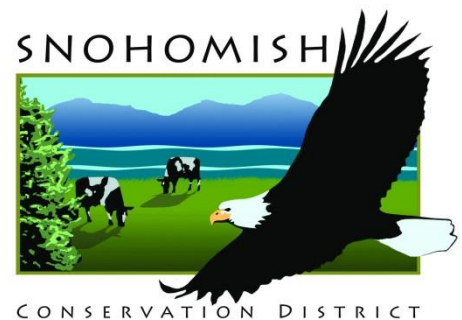


Woods Creek Action Plan for Riparian Restoration



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August 2012



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Introduction

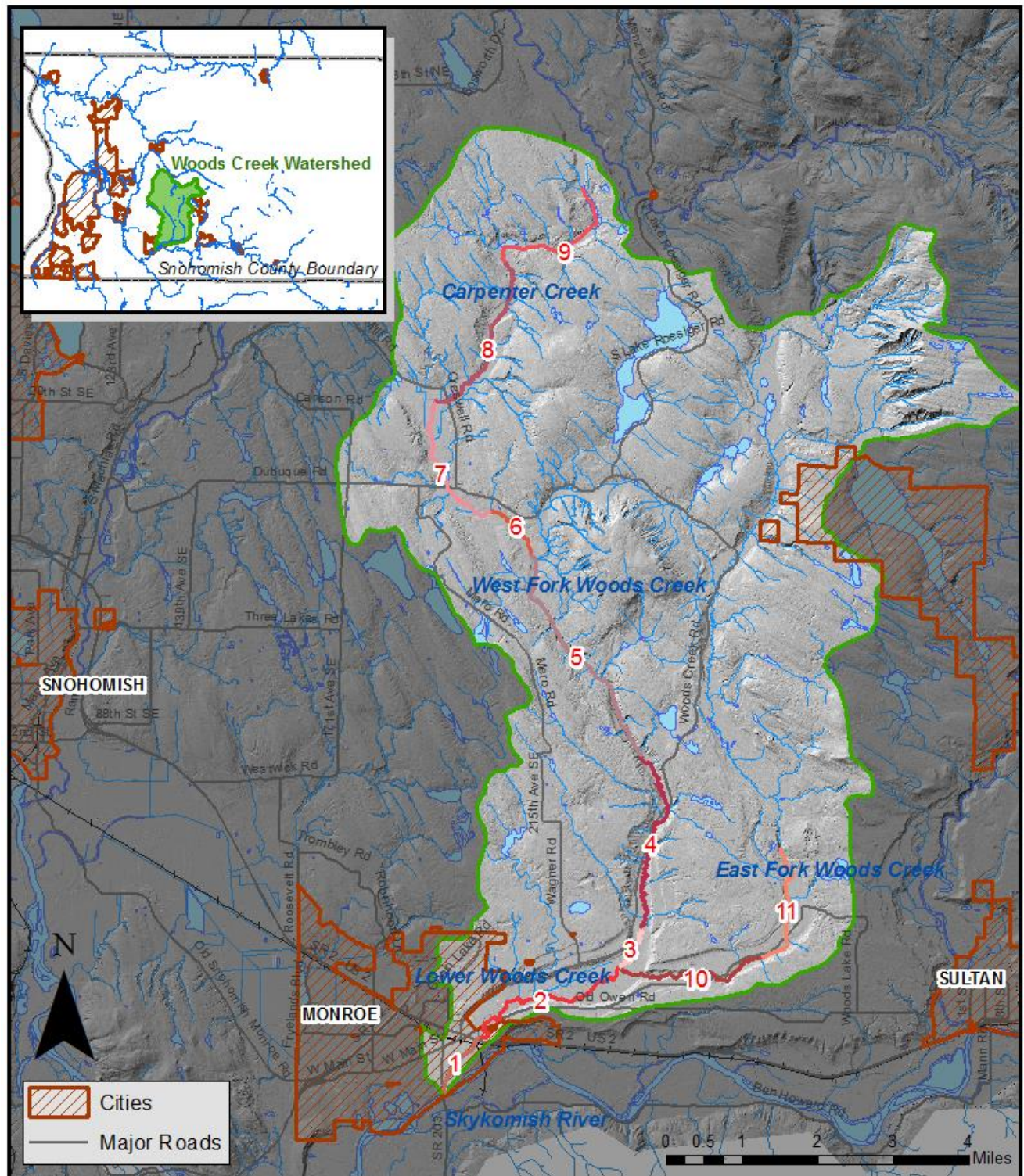
This Woods Creek Action Plan for Riparian Restoration outlines riparian enhancement targets, priority restoration areas within the watershed, and a proposed implementation budget.

