Hangman (Latah) Creek Watershed Fecal Coliform, Temperature, and Turbidity Total Maximum Daily Load

Water Quality Improvement Report

Executive Summary

DEPARTMENT OF ECOLOGY
State of Washington

SCCD
Spokane County Conservation District
Bringing People and Resources Together

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Cover photo: Hangman Creek in the canyon-like reach north of Keevey Road (photo by Walt Edelen, Spokane County Conservation District)

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Executive Summary

What is a Total Maximum Daily Load (TMDL)?

The federal Clean Water Act established a process to identify and clean up polluted waters. Each state is required to have water quality standards designed to protect, restore, and preserve water quality. Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the 303(d) list.

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each pollutant of the water bodies on the 303(d) list. A TMDL is the highest amount (or load) of a pollutant a surface water body can receive and still meet water quality standards. The difference between the TMDL and the current amount of pollutant coming from point (discrete) and nonpoint (diffuse) sources is how much pollution needs to be reduced or eliminated to achieve clean water. The Washington Department of Ecology (Ecology), local governments, agencies, and the community develop a strategy to control the pollution and a monitoring plan to assess effectiveness of the water quality improvement activities.

Why is Ecology conducting a TMDL study in this watershed?

Hangman Creek (also known as Latah Creek) is a trans-boundary watershed that begins in the foothills of the Rocky Mountains of northern Idaho, extends over the southeastern portion of Spokane County, Washington (Figure 1), and is a tributary to the Spokane River. It encompasses over 689 square miles (approximately 441,000 acres). The TMDL allocations are limited to the 446 square miles of watershed within Washington, although some TMDL success depends on upstream controls on the Coeur d'Alene Reservation and Idaho.

The watershed is dominated by dryland farming, but like other eastern Washington watersheds, is experiencing increases in urbanization and changes in land use practices. The watershed contains remnant populations of genetically distinct redband trout and other native and introduced fish species.

Ecology and the Spokane County Conservation District (SCCD) are developing TMDLs because several parts of Hangman Creek were identified on the 1998 303(d) list of impaired waters for not meeting state water quality standards for fecal coliform, dissolved oxygen, pH, and temperature. Hangman Creek and several of its tributaries (Little Hangman Creek, Rattler Run Creek, and Rock Creek) were also included on the 2004 303(d) list of impaired waters for not achieving state water quality standards for fecal coliform, dissolved oxygen, turbidity, and temperature. Additional data collected for this study identified other water quality impairments that are included on the 2008 303(d) list. The water quality impairments addressed by this TMDL are listed in Table ES1.

In addition to developing TMDLs specific to the Hangman Creek watershed, a phosphorus load allocation was recommended for Hangman Creek by the draft *Spokane River/Lake Spokane Dissolved Oxygen TMDL.* The Spokane River and Lake Spokane exhibit depressed dissolved oxygen (DO) levels during low flow in the summer months. Phosphorus loads from Hangman Creek and other sources in the Spokane River basin contribute to algae growth in the lake that eventually depress oxygen levels. Since phosphorus is often attached to suspended sediment, efforts to reduce turbidity may help increase Spokane River DO.

Table ES 1. Hangman Creek water shed reaches on the 303(d) list.

Waterbody Name	Listed Parameter	Listing Identification Number
Hangman Creek	Fecal Coliform	16862
		16863
		6726
		41992
		45242
		45250
		45268
		46493
		46497
	Temperature	3736
		48370
		48371
		48372
		48373
		48374
		48375
		48376
		48377
		48378
		48379
		48380
		48381
		48382
	Turbidity	40942
Little Hangman Creek	Fecal Coliform	41994
	Turbidity	40940
Rattler Run Creek	Fecal Coliform	45310
	Temperature	48303
	Turbidity	40941
Rock Creek	Fecal Coliform	41996
		45312
		46317
	Temperature	48333
	Turbidity	40943
California Creek	Fecal Coliform	46287
California Creek	Temperature	48340
Unnamed Creek	Fecal Coliform	45553
Cove Creek	Fecal Coliform	45629
Marshall Creek	Temperature	48368

Goals and objectives

The goal of this TMDL is to develop a plan to meet water quality standards for fecal coliform bacteria, temperature, and turbidity in Hangman Creek and its tributaries. The following technical analysis and *Implementation Strategy* will accomplish this goal by:

1. Characterizing fecal coliform bacteria, heat, and suspended sediment loading from various parts of the basin.
2. Incorporating previously conducted temperature modeling work into a temperature TMDL.
3. Setting of (TMDL) allocations on fecal coliform, temperature, and suspended sediment/turbidity.
4. Outlining an *Implementation Strategy*

Originally, this TMDL study also included a phosphorus load analysis from Hangman Creek to the Spokane River. The loading analysis used the same methods and models as this report's turbidity and suspended sediment TMDL analysis. The phosphorus analysis is not included in this report because it did not explore the role of phosphorus in causing pH or dissolved oxygen criteria violations in the Hangman watershed. A dissolved oxygen, pH, and nutrient TMDL for Hangman Creek will be completed in 2009–2010.

Study methods

Ecology used field data from historical and current studies conducted by the SCCD, Ecology, and others to develop the TMDLs. Most of the historical data were collected in the 1990s and early 2000s. Recent sampling by the SCCD for the development of this study included 19 sites on Hangman Creek and its tributaries. Sampling occurred from December 2003 through August 2004. All Ecology and SCCD samples were collected under approved quality assurance project plans. Data quality objectives in all studies were reviewed, evaluated, and met.

In 2002 Hardin-Davis, Inc., with assistance from SCCD, monitored and modeled Hangman Creek water temperature under a separate watershed study. Recognized methods of field data collection were used and documented. The model used was the Stream Network Temperature Model (SNTEMP), an analytical tool supported by the U.S. Fish and Wildlife Service and U.S. Geological Survey. The Hardin-Davis study data were used as a starting point for the temperature TMDL analysis in this report. Ecology completed the analysis with additional shade modeling and water temperature data evaluations.

Several statistical methods were used on the temperature, fecal coliform, turbidity, and suspended sediment data. Statistical tests were run using WQHYDRO® (Aroner, 2007) and Microsoft Office Excel® (2003) software. For example, the fecal coliform TMDL analysis was based on a statistical approach called the Statistical Rollback Method (Ott, 1995) and another statistical method for calculating annual load estimates. Suspended solids evaluations were performed using a multiple regression analytical method by Cohn (1988) with SYSTAT® software.

The Watershed Analysis Risk Management Framework (WARMF) model was used to evaluate suspended sediment loading from all types of land uses and sources in the watershed. The initial Hangman Creek watershed model was developed by Cadmus and CDM through an EPA Region 10 grant (Cadmus Group, Inc. and CDM, 2007). The software is supported by the EPA Office of Environmental Research and originally developed by the Systech Corporation (Systech, 2001). With additional data from local agencies, Ecology further calibrated the model to observed water quality data and developed scenarios for future sediment control practices. Model output from current and future scenarios were compared for the likelihood that aquatic life, including trout populations, would be harmed by the duration and intensity of suspended sediment events.

