SWAN LAKE WATERSHED
TMDL IMPLEMENTATION PROGRAM

Target Status Report

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1.0 INTRODUCTION

The Technical Advisory Group (TAG) of the Swan Ecosystem Center (SEC) has been working since 2004 to prioritize implementation of water quality monitoring and watershed restoration recommendations from the *Water Quality Protection Plan and TMDLs for the Swan Lake Watershed* (DEQ 2004). The purpose of this document is to summarize the work that has been completed to date and to present recommendations for future Total Maximum Daily Load (TMDL) implementation strategies. Additionally, the document is intended to assist the Montana Department of Environmental Quality (DEQ) in evaluating success in achieving the objectives of the Swan TMDL and ensuring full support of beneficial uses throughout the watershed.

1.1 The Swan Lake Watershed and TMDL

The Swan Valley watershed in Northwest Montana is approximately 410,000 acres in size and has a stream network of nearly 1,300 miles. It is located in parts of Missoula, Lake and Flathead counties. The Swan River flows north from its headwaters in the Mission Mountains to Swan Lake, eventually emptying into Flathead Lake at Bigfork. The watershed includes the small communities of Condon, Salmon Prairie and Swan Lake. Most of the land is managed in a square-mile checkerboard pattern by the Flathead National Forest, Plum Creek Timber Company and to a lesser extent the Swan River State Forest. Private residences are scattered along the Swan River and State Highway 83, which parallels the river.

The Swan Basin is listed as a high priority watershed by the DEQ, and Swan Lake is an A-1 classified waterbody. Swan Lake and six tributaries of the Swan River were listed on Montana's 303(d) list until the Environmental Protection Agency (EPA) approved TMDLs addressing impairments to their beneficial uses. During the TMDL development process, all but two of these streams, Goat and Jim Creeks, were removed from the 303(d) list. The US EPA approved the Water Quality Protection Plan and TMDL for the Swan Lake Watershed in June 2004. Based on the results of data collection efforts in the Swan TMDL, the Swan Basin appears to be recovering from past water quality impacts. Nevertheless, serious threats to water quality and beneficial use support remain throughout the basin and are likely to increase as land in the Swan Valley is converted from timber production to residential use.

1.1.1 Swan Lake

Swan Lake is generally characterized by excellent water quality, with levels of nutrients, primary production, and chlorophyll *a* typical of an oligotrophic lake (low levels of nutrient inputs and low productivity). However, during late summer and early fall in the deepest parts of the lake, dissolved oxygen (DO) concentrations decline to unusually low levels. This is particularly evident in the south basin of the lake, where DO concentrations as low as 0.1% of saturation have been recorded. Low DO concentrations are of concern due to their potential to harm aquatic life, particularly bull trout, which are listed as a threatened species under the federal Endangered Species Act.

Swan Lake appears to be predisposed to DO problems by its own morphometry. According to the conclusions of the TMDL, this situation appears to have been exacerbated by excessive loading of particulate organic carbon (POC). Although POC source loading has decreased in recent decades, dissolved oxygen levels in Swan Lake have remained near zero, suggesting that DO recovery has not been concurrent with pollutant source reduction in the watershed. The cause and effect relationships between pollutant loading, lake morphometry, and DO levels within the lake remain poorly understood. In order to verify that restoration and pollution source reduction efforts are effective in improving DO levels, and to ensure the continued health of both Swan and Flathead Lakes, SEC has taken the lead in implementing the monitoring plan recommended in the TMDL.

1.1.2 Swan Basin Streams

When the Swan TMDL project began, six streams (Jim, Elk, Lion, Piper, Goat, and Squeezer Creeks) were listed as threatened or impaired on the 1996 303(d) list. More recent and accurate data collected and reviewed during TMDL development indicated that all of these streams except Goat Creek and Jim Creek were fully supporting all of their beneficial uses. Jim Creek was determined to be impaired due to sediment and associated habitat conditions. Goat Creek was determined to be impaired by elevated suspended sediment.

2.0 DATA SUMMARY AND TMDL COMPLIANCE

In this section, data collected by SEC and, where relevant and available, other stakeholder groups, is used to evaluate progress in meeting the water quality targets established in the TMDL document.