Woods Creek has been identified as a high priority watershed in regional salmon planning efforts and water pollution remediation plans. For these reasons, watershed partners identified the need for further analysis and prioritization of the needs of the basin in order to develop a work plan. Using the limited resources available in the most effective way to achieve habitat and water quality targets is the Snohomish Conservation District's goal. Snohomish County Surface Water Management began this prioritization work with an assessment of habitat conditions in the watershed and will be releasing the *Woods Creek Watershed Habitat Conditions Report*. The Snohomish County project focused primarily on habitat conditions for salmonids in the mainstem of the creek. This Action Plan serves as an addendum to the *Habitat Conditions Report* and further prioritizes riparian restoration projects along both the mainstem and the major tributaries. The Action Plan also develops riparian enhancement goals in priority reaches as well as a timeline and projected budget.

Woods Creek is a major tributary of the lower Skykomish River and drains an area of nearly 61 mi². Elevation ranges from 2,370 ft in the upper watershed to 40 ft where it joins with the Skykomish River (tributary to the Snohomish River) at river mile 24 in the City of Monroe (Figure 1). This watershed is the largest Puget Lowland watershed in the Skykomish River basin and supports runs of Chinook (threatened), steelhead (threatened), bull trout (threatened), coho (species of concern), chum, and pink salmon. It is on the Clean Water Act Section 303(d) list for fecal coliform bacteria contamination (Lower Snohomish River Tributaries TMDL) and is being included in the Skykomish River TMDL for temperature that the Department of Ecology is currently developing. Implementing a robust riparian enhancement effort in the watershed will lead to improved habitat conditions for salmonids as well as improved water quality. Specifically, results will include:

- Reduced fecal coliform and pollutants through filtration
- Shading of stream to keep waters cold
- Long-term source of large wood to channel
- Bank stabilization to reduce fine sediment inputs
- Increased cover for salmonids

The Woods Creek watershed is divided into the Lower, West Fork (named Carpenter Creek at the headwaters), and East Fork Woods Creek subbasins (Figure 1). The two nearly equal sized subbasins of the West and East Forks come together to form Lower Woods Creek at river mile 3.9. On the East Fork, there is a natural waterfall at river mile 4.2 preventing anadromous fish passage. Both the Snohomish County Surface Water habitat conditions analysis and this riparian enhancement action plan focus analysis on the Lower, West Fork and East Fork of Woods Creek to the waterfall. These reaches will be referred to as the mainstem. The mainstem was further divided into eleven analysis reaches based on both the gradient of the channel and the land-use of the surrounding area (Figure 1).



Water Temperature Data

Methodology

Two sets of water temperature data were used to develop this Action Plan: continuous temperature data collection in the mainstem (Snohomish County Surface Water Management, 2009, 2010, 2011) and data collected in the major tributaries.

Snohomish County collected water temperatures at six locations along the mainstem of Woods Creek the summers of 2009 and 2010 and three locations the summer of 2011 (Figure 2). This data was acquired using data loggers that continuously collected temperature data between the dates of June 15th through September 15th, following the Department of Ecology's guidance for continuous temperature monitoring (WA DOE, 2003).

In addition, the Snohomish Conservation District collected data at the mouth of five major tributaries to determine whether they were warming or cooling the water in the mainstem (Figure 2). At each of these tributaries, temperature data was collected in the tributary near the confluence and in the mainstem just upstream of the confluence. Data was collected between the hours of 9 and 11am on five dates between July 17th and August 23rd, 2012. A Student's T-test was used to analyze the difference between the temperature of the tributary and that of the mainstem.