TMDL analyses

Fecal coliform bacteria

Washington State uses fecal coliform bacteria as an indicator of a creek's suitability for direct contact. Many areas in Hangman Creek watershed have fecal coliform counts posing a health risk to swimmers, fisherman, and others. The health threats are not constant, but bacteria load reductions are necessary to reduce the risk of illness.

The Statistical Rollback Method (Ott, 1995) was used to determine how much fecal coliform needed to be reduced at individual sites to meet the water quality criteria. The estimated wasteload allocations for point source pollution and load allocations for nonpoint sources in the watershed are shown in Tables ES2 and ES3, respectively.

Because bacteria counts are especially high during storm events, most of the sources are probably nonpoint runoff from farms, towns, and residential areas. Storm events cause high counts in all seasons. Some wastewater treatment plants (WWTPs) had poor disinfection practices in the past that have recently improved. The WWTP bacteria limits are based on their current NPDES permits, or have been adjusted to protect public health by reducing the risk of waterborne illness. According to more recent Ecology records, all WWTPs are in compliance with the target reductions recommended in Table ES2.

Table ES 2. Fecal coliform wasteload allocations for point sources discharging to Hangman Creek and its tributaries.*

Point Source	Wasteload Allocation (10^8 cfu/day)[1]	Current Load[2] (10^8 cfu/day)	Target Reduction[4] (percent)
Tekoa WWTP[3]	31	140	78
Fairfield WWTP	18	90	80
Rockford WWTP	20	47	57
Freeman School District WWTP	1.6	1.9	16
Spangle WWTP	6.6	2.2	0.0
Cheney WWTP	100	–	0.0
WSDOT[6] Stormwater	NC[4]	NC	72
Spokane County Stormwater	NC	NC	72
city of Spokane Stormwater	NC	NC	72

* According to the most recent monitoring records, the WWTPs are in compliance with these fecal coliform target reductions.

[1] 10^8 cfu/day is 100,000,000 colony forming units per day.

[2] Current load calculated on 2003-2004 data

[3] WWTP is wastewater treatment plant.

[4] Target reductions assume the National Pollutant Discharge Elimination System (NPDES) permit has a monthly effluent geometric mean limit of 100 cfu/100 mL and a weekly maximum of 200 cfu/100 mL. For stormwater, the target basis is less than 10 % of the samples are greater than 200 cfu/100 mL (cfu/100 mL is colony forming units per 100 milliliters).

[5] NC is not calculated.

[6] WSDOT is Washington State Department of Transportation.

Table ES 3. Fecal coliform load allocations for Hangman Creek reaches and tributaries.

Reach Name	Load Allocation (10^8 cfu/day)[1]	Current Load (10^8 cfu/day)	Target Reduction (percent)
Hangman Creek at State Line (Road)	5,600	20,000	72
Little Hangman Creek	560	1700	67
Hangman Creek at river mile 53.8[2]	6,200	22,000	72
Hangman Creek at Fairbanks Rd	2,400	5,400	56
Hangman Creek at Spring Valley Rd	2,800	8,000	65
Hangman Creek at Marsh Rd	3,300	4,900	32
Cove Creek	13	60	79
Unnamed tributary at Griffith Rd	3.0	4.1	25
Unnamed tributary at Roberts Rd	1.5	3.0	61
Hangman Creek at Roberts Rd	5,100	7,000	27
Hangman Creek at Bradshaw Rd	6,800	17,000	60
Rattler Run Creek at the mouth[3]	23	150	85
Rattler Run Creek nonpoint	5	60	92
Hangman Creek at Keevy Rd	3,700	17,000	78
Hangman Creek at river mile 21.4	2,900	6,700	56
Rock Creek at the mouth	660	2,200	70
Rock Creek at Jackson Rd	2,400	7,500	68
Rock Creek at Rockford	240	740	67
Spangle Creek at the mouth[3]	8.6	12	28
Spangle Creek nonpoint	2.0	10	80
Hangman Creek at Duncan	7,000	7,800	10
California Creek at the mouth	25	32	23
California Creek at Marsh Rd	7.1	14	49
Marshall Creek at the mouth	8.3	18	54
Marshall Creek at McKenzie Rd	30	30	0.0
Hangman Creek at mouth	230	820	72

[1] 10^8 cfu/day is 100,000,000 colony forming units per day.
[2] River mile is the number of miles upstream from the mouth of Hangman Creek.
[3] Nonpoint load allocations for Spangle and Rattler Run Creeks are the total allowed loads from nonpoint sources. The load allocations at the mouths of these creeks include the nonpoint allocation and the WWTP.

The following conclusions and recommendations are based on this fecal coliform bacteria TMDL evaluation:

Conclusions

- Bacteria loads at the mouth of Hangman Creek appear to be decreasing over the long-term, but this may be a result of declining streamflows rather than declining fecal coliform counts.
- Fecal coliform counts exceed one or both parts of the Washington State criteria at several locations in the watershed at various times throughout the year, but no location appeared to be chronically contaminated.
- Storm events at any time of the year result in elevated bacteria counts in many reaches of the watershed, and are the main cause of criteria violations that require TMDL load reductions.
- The sources of bacterial contamination in the watershed are not obvious, but may include livestock access to banks and water, malfunctioning on-site septic systems, faulty or aged WWTP disinfection systems, waterfowl and wildlife, and stormwater runoff.
- Disinfection practices at some WWTPs have improved over the past few years and now consistently comply with NPDES permit limits.
- Implementing a 72% bacteria load reduction at the mouth of Hangman Creek during July through September should be adequate to reduce bacteria loads throughout the year if actions are taken that treat low-flow and high-flow sources of contamination. Other reaches and tributaries require bacteria loads to be reduced by 10% to 85%.

Recommendations

- The mouth of Hangman Creek and reaches where informal swimming occurs should be the highest priority areas for bacteria abatement action.
- Ecology will need to work with EPA, the Coeur d'Alene Tribe, and Idaho to reduce bacteria loads in upper Hangman Creek, Little Hangman Creek, and Rock Creek.
- Most sites require more sampling to better identify sources of bacteria and seasonal patterns, especially where livestock, wildlife, and waterfowl sources are suspected.
- Direct livestock access to riparian areas should be limited to prevent fecal wastes from directly or indirectly entering the waterways.
- Limiting Tekoa WWTP effluent fecal coliform counts to a monthly geometric mean of 100 cfu/100 mL and a weekly geometric mean of 200 cfu/100 mL would ensure downstream criteria are met during low-flow conditions.
- As required by the Municipal Phase 2 Stormwater NPDES Permit, permit holders must map their stormwater systems. If any stormwater entity determines that a stormwater outfall may be contributing bacteria to surface water, they should notify Ecology permit managers and work cooperatively to ensure fecal coliform reductions are achieved.
- All possible sources of fecal coliform should be addressed through source best management practices (BMPs).

Temperature

The temperature TMDL is built from work previously conducted for the Hangman Creek Watershed Planning Unit under the Watershed Planning process. Hardin-Davis (2003) collected temperature and streamflow data with assistance from the SCCD. They used the data for a Stream Network Temperature (SNTEMP) model. SNTEMP simulates average and maximum daily temperatures along a stream under steady-state flow conditions (USGS, 2006). The model included 34.5 river miles from Hays Road to the mouth of Hangman Creek.

