documented and the solutions already known.

System potential mature riparian vegetation: That vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System potential shade: The effective shade produced by system potential mature riparian vegetation.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and

(4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
GIS	Geographic Information System software
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Commission
SRSRB	Snake River Salmon Recovery Board
STI	(See Glossary above)
TMDL	(See Glossary above)
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

Units of Measurement

ft	feet
m	meter