Results

Mainstem

The State of Washington Water Quality Standard (WAC 173-201A) sets the threshold temperature for Woods Creek at 16°C for core summer salmonid habitat. This temperature is not to be exceeded more than once every ten years on average. On the mainstem, none of the sites monitored met this requirement as they all exceeded 16°C multiple times during the summer analysis period (June 15th – Sept. 15th). The seven day average of the daily maximum (7DAD Max) is reported below, along with the number of days the 7DAD Max exceeded 16°C, and the percentage of the days during the summer this threshold was exceeded (Table 1). Differences between the years are likely due to differences in air temperatures, but patterns show that certain reaches of the mainstem produce warmer water than others. For example, Sites D and E are consistently warmer than Site C even though Site C is downstream. One potential explanation (discussed in more detail later) is that Site C is downstream of a 4 mile reach running through land zoned for forestry while the upstream reaches run through land zoned for Rural 5-acre parcels.

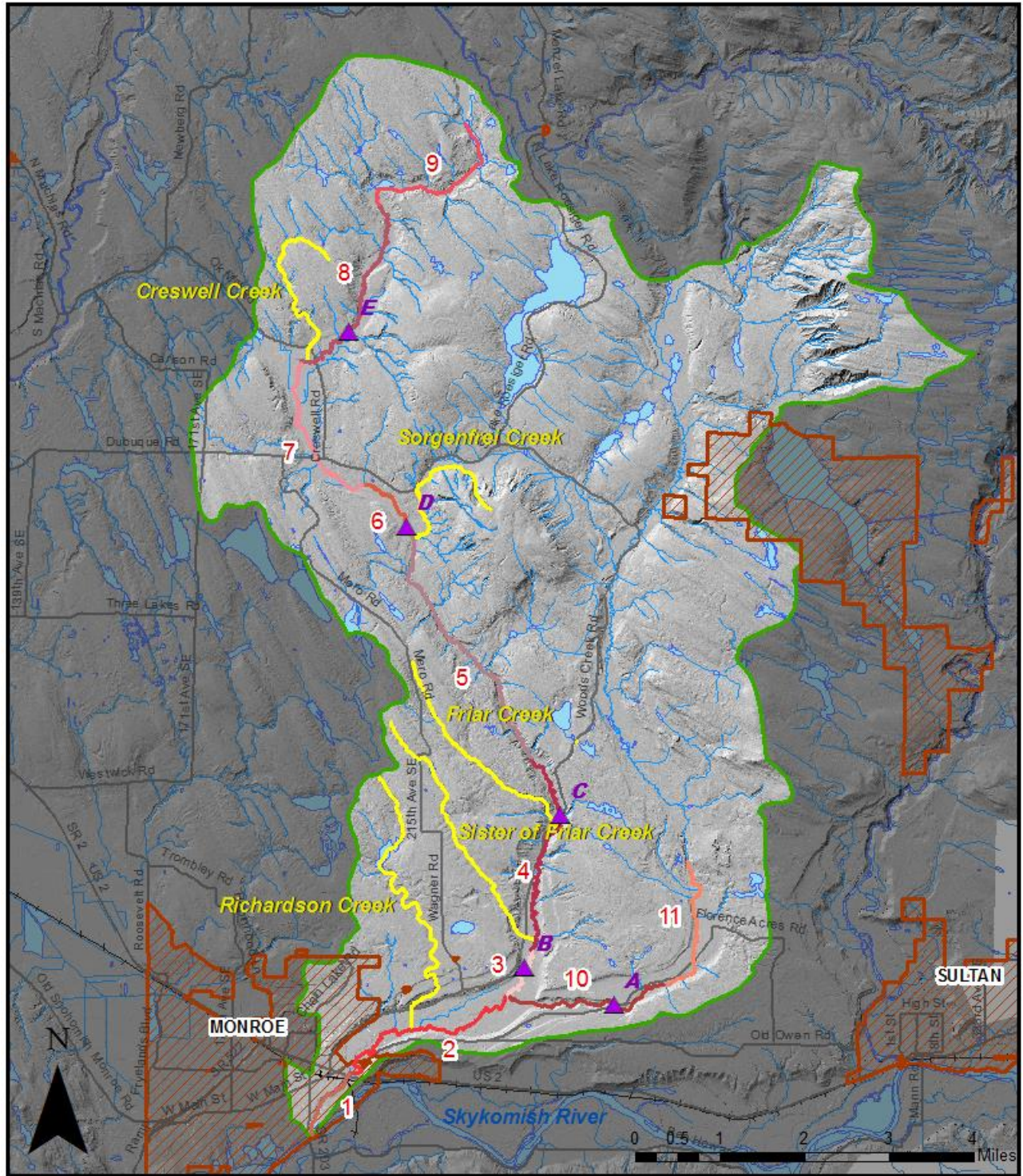


Figure 2. Water temperature analysis locations. Snohomish County data loggers continuously collected water temperature data in the mainstem of Woods Creek (Lower, West Fork, Carpenter, and East Fork) at six locations the summers of 2009, 2010, and 2011 (purple triangles). Additionally, water temperature data was collected on six dates in July and August of 2012 in five tributaries (yellow). Data collection for the tributaries consisted of sampling in both the tributary near the confluence and in the mainstem just upstream of the confluence. Sorgenfrei Creek and Sister of Friar Creek both has significantly lower water temperatures than the mainstem ($p < 0.05$).

Table 1. Mainstem water temperature (2009-2011). The maximum seven day average of the daily maximum (7DAD Max), number of days the 7DAD Max exceeded the state water quality threshold of 16°C for the Woods Creek watershed, and the percentage of days the 7DAD Max exceeded this threshold between June 15th and Sept. 15th are shown below for the five data collection sites (Figure 2) during 2009, 2010, and 2011.