The SNTEMP model is a well-known tool for evaluating the effects of shade, water volumes, and channel alterations on average and maximum temperatures in moving water. The Hardin-Davis (2003) work demonstrated that average temperatures could not meet the 17.5ºC water quality criterion under current stream conditions. Small increases in flow (3 cfs) or an increase in shade from current average shade conditions of 20% to shade of 70% did not lower water temperatures enough to meet the criterion.

To meet TMDL requirements, additional analysis in this report was necessary to provide site-specific recommendations for increased shade along the creek, and to evaluate effluent temperature limits for some WWTPs. Ecology conducted additional geographic information system (GIS) and modeling analyses using three specialized software tools:

- Oregon Department of Environmental Quality's Ttools extension for ArcView (ODEQ, 2001) was used to sample and process GIS data for the Shade model.
- Ecology's Shade model (Ecology, 2003) was used to estimate shading of Hangman Creek from the Idaho border to the mouth. Shade was calculated at 100-meter intervals along the streams and then averaged over 1000-meter intervals.
- The rTemp model was used to estimate future stream temperatures after full shading is attained upstream and downstream of the Tekoa WWTP so maximum effluent temperature limits could be calculated.

Tributaries were not analyzed directly from aerial photos and GIS tools. The tributaries and perennial streams in the Hangman Creek watershed are narrow enough that riparian vegetation shade would usually dominate stream cooling compared to geographic features. Shade curves and a shade table were created from the Shade model vegetation regional analysis. Shade potential for tributaries can be estimated when channel direction and widths are known.

The water quality standards require the water in Hangman Creek to maintain a 7-day average daily maximum (7DADM) temperature of 17.5°C. If the 7DADM exceeds 17.5°C due to natural conditions, the natural condition temperature becomes the criterion. Cumulative sources to the stream must not increase water temperatures by 0.3ºC. Ecology cannot determine true natural conditions for the watershed because reference conditions, models, and background data that would accurately assess the true natural conditions are lacking.

Instead, Ecology uses a condition referred to as the *system potential*. System potential is the estimated water temperature if mature riparian vegetation and microclimate conditions were present along with any local groundwater and any channel or streamflow improvements planned for the future. The modeled shade in the system-potential scenario is based on the direction of the stream compared to the path of the sun and the native vegetation characteristics normally found in an undisturbed riparian area. Hangman Creek system-potential scenario assumed no changes in streamflow, groundwater, or channel conditions. The most appropriate system-potential shade scenario was a combination of willows and pines, 100-feet wide, on both sides of the creek:

- 35 foot width of willow at a 75% density and maximum height of 30 feet
- 65 foot width of pines at a 50% density and maximum height of 80 feet

The Hangman Creek mainstem model results for system-potential shade and the current shade conditions are graphically displayed in Figure ES1. The average difference between current and system-potential shade was 26%, with the greatest need for additional shade in the upper 18 miles of the watershed and along the last six miles near the mouth. Some ecoregional features in the watershed may not allow the recommended riparian widths and vegetation heights. Additional temperature decreases may be possible with channel restoration, sediment controls, and wetland restoration.

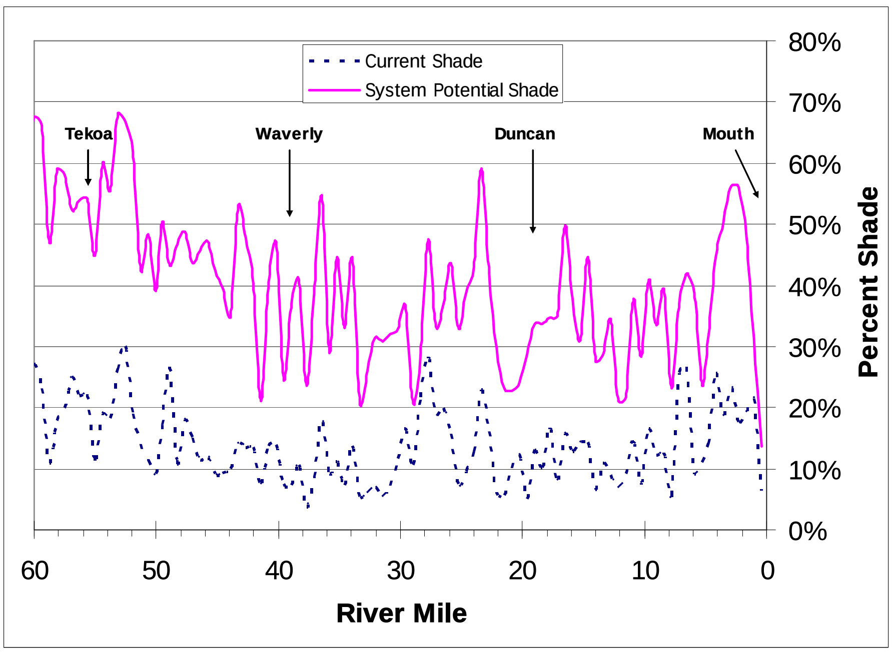

Figure ES 1. Current conditions and system-potential shade estimates *(1000-meter averages) along Hangman Creek based on the shade model.*

Table ES4 provides the amount of increased shading recommended for individual sites along Hangman Creek on the 2004 303(d) list and for the 2008 303(d) list sites. Tributaries are also listed in the table. These were not directly modeled, so they require a different approach. The shade curve (Figure ES2) is based on the system-potential shade used in the Shade model for the mainstem Hangman Creek. As channel measurements and orientation data are gathered at tributary sites, a system shade potential can be compared to existing conditions and a load allocation can be assigned.

Table ES 4. Percent of effective shade required to meet heat load allocations.

Reach Location	Shade Required (percent)
Rattler Run Creek at the mouth	Use Shade Curve
Rock Creek at the mouth	Use Shade Curve
California Creek at the mouth	Use Shade Curve
Marshall Creek at the mouth	Use Shade Curve
Hangman Creek at river mile 3.6	45
Hangman Creek above Marshall Creek	32
Hangman Creek at Hangman Valley Golf Course	28
Hangman Creek at river mile 18.2	34
Hangman Creek at Duncan	34
Hangman Creek at Latah Road	42
Hangman Creek at Keevy Road	37
Hangman Creek at Bradshaw Road	21
Hangman Creek at Hays Road	29
Hangman Creek at Roberts Road	40
Hangman Creek at Spring Valley Road	47
Hangman Creek at Fairbanks Road	48
Hangman Creek above Tekoa WWTP	50

Shade Required is the percent of the water surface effectively in shade from the surrounding vegetation.

WWTP is wastewater treatment plant.

Use Shade Curve indicates that the percent effective shade from vegetation is estimated from the shade curved based on the stream's width. The shade curve was developed from Shade model vegetation regional analysis.

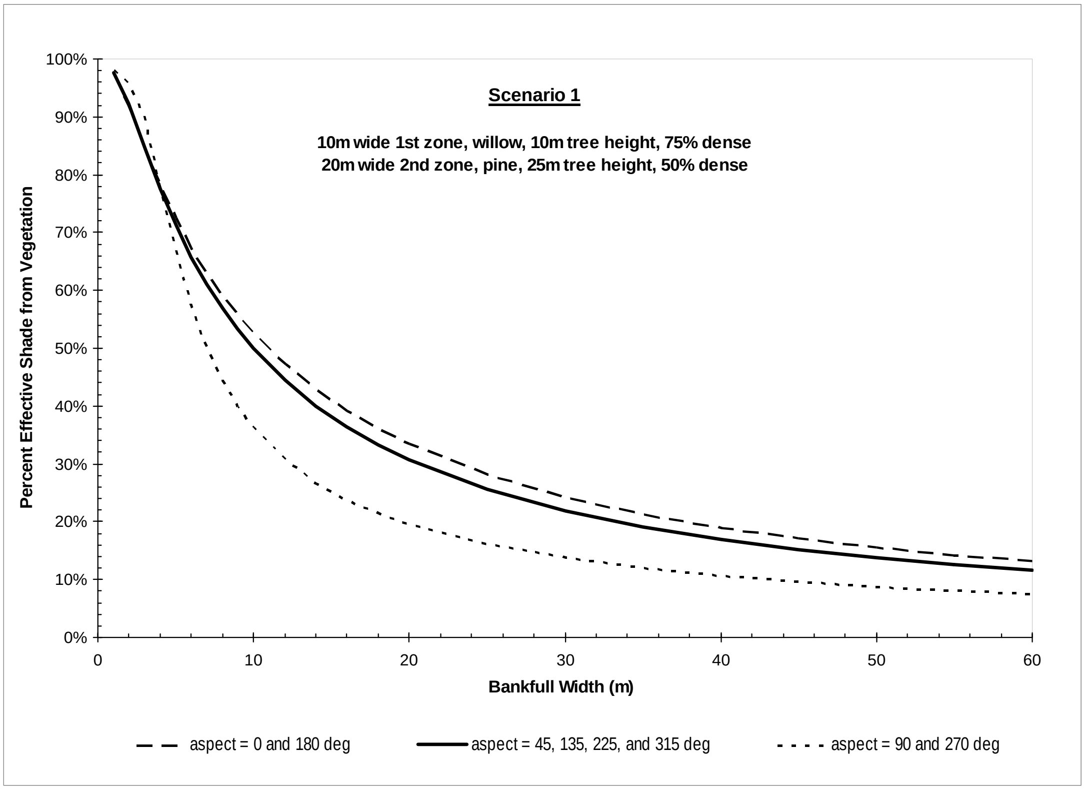

Figure ES 2. Shade curves for the Hangman Creek watershed*. A stream with an aspect of 0 or 180 degrees is oriented north and south.*

The water quality standards allow an increase of 0.3ºC over natural conditions for all human-caused sources for establishment of the temperature allocations. Point sources also must be regulated to meet the incremental warming restrictions established in the standards to protect cool water periods. This is especially important in the late spring and early fall when stream temperatures may be lower than effluent temperatures but dilution from streamflows is low.

Because water temperatures may exceed 17.5ºC on a 7-day average daily maximum in wastewater-receiving water areas of the watershed from late April through October, all point sources required temperature wasteload allocation evaluations. Unfortunately, few of the six WWTPs have monitored temperature, and nothing is known about stormwater temperatures. However, only two WWTPs discharge during the hottest period of the year when effluent may pose the most serious instream temperature problem. Temperature monitoring will be included in all NPDES permits, and temperature wasteload allocations have been recommended.

As summer Hangman Creek temperatures approach or exceed 17.5°C, the temperature at the edge of any mixing zone equals or exceeds criteria, so any additional warming from effluent would be a violation of criteria. This posed a special problem for establishing effluent temperature limits for Tekoa and Spangle WWTPs since seasonally they lack adequate dilution factors during these periods even when site-potential shade would be present.

Enough water temperature and flow data just upstream of the Tekoa WWTP were available to estimate a set of monthly maximum effluent temperature permit limits. The model rTemp was used with the shade output from the Shade model to predict daily maximum temperatures under Hangman Creek system-potential shade conditions. Average monthly 7DADM temperatures for June, July, and August were 18.2º C, 21.5º C, and 17.7º C, respectively. The Tekoa WWTP monthly maximum effluent will be limited to these temperatures. The limits are also applied to the Spangle WWTP until local data can be collected.

In the Hangman Creek watershed, three WWTPs discharge into wetland treatment systems:

- Fairfield (Rattler Run)
- Freeman School District (Little Cottonwood Creek)
- Cheney (Minnie Creek)

Historically only the Fairfield wetland system has periodically discharged effluent to the stream during the critical season. Infiltration and inflow improvements will prevent these critical season discharges. Therefore, this TMDL establishes the WLAs for effluent temperature from the three wetland systems as no discharge to the stream during June, July and August (Table ES5). If one of these WWTPs needed to discharge during this critical period, Ecology will require them to meet the WLAs established for Tekoa until site specific WLAs can be developed with local data.

Rockford WWTP cannot discharge during the most critical months of June through August due to a permit requirement to only discharge when there is a minimum 3.5 dilution factor. Additional monitoring data required by the Ecology Water Quality Program policy for NPDES permitees should supply site-specific data so effluent temperature limits can protect Rock Creek water quality.

The WLAs for the six WWTPs are shown in Table ES5.

Table ES 5. **Temperature Wasteload Allocations.** **(***As 7-day average daily maximum effluent temperatures) for municipal wastewater treatment plant (WWTP) Discharges*

Facility	September - May	June	July	August
Tekoa WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	18.2˚C	21.5˚C	17.7˚C
Spangle WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	18.2˚C	21.5˚C	17.7˚C
Rockford WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	No discharge	No discharge	No discharge
Fairfield WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	No discharge	No discharge	No discharge
Freeman School District WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	No discharge	No discharge	No discharge
Cheney WWTP	As calculated by WAC 173-201A-200(1)(c) (i) – (vii)	No discharge	No discharge	No discharge

All NPDES-permitted discharges in the state are now required to increase the temperature monitoring frequency of their effluents and receiving waters. The monitoring will provide data to ensure the treatment methods of wastewater and stormwater are properly designed to dissipate heat before entering the receiving water. Storm events over seven days during the critical period are unlikely in the Spokane area. So, stormwater temperature effects on Hangman Creek may not occur.

If monitoring demonstrates effects on water temperatures, limits and wasteload allocations will need to be revised.

The following conclusions and recommendations are based on this temperature TMDL evaluation:

Conclusions

- Many reaches of Hangman Creek and its tributaries cannot meet the 7-day average daily maximum (7DADM) 17.5ºC temperature criterion during the June-August critical (low-flow) period.
- Groundwater and springs play an important cooling role in the lower 10 miles of Hangman Creek below its confluence with Marshall Creek.
- A buffer of mature riparian vegetation along the banks of the creek and its tributaries is expected to decrease instream average daily maximum temperatures to system-potential levels.
- Site-specific metrics of channel width and aspect will be necessary to apply the shade curve load allocations to tributaries and perennial streams.