	Site A			Site B			Site C			Site D			Site E		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Maximum 7DAD Max (°C)	21.6	18.8	NA	22.6	19.1	NA	19	17.5	16.1	22	18.6	17.4	19.6	19.2	17.2
Days 7DAD Max exceeded 16°C	62	46	NA	79	50	NA	28	21	1	73	43	25	53	46	30
% of days 16°C exceeded	67%	49%	NA	85%	54%	NA	30%	23%	1%	78%	46%	27%	57%	49%	32%

Tributaries

For each of the five tributaries analyzed, the difference between the average water temperature of the tributary where it entered the mainstem and the average temperature of the mainstem at that location was calculated (Table 2). Creswell Creek went dry after the first sampling data so was not analyzed further. Of the four remaining tributaries, both Sorgenfrei and Sister of Friar Creeks were significantly colder than the mainstem ($p < 0.05$). Sorgenfrei was, on average, 0.9 °C colder than the mainstem and Sister of Friar was, on average, 2.1°C colder. This suggests that these two streams are important cold water inputs for the Woods Creek watershed as well as important cold water refuges for juvenile fish during warm summer months. Friar and Richardson Creeks showed no significant difference in temperature from the mainstem.

Table 2. Tributary and mainstem water temperature comparison (2012). The average of water temperature data collected at five tributaries on six dates in July and August of 2012 is shown below. Average temperatures are given for the tributary near the confluence and in the mainstem just upstream of the confluence. Sorgenfrei Creek and Sister of Friar Creek both has significantly lower water temperatures than the mainstem ($p < 0.05$).

	Avg. water temp. of tributary (°C)	Avg. water temp. of mainstem (°C)	Difference (°C)
Creswell	-	15.6	-
Sorgenfrei	14.3	15.2	-0.9 *
Friar	15.2	14.6	0.6
Sister of Friar	13.2	15.3	-2.1 *
Richardson	15.8	15.9	-0.1

*Tributaries were significantly colder than mainstem, Student's T-test, $p < 0.05$.