Recommendations

- Channel restoration measures, including the restoration of a functioning riparian area, should be implemented throughout the watershed to reduce heat loads on the stream. Typically a healthy functioning riparian area is considered a minimum of 35 feet wide on average.
- Monthly wastewater treatment plant (WWTP) effluent 7DADM temperatures for facilities in Tekoa and Spangle are based on receiving water temperatures in June through August under system-potential shade conditions. Additional temperature monitoring data required in NPDES permits will allow refinement of these 7DADM effluent limits.
- Cheney, Fairfield, and Freeman School District wetland treatment system effluents do not discharge when instream receiving water temperatures are greater than 17.5 ºC. Monitoring the temperature of discharges will be required. If discharge needs to occur during the critical period these facilities will be required to meet the WLAs for Tekoa until site specific limits can be calculated.
- Rockford WWTP does not discharge effluent during critical temperature months, but additional temperature monitoring will be required under Ecology policies. Some effluent temperature limits may be necessary during low streamflow and elevated temperature conditions in April and May.
- All WWTPs should comply with Ecology Water Quality Program policy requiring receiving water and effluent temperatures and discharge volumes monitoring during the spring through fall season. These data will help to understand thermal and dilution cycles so that compliance schedules and operational/facility options can be designed.
- Watershed managers will need to ensure streamside shading and other heat reduction measures are conducted in coordination with WWTPs. Effluent temperature allocations will become better defined as stream temperatures are lowered to their system potentials.

- Spokane County, the city of Spokane, and WSDOT Phase 2 municipal stormwater thermal effects are not expected to impact Hangman Creek because 7-day storm events are unlikely during the June to August critical period. But, permit holders should evaluate their systems and prevent stormwater heating of Hangman Creek, especially during the late spring and early fall periods.

Turbidity and Total Suspended Solids

Turbidity and suspended solids have been longstanding problems in Hangman Creek. In 1980 and in 1988, Hangman Creek Water Quality Index scores were among the worst in the state for turbidity and suspended solids (Singleton and Joy, 1981; Hallock, 1988). Naturally eroding streambanks and upland soils in various parts of the watershed have been further destabilized by poor road-building practices and some agricultural practices. The sediment and associated turbidity degrade aquatic habitats and transport excessive amounts of nutrients in Hangman Creek and the Spokane River.

According to Ecology monthly monitoring data at the mouth of Hangman Creek, total suspended solids (TSS) concentrations and turbidity have decreased over the past 10 years. This decrease is partially due to lower than normal discharge volumes, but it can also be attributed to efforts to improve the stream channel, restore riparian areas, and a switch to less erosion-prone farming practices.

However, recent fish and benthic macroinvertebrate sampling results indicate most of the watershed has a poor aquatic community structure that is partly the result of sediment impacts (SCCD, 1998; Peters, Kinkead, and Stanger, 2003; McLellan, 2005; Lee, 2005; Ecology, 2005). Each year Hangman Creek aquatic life communities are subject to several intense turbidity events of extended duration that have negative habitat, behavioral, and health effects on the aquatic life. Sediment transport from Hangman Creek to the Spokane River is also a great concern to water quality management of Lake Spokane and the operation of several dams along the Spokane River.

Turbidity is regulated under Washington State water quality standards with specific criteria; suspended sediments are not. Turbidity loads cannot be calculated because turbidity is a measure of visibility through water, not a concentration of something in the water. However, the turbidity listings in this watershed call attention to the serious problem of erosion and excessive sediment transport in these streams. The designated use of "salmonids spawning, rearing, and migration" is impaired by elevated suspended sediment and could have also been listed on the 303(d) list under the water quality standards narrative criteria. Therefore, this TMDL will set allocations for TSS to address the impairment of the narrative criteria.

Several tools were used to examine the suspended sediment and turbidity data from the Hangman Creek watershed to evaluate different parts of the problem. Statistical tests were run to compare sediment and turbidity values. A multiple regression analyses method by Cohn (1988) was used to simulate the seasonal pattern of suspended sediment loading at the mouth of Hangman Creek over a 14-year period. The WARMF model was developed to see where sediment loads were coming from and how they were transported through the watershed.

EPA, Coeur d'Alene Tribe, Ecology, and SCCD agreed that an assessment of the whole watershed was necessary to evaluate the sources, transport, and relationship between TSS loads and watershed landscape, land uses, and hydrology. CDM (2007) divided the watershed into 36 catchments in the WARMF model to characterize hydrology and sediment delivery (Figure ES4). Local soils, land uses, climate, and geographic features of the land and stream channels were generalized within each of the 36 catchments of the WARMF model. The average size of the catchments was 12,000 acres with a range of 576 acres to 27,785 acres. Model results were calculated daily based on rainfall, temperature, and point source inputs.

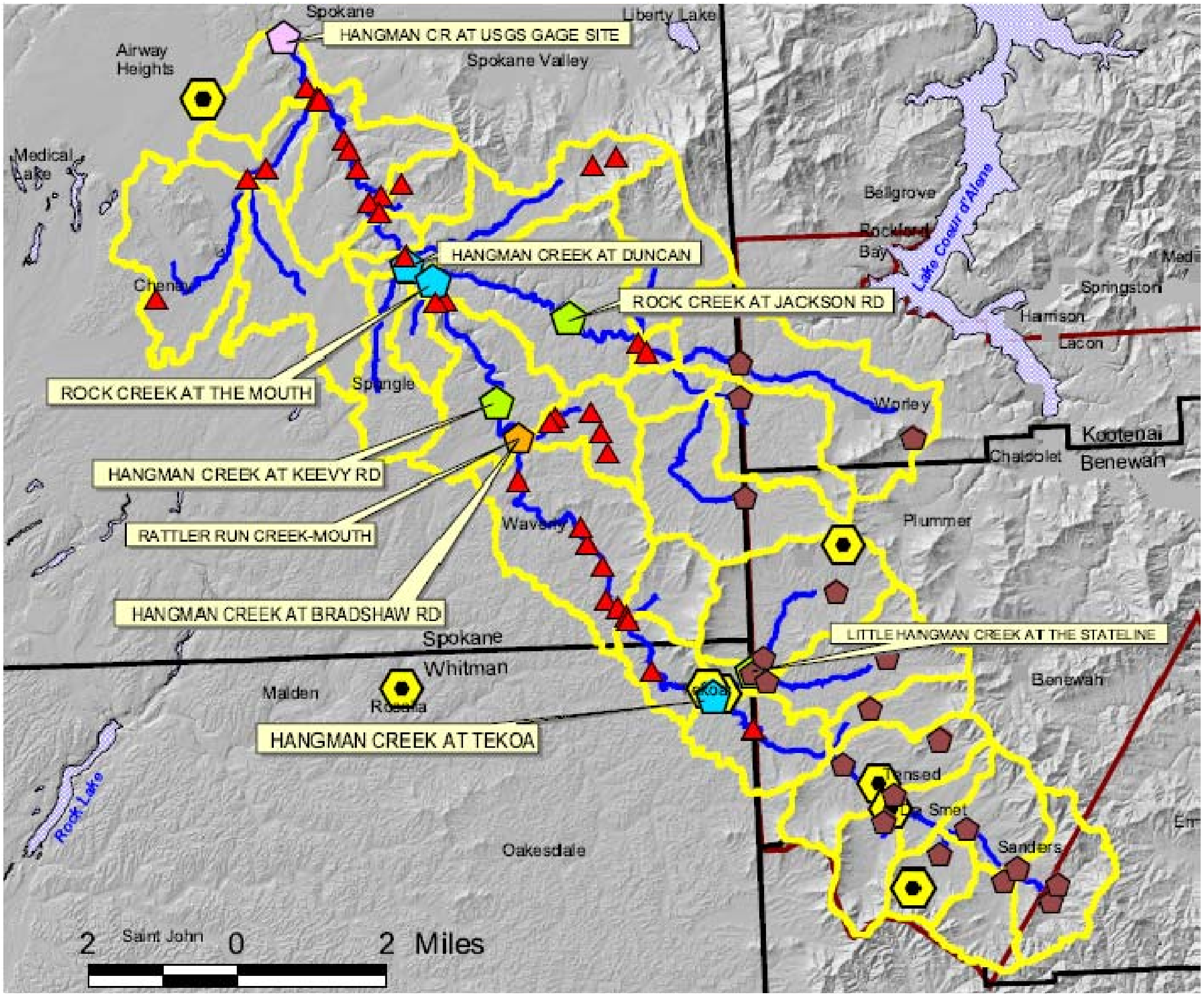

Figure ES 3. Delineated catchments and stream layout. *For the Hangman Creek watershed Analysis Risk Management Framework (WARMF) model (Cadmus Group and CDM, 2007).*

The model analysis estimated the suspended sediment/TSS loads and reductions that could be expected after a progressive set of BMPs were in place. The reductions were estimated for the mouth of Hangman Creek, 303(d) sites, and other critical tributary sites in the watershed. The characteristics of an estimated full protection scenario are used to determine necessary reductions of total suspended solids. The following actions were identified by the Advisory Committee as the scenario that would result in full protection of the designated uses:

- Convert 60% of the agriculture in the watershed to direct seed or conservation practices.
- Reduce the streambank erosion in the upper watershed (above Fairfield) by 50%, and high-bank erosion in the lower watershed from Lake Missoula flood sediments by 10%.
- Increase forest cover in catchments above Rockford and Tensed by 50%.
- Limit residential growth to levels below 10% in the lower watershed (catchments 3, 4, 7, 9 and 10).
- Have riparian buffers established all along the mainstem channels and tributaries.

The annual suspended sediment loads at the mouth of Hangman Creek under the estimated full protection scenario are 20% to 30% lower than the simulated current condition (Table ES6). The annual variability is induced both by the intensity and frequency of runoff events and the location of those events within the watershed. Years with higher annual flows will also naturally generate more streambank erosion from the high streambanks along the lower reaches of Hangman Creek that are not easily remedied even under the estimated full protection scenario actions.

Table ES 6. Suspended sediment reduction. *Predicted from WARMF model scenario estimates for annual suspended sediment loading from Hangman Creek to the Spokane River. WARMF model current and estimated full protection scenario condition results were compared.*

Water Year	Multiple Regression Model (tons/year)	Estimated Reduction	Estimated Load Capacity (tons/year)
1999	188,252	22%	147,206
2000	90,677	25%	67,872
2001	1,604	31%	1,109
2002	73,770	28%	53,326
2003	16,503	21%	13,101
2004	30,605	32%	20,846
2005	2,832	29%	2,022

The WARMF model suggested major sediment erosion generated from the same sources that have been discussed in previous reports for the watershed (SCCD, 1999; 2002; 2005a; 2005b). Conventional agricultural practices and streambank erosion are the largest sediment sources in most areas of the watershed. Table ES7 summarizes the overall estimated suspended sediment reduction for the 303(d) listed areas if the estimated full-protection activities are implemented.

Table ES 7. WARMF model simulation results for overall suspended sediment reductions and source reductions. *Estimated at 303(d) sites in the Hangman Creek watershed.*

<table>
<tr><td rowspan="3">Hangman Creek
at Bradshaw Road</td><td rowspan="3">19%</td><td>Conventional Agriculture</td><td>56%</td></tr>
<tr><td>Streambanks</td><td>74%</td></tr>
<tr><td>Rangelands</td><td>31%</td></tr>
<tr><td>Little Hangman Creek</td><td>15%</td><td>Conventional Agriculture</td><td>55%</td></tr>
<tr><td>Rattler Run Creek</td><td>15%</td><td>Conventional Agriculture</td><td>54%</td></tr>
<tr><td rowspan="3">Rock Creek
at Jackson Road</td><td rowspan="3">17%</td><td>Conventional Agriculture</td><td>55%</td></tr>
<tr><td>Rangelands</td><td>18%</td></tr>
<tr><td>Streambanks</td><td>90%</td></tr>
</table>

The results of the estimated full protection scenario were used to estimate the daily suspended solids concentration at the mouth of Hangman Creek. The severity of impacts to various fish populations from suspended sediment scores were calculated from a formula developed by Newcombe and Jensen (1996). Estimated full protection scenario TSS events were compared to the current conditions (Figure ES6). Significant improvements were predicted for the number, intensity, and duration of the events. The BMPs throughout the watershed were successful in either lowering or shortening the duration of the highest lethal and sub-lethal conditions scores. Lethal and sub-lethal conditions in late spring and summer and in the early fall were eliminated. These are the critical spawning and emergence periods for fully protecting and enhancing redband and other trout populations.