Exploration of Potential Causes of High Temperatures

Two potential reasons stream temperatures are colder in some reaches are shading provided by riparian vegetation and the amount of cold water inputs from groundwater. We therefore did some analysis of the land-cover in Woods Creek to explore whether or not there was a relationship with water temperatures. The amount of forest cover in the riparian zone was analyzed as a proxy for shading in both the mainstem and the tributaries. Forest and wetland cover was also analyzed within the entire subbasin for each of the four major tributaries under the assumption that increased forest and wetland cover results in increased groundwater recharge.

Methodology

Land cover data (2009) developed by Snohomish County using multi-spectral, high resolution satellite imagery was used for analysis (SWM, 2012). Land cover is classified into the following categories: grass/pasture/lawn, shrubs and small trees, forest, wetlands, bare earth/dormant, impervious surface, and open water/gravel bar.

In the mainstem, land-cover data within 150 ft and also within 50 ft of the edge of the channel was analyzed to determine the percent of forest and wetland cover within each of the eleven analysis reaches. This data was compared to water temperatures at the five temperature monitoring sites in the mainstem and was also used to calculate riparian enhancement targets in the Action Plan below.

In the four major tributaries, land-cover data within 150 ft of the edge of the channel as well as within each contributing subbasin was analyzed to determine the percent of forest and wetland cover. Correlations were run between the water temperature at the mouth of each tributary and the following parameters: forest cover within 150 ft of channel, forest and wetland cover within 150 ft of channel, forest cover within tributary subbasin, and forest and wetland cover within tributary subbasin. No correlations were found, possibly due to the small sample size.

Results

Mainstem

Data for each of the eleven analysis reaches (see Figure 1) indicates that much of the riparian zone along Woods Creek is degraded. Reaches two (Lower Woods Creek), three (West Fork), four (West Fork) and eleven (East Fork) have the lowest percentage of forest or wetland in the 150 ft riparian zone. These are recommended as the highest priority for riparian enhancement work along the mainstem.

Comparing the riparian condition data below with the water temperature data suggests a relationship. Reach 5 has the highest percentage of forest and wetland cover within 150 ft of the channel at 89%. Most of this reach is within the portion of the watershed that is zoned for forestry so the high percent of forest cover is to be expected (the majority of the mainstem runs through rural-5 acre zonation). Water temperatures at Site D located upstream of Reach 5 are warmer than those at Site C, downstream of Reach 5. This data suggests that reforestation efforts may have a positive impact on reducing stream

temperatures. It is unclear, however, whether the condition of the riparian zone or the condition of the contributing area (also forested) is leading to lower stream temperatures and whether or not lower stream temperatures are due to localized water shading or groundwater contributions.

Table 3. Land-cover along mainstem. The percent forest and wetland combined cover within both 50 ft and 150 ft of the edge of the mainstem are given for each of the eleven analysis reaches.

Reach	% forest and wetland w/in 50' channel	% forest and wetland w/in 150' channel
1	86%	79%
2	53%	42%
3	23%	31%
4	53%	52%
5	89%	89%
6	76%	60%
7	73%	71%
8	88%	81%
9	90%	86%
10	72%	63%
11	52%	52%

Tributaries

Analysis of forest and wetland cover in both the 150 ft riparian zone and the entire contributing area for the tributaries did not reveal any significant correlations. It is, therefore, unclear as to the reasons why Sorgenfrei and Sister of Friar Creeks are colder than the mainstem and the other tributaries. We speculate there is a relationship between water temperature and the amount of forest cover although a larger sample size would be needed to determine whether a significant correlation exists. Wetland cover would be another topic to research further as wetlands increase groundwater infiltration and may have a relationship with cold groundwater inputs to the stream. On the other hand, wetlands may also be a source of warmer water due to the increased exposure to solar radiation.

It is also noted that although Sister of Friar Creek contributes colder water to the mainstem just upstream of monitoring Site B, water temperatures in the mainstem still increase between Sites C and B. Nevertheless, these colder tributaries likely provide essential cold water refuge from the mainstem for rearing juvenile salmon during summer months.