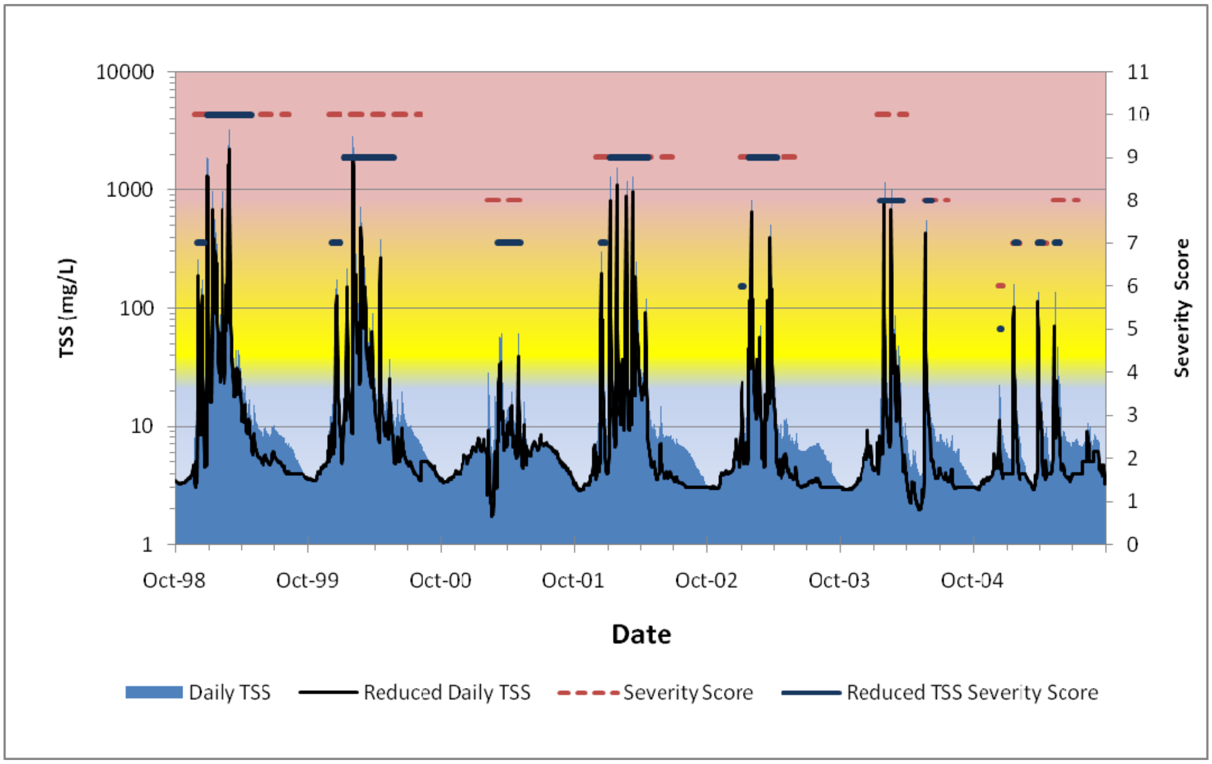

Figure ES 4. A comparison of estimated current and estimated full protection (reduced) scenario suspended sediment conditions. *For trout species at the mouth of Hangman Creek including lethal and sub-lethal severity scores calculated from the formula by Newcombe and Jensen (1996).*

Data for tributary and upstream reach areas are not available to do a similar analysis. But TSS reductions estimated by the WARMF model (Table ES7) are expected to yield similar improvements. Aquatic communities should improve as the duration and intensity of TSS events are decreased from implementing BMPs. Sediment rating curves should be developed for key sites to monitor changes.

The differences between the current and estimated full protection scenario results provide the suspended sediment targets for six sub-watersheds of Hangman Creek. Table ES8 summarizes the relative distribution and the overall suspended sediment reduction for the various sub-watersheds. Future load analyses will need to consider the large amount of sediment stored within the watershed channels and how the transport rate of that sediment to the mouth of Hangman Creek or its major tributaries varies from year to year.

Table ES 8: Estimated distribution of sources generating suspended sediment.
In sub-watersheds of Hangman Creek under current condition WARMF model scenarios and estimated source reduction expected with implementation of estimated full protection scenario actions.

Sub-Watershed	Current percent of sources	Estimated source reduction	Land Area percent of watershed
Upper Hangman Creek	35%	26%	20%
Little Hangman Creek and Hangman Creek from Tekoa to Bradshaw	26%	16%	19%
Hangman Creek from Bradshaw to Duncan and Rattler Run	1%	15%	8%
Rock Creek	20%	18%	27%
Marshall Creek	2%	8%	11%
Lower Hangman Creek	16%	11%	15%

The most obvious example of the problem of sediment transport rates is cross-border loading. Approximately 35% of the Hangman Creek watershed lies in catchments of Rock Creek, Little Hangman Creek, and upper Hangman Creek in the Coeur d'Alene Indian Reservation and in Idaho. Up to 60% of the water is delivered from these catchments annually.

A cooperative strategy between regulatory and governmental jurisdictions to develop and implement this TMDL yields a more comprehensive approach to controlling suspended sediment and turbidity sources in the watershed. The load and wasteload allocations established in this TMDL can only apply to pollutant loading sources located in the Hangman Creek watershed downstream of the Idaho border. Washington State cannot dictate to the Coeur d'Alene Tribe or the state of Idaho what measures they need to take in their portion of the Hangman Creek watershed, or how to allocate suspended sediment loads in their jurisdictions. However, with support and permission from the Coeur d'Alene Tribe this TMDL incorporates an assumption that sediment in upstream waters at the WA/ID border will be reduced to meet water quality standards at the border. This assumption includes no inferences regarding historic flows in the watershed. Reducing sediment loads in the upper reaches of Hangman Creek, Little Hangman Creek, and Rock Creek depend on long-term cooperation between Washington, the Coeur d'Alene Tribe, and Idaho to implement erosion control measures.

The load allocations for both the sub-basin geographic areas and the 303(d) listed segments are summarized in Table ES9. The sub-basin load allocations are estimates of the reductions from the entire land area that are necessary to meet the load allocation at the 303(d) listed stream segment.

Table ES 9. Total suspended solids load allocations for geographic sub-basins and 303(d) listed stream segments.

	Sub-basin	303(d) listed segment	Estimated % reduction	
			Basin	303(d)
Hangman Creek	Upper Hangman Creek	Hangman Creek at Bradshaw Road (ID 40942)	26%	19%
	Hangman Creek from Tekoa to Bradshaw Rd		16%	
	Hangman Creek from Bradshaw Rd to Duncan		15%	n/a
	Lower Hangman Creek		11%	
Tributaries	Little Hangman Creek	Little Hangman Creek (ID 40940)	16%	15%
	Rattler Run Creek	Rattler Run Creek (ID 40941)	15%	15%
	Rock Creek	Rock Creek at Jackson Road (40943)	18%	17%
	Marshall Creek		8%	n/a

n/a – there are no 303(d) listed segments in this geographic area.

The current TSS NPDES permit limits for the six municipal WWTPs in the Washington portion of the watershed are adequate for TSS control in the watershed. The combined WWTP loads are insignificant compared to the event-based loads driving field and streambank erosion.

Stormwater in areas under Phase 2 and construction permits will need to be adequately managed to reduce TSS loads to lower Hangman Creek and its tributaries. BMPs for TSS in municipal stormwater are well-known and effective in reducing 80% of TSS in runoff. Therefore, if the jurisdictions are in compliance with the Stormwater Phase II NPDES permit, they will be in compliance with TSS wasteload allocations under this TMDL. The estimated full protection scenario limited increased residential land use to less than 10% over current conditions. If residential land use exceeds the estimated full protection scenario, wasteload allocations may need to be reevaluated.

Wasteload allocations for all point sources are shown in Table ES10.

Table ES 10. Total suspended solids wasteload allocations for the Hangman Creek watershed.

Source	Permit Requirements		WLA
	Average Monthly Limit	Average Weekly Limit	
Tekoa WWTP	30 mg/L, 34.5 lbs/day	45 mg/L, 51.7 lbs/day	same
Fairfield WWTP	15 mg/L, 29.0 lbs/day	23 mg/L, 44.5 lbs/day	same
Spangle WWTP	15 mg/L, 8.5 lbs/day	23 mg/L, 12.8 lbs/day	same
Rockford WWTP	30 mg/L	45 mg/L	same
Freeman School District #358	20 mg/L, 7.2 lbs/day	30 mg/L, 10.8 lbs/day	same
Cheney WWTP	15 mg/L, 338 lbs/day	23 mg/L, 507 lbs/day	same
Industrial Facility Stormwater[1]	27 mg/L	88 mg/L[2]	same
Spokane County Stormwater	All known and reasonable treatment		80% reduction[3]
city of Spokane Stormwater	All known and reasonable treatment		80% reduction[3]
Washington Department of Transportation Stormwater	All known and reasonable treatment		80% reduction[3]
Construction Site Stormwater[4]	All necessary best management practices Turbidity Benchmark: 25NTU Background and discharge sampling required Turbidity Limit: 5 NTU over background or when background is over 50 NTU less than a 10% increase over background		same

[1]No permitted industrial facilities currently exist in the watershed.
[2] Limit is a maximum daily (not average weekly).
[3]Best management practices estimate 80% removal of TSS from stormwater sources (Ecology, 2004).
[4] Construction stormwater NPDES permit regulates turbidity but does not regulate TSS.

Conclusions

- Significant cross-border TSS loads will require close cooperation with the Coeur d'Alene Tribe and Idaho to establish erosion reduction measures and improve Hangman Creek, Little Hangman Creek, and Rock Creek.
- Turbidity and suspended sediments have been longstanding problems in Hangman Creek. Naturally erosive streambanks and erosive upland soils in various parts of the watershed have been further destabilized by poor road building and agricultural practices.
- The duration and intensity of suspended sediment events have lethal or sub-lethal effects on native redband trout and other fish populations in the watershed. Events during the mid-to-late spring through the fall periods are especially damaging to aquatic communities.
- The sediment and associated turbidity have not only degraded aquatic life and habitats, but they have transported excessive amounts of sediment, nutrients, and other contaminants within Hangman Creek and to the Spokane River.

- Elevated suspended sediments and turbidity have been most pronounced in January through May, especially when conventionally tilled fields are susceptible to erosion by rains falling on partially frozen and snow-covered soils with little residue and high water erodes streambanks (SCCD, 2002).
- An estimated 20% to 30% in annual TSS loads to the Spokane River will be reduced if estimated full protection actions are implemented. Sediment loads in 303(d) listed areas of the watershed will be reduced by a long-term annual average of 15% to 19%.
- For this TMDL, reductions of TSS loads are an adequate surrogate for the turbidity 303(d) listings in the watershed.
- The estimated full protection scenario and associated load reductions will reduce the number, intensity and duration of TSS events. This will reduce the number of lethal and sub-lethal impacts on trout and other fish, especially during the most sensitive life-stages in the mid-to-late-spring through fall. Successful implementation of these measures will provide full protection for these sensitive life-stages and improve the fish communities in the watershed.

Recommendations

- Aquatic communities and suspended sediment loads should continue to be monitored to establish baselines and to measure success with erosion control and other improvements. Sediment rating curves should be established for key sites in the watershed.
- Conversions of conventional agricultural practices to conservation practices is needed to meet the load allocations in this TMDL as this action will have the biggest impact in reducing TSS in the watershed.
- Streambank erosion control is necessary to decrease sediment generation and transport especially in the reaches between Fairfield and Tekoa.
- Municipal and construction stormwater discharges are potential sources of TSS during storm events. Spokane County, city of Spokane, and Washington State Department of Transportation have coverage under the state municipal stormwater permits in the residential growth areas in the lower reaches of Hangman Creek and Marshall Creek. Common stormwater BMPs should prevent an estimated 80% of the stormwater TSS load from reaching Hangman Creek.
- WWTPs are insignificant sources of turbidity and solids in Hangman Creek compared to event-based erosion. Current municipal NPDES permits limit TSS to loads far lower than are of concern in the watershed, and permit limits will be adequate as wasteload allocations.
- WARMF or a similar model should be supported with better local data for calibration and scenario-building.
- Load allocation and compliance point locations (see Table 31) should be included in category 4A (has a TMDL) of the next Washington water quality assessment for TSS.

Implementation strategy

The *Implementation Strategy* (1) describes the roles and authorities of cleanup partners and programs and (2) provides a strategy to achieve the water quality standards for fecal coliform bacteria, total suspended solids/turbidity, and temperature. Because of regional interest in reducing Hangman Creek's phosphorus contribution to the Spokane River, the *Implementation Strategy* also includes strategies to reduce nutrients. The development of this plan was a collaborative effort by a diverse group of interests in the watershed.

Implementation activities will generally involve the Spokane County Conservation District (SCCD); Washington State Department of Ecology (Ecology); Spokane County; the city of Spokane; the six WWTPs; the Coeur d'Alene Tribe; and the U.S. Environmental Protection Agency (EPA). Implementation will be jointly facilitated and tracked by the SCCD and Ecology. These agencies will also involve other agencies and groups, such as the Spokane Regional Health District; the Direct Seed association; Washington State University Extension; seed and fertilizer companies; local producer-based cooperatives; the Natural Resources Conservation Service (NRCS); and the Farm Service Agency. To effectively reduce nonpoint source pollution, these agencies will need to seek cooperation with private landowners to implement BMPs designed to address the pollution issues.

After EPA approves this TMDL, a *Water Quality Implementation Plan* (WQIP) must be developed within one year. Interested and responsible parties will work together to develop the WQIP. It will describe and prioritize specific actions planned to improve water quality and achieve water quality standards.

The six WWTPs and the three stormwater jurisdictions covered by stormwater permits were assigned wasteload allocations in this TMDL to ensure they do not contribute to water quality standards violations. These wasteload allocations will be implemented through their National Pollutant Discharge Elimination System (NPDES) permits. Ecology recognizes the difficultly of achieving some of the wasteload allocations established in this document and will work collaboratively with the dischargers to develop a comprehensive strategy to protect water quality.

A Hangman Creek Advisory Committee was formed in April 2004. In addition to the point sources in the watershed, the committee identified 11 water quality nonpoint issues that were potential sources of the water quality problems in the watershed:

1. Sediment/nutrients from agricultural operations.
2. Sediment/fecal coliform from livestock and wildlife.
3. Nutrients/chemicals from residential uses.
4. Sediment/nutrients from agricultural field ditches.
5. Nutrients/fecal coliform from improper functioning septic systems.
6. Sediment from gravel and summer roads.
7. Sediment from sheer or undercut banks.
8. Sediment/fecal coliform from stormwater.
9. Sediment from poor forestry management.

10. Sediment from roadside ditching.

11. Solar heating from lack of riparian shade.

To address the nonpoint sources, the advisory committee developed a list of BMPs to address each of the nonpoint source water quality issues identified. Stormwater is included because much of the watershed is not covered under a stormwater permit. Many of the BMPs address more than one of the water quality issues. To address the water quality parameters in this TMDL, pollution reductions will be accomplished through BMPs that:

- Reduce erosion.
- Reduce runoff carrying sediment.
- Reduce livestock impacts.
- Increase shading of streams.
- Inform and educate watershed residents about water quality issues.

Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of this water improvement plan are met. There are many sources of funding and technical assistance to facilitate implementing this TMDL.

In developing the WQIP, Ecology and the SCCD will ensure the plan addresses the recommendations made in this report. They will work with local people to create this plan, choosing the combination of possible solutions they think will be most effective in their watershed. Elements of this plan include:

- Who will commit to do what.
- How to determine if the implementation plan works.
- What to do if the implementation plan doesn't work.
- Potential funding sources.

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