Recommended Action Plan

Planting Targets along the Mainstem

Land-cover analysis within 150 ft of the channel indicates that reaches two (Lower Woods), three (West Fork), four (West Fork), and eleven (East Fork) had the lowest percentage of forest and wetland cover within the watershed. These are, therefore, the highest priorities for riparian enhancement.

To determine specific riparian enhancement acreage targets for each of the eleven analysis reaches, a more detailed analysis of land-cover within 50 ft of the channel was done (Table 4). Although scientific literature supports a wider riparian buffer for proper ecological functioning (Pollock & Kennard, 1998), 50 ft was chosen for this initial goal setting due to the size of parcels in this watershed. Planting a wider buffer is always encouraged. Through conversations with watershed partners, a goal of 80% forest and wetland cover within 50 ft of the channel was chosen. This equals a total of 45 acres of riparian enhancement needed along the mainstem.

Table 4. Planting targets along mainstem. Acres of additional forest needed to achieve the following targets for percent forest and wetland cover within 50 ft from the channel edge for each of the eleven analysis reaches. The 80% target (highlighted yellow) was chosen for this action plan.

Reach	Acres needed within 50' buffer to achieve a forest and wetland cover of:					
	75%	80%	85%	90%	95%	100%
1	0	0	0	0	1	2
2	9	11	13	15	17	19
3	7	8	8	9	10	10
4	10	13	15	18	20	22
5	0	0	0	0	3	6
6	0	1	1	2	3	3
7	1	2	4	5	7	9
8	0	0	0	1	3	6
9	0	0	0	0	2	3
10	1	3	4	6	7	9
11	6	8	9	11	12	13
Totals	34	45	55	67	85	103

Prioritization of the Tributaries

Protection

Sorgenfrei and Sister of Friar Creeks had significantly lower temperatures than the mainstem at the confluence ($p < 0.05$). For this reason, protection of the contributing factors associated with cold stream temperatures should be prioritized (Figure 3). These include: forest cover within riparian zone, forest cover within entire sub-basin, soil health in sub-basin, and wetland cover. These factors will provide shade to surface waters and increase groundwater infiltration which may lead to increased groundwater input to the streams.

Restoration

Friar and Richardson Creeks did not have significantly different water temperatures than the mainstem at the confluence. For this reason, restoration of contributing factors associated with cold stream temperatures should be prioritized (Figure 3). These include: forest cover within riparian zone, forest cover within entire sub-basin, soil health in sub-basin, and wetland cover. Tributary streams provide important cold water refuge for juvenile salmon during summer months.

Next Steps

The Snohomish Conservation District recommends the formation of a Woods Creek Working Group to work together to achieve the goals laid out in this Action Plan.

In addition to the riparian enhancement targets established, many other equally important actions will also contribute to decreased water temperatures as well as improved salmon habitat. Preservation of remaining forests and wetlands throughout the watershed will increase groundwater infiltration, and protect against hydrologic changes due to climate change.

To implement the riparian enhancement goals in this plan, a total of 45 acres is to be planted along the mainstem with additional acreages in Richardson and Friar Creek. Estimates of total acreages in the tributaries was not calculated, although this is suggested for future goal setting.

Watershed partners established an estimated \$15,000 average needed to restore one acre of riparian habitat including 3 years of maintenance. A large portion of this cost is labor for site preparation (weed removal) so site conditions will dictate the exact cost. **The total cost for implementing the mainstem riparian enhancement work is, therefore, estimated to be \$675,000.**

As part of this riparian enhancement goal for the watershed, a program to survey and eradicate knotweed must be implemented. Knotweed threatens the long-term health of riparian forests by out-competing native shrubs and young trees. A systematic eradication program that begins work in the headwaters of the system and works downstream is necessary.

Proposed Timeline

2013	15 acres planted, knotweed survey & eradication
2014	15 acres planted, knotweed survey & eradication
2015	15 acres planted, monitoring and maintenance, knotweed eradication
2016	monitoring and maintenance, knotweed eradication
2017	monitoring and maintenance, knotweed eradication

References

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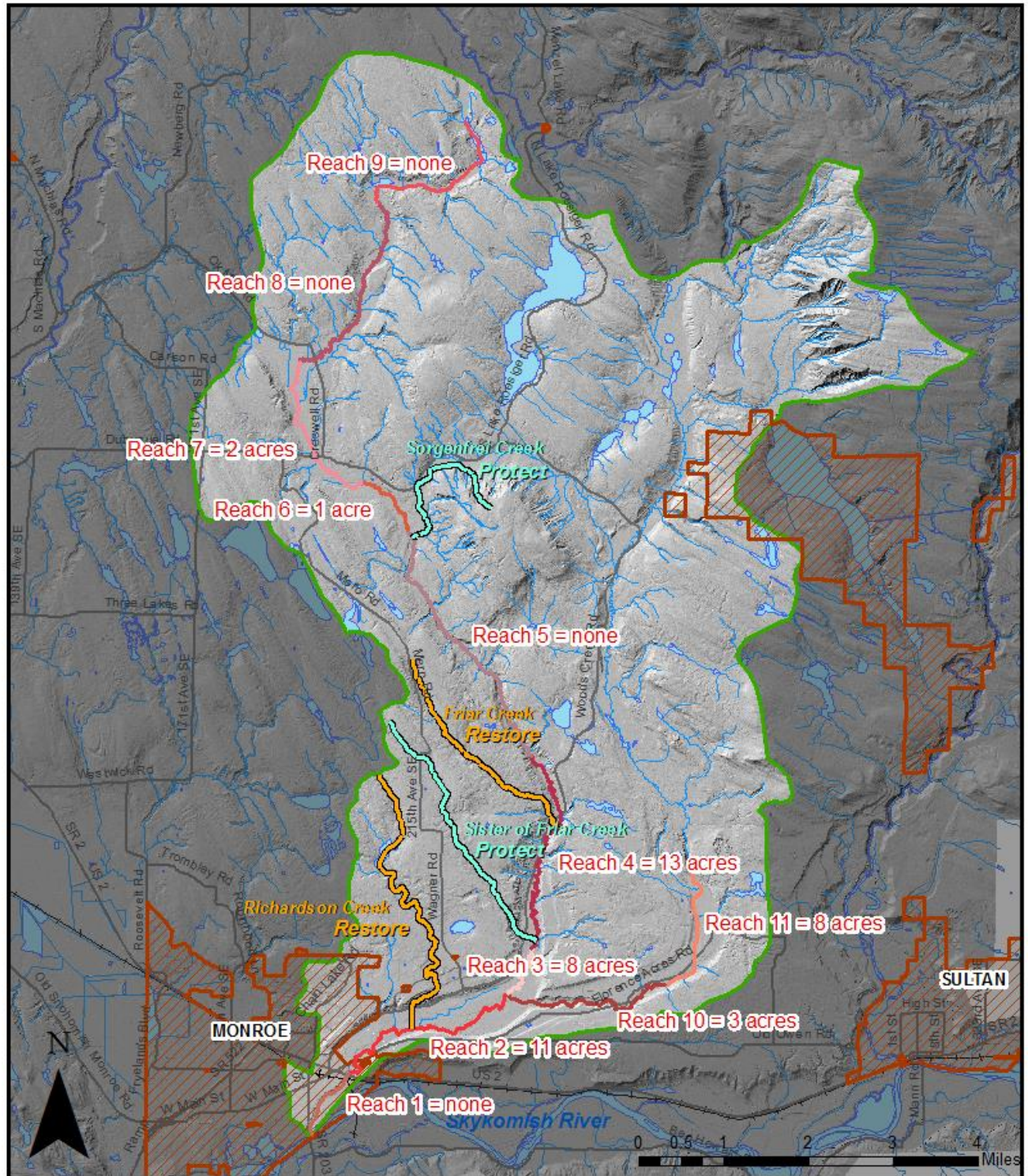


Figure 3. Recommended riparian enhancement. Riparian enhancement acreage goals are given for each of the eleven analysis reaches to bring the combined forest and wetland cover within 50 ft of the channel to 80%. The four tributaries analyzed for water temperatures are prioritized for restoration (orange) or protection (cyan).