2.1 Swan Lake Target Status Summary

In 1996, Swan Lake appeared on the Montana 303d list for partial support of its aquatic life and cold water fisheries beneficial uses because of siltation, organic enrichment and low dissolved oxygen. For the 2002 revisions to the 303d list, the causes of impairment were changed to siltation only, and the use support condition was downgraded to threatened. The data review completed for the TMDL confirmed the 2002 listing decision, which remains unchanged on the 2006 303d list, the most recent list completed by DEQ (**Table 1).**

Table 1. ***Swan Lake 303(d) Listing Status***

1996 Use Support Conditions	1996 Probable Cause of Impairment	2002 Use Support Conditions	2002 Probable Cause of Impairment	2006 Use Support Conditions	2006 Probable Cause of Impairment
Partial Support for aquatic life and cold water fish	Siltation, Organic enrichment, DO	Threatened for aquatic life and cold water fish use support	Siltation	Threatened for aquatic life and cold water fish use support	Siltation

In the *Water Quality Protection Plan and TMDLs for the Swan Lake Watershed* (DEQ 2004), a TMDL for Swan Lake was established. The TMDL called for no increases in loading of particulate organic carbon or nutrients to the lake from Swan River. Because the status of the lake appeared to be threatened, not impaired, DEQ determined that loading did not need to decrease from current levels.

To track progress towards ensuring beneficial use support in the lake, DEQ established two primary water quality targets and three secondary targets. According to the Swan TMDL document (DEQ 2004), primary targets are based on direct measures or direct indicators of beneficial uses within the lake. Secondary targets are based on loading conditions or surrogates for loading conditions within the watershed. The difficulty in establishing baseline conditions and the time that could be involved with identifying trends associated with the primary targets for Swan Lake make the use of secondary targets desirable, according to DEQ. These secondary targets help identify potential problems or progress toward resolving water quality concerns in the watershed.

Compliance with the Swan Lake TMDL targets is evaluated below.

2.1.1 Swan Lake Primary Target 1

No decreasing percent saturation of dissolved oxygen (DO) in the bottom waters of Swan Lake and no increase in the spatial extent of the low DO area in the lake.

According to the TMDL document (DEQ 2004) the rationale for this target is as follows:

> *This target addresses the primary reason for the listing of Swan Lake as a threatened waterbody on Montana's 303(d) list. In spite of the fact that the low DO in Swan Lake may not be unusual, it must be monitored for a period of time to ensure that conditions are not becoming worse due to human actives…*

2.1.1.1 Dissolved Oxygen Concentrations and Percent Saturation

Status of Primary Target 1

The lowest dissolved oxygen (DO) concentrations and percent saturation in Swan Lake typically occur in the deepest portions of the lake in the early fall, prior to turnover. SEC collected fall DO data in 2004, 2005 and 2006 in the lake's north and south basins, its deepest locations, and DEQ collected data in the north basin in 2007. In order to evaluate possible trend patterns, these recent data were compared to data collected by the Flathead Lake Biological Station in 1990 and 1992, and by the Plum Creek Timber Company in 1996 and 2001. Although additional historic data were available, they were collected prior to September 21st, which was used as a cutoff for fall data. No percent saturation was available for the historic data, so concentration in mg/l was used as a proxy.

In the north basin, relevant data were available from 1996 to 2007. From a high of 5.2 mg/l in 1996, fall DO concentrations in the north basin declined annually to a low of 2.43 mg/l in 2004, and have risen steadily since to 4.31 in 2007. In the south basin, DO concentrations have been much lower, reaching a low of 0.07 mg/l in 1992 and a high of 1.42 mg/l in 1999 (**Figure 1** and **Table 2).** No trend is apparent in the data, but DO concentrations in the south basin, which was the main area of concern in the TMDL, showed no obvious sign of decline, suggesting that Primary Target 1 for Swan Lake is being met. Additional data are being collect in 2008 and another year of monitoring is planned for 2009.

Figure 1. ***Minimum Dissolved Oxygen Concentrations in the North and South Basins of Swan Lake, 1990 to 2007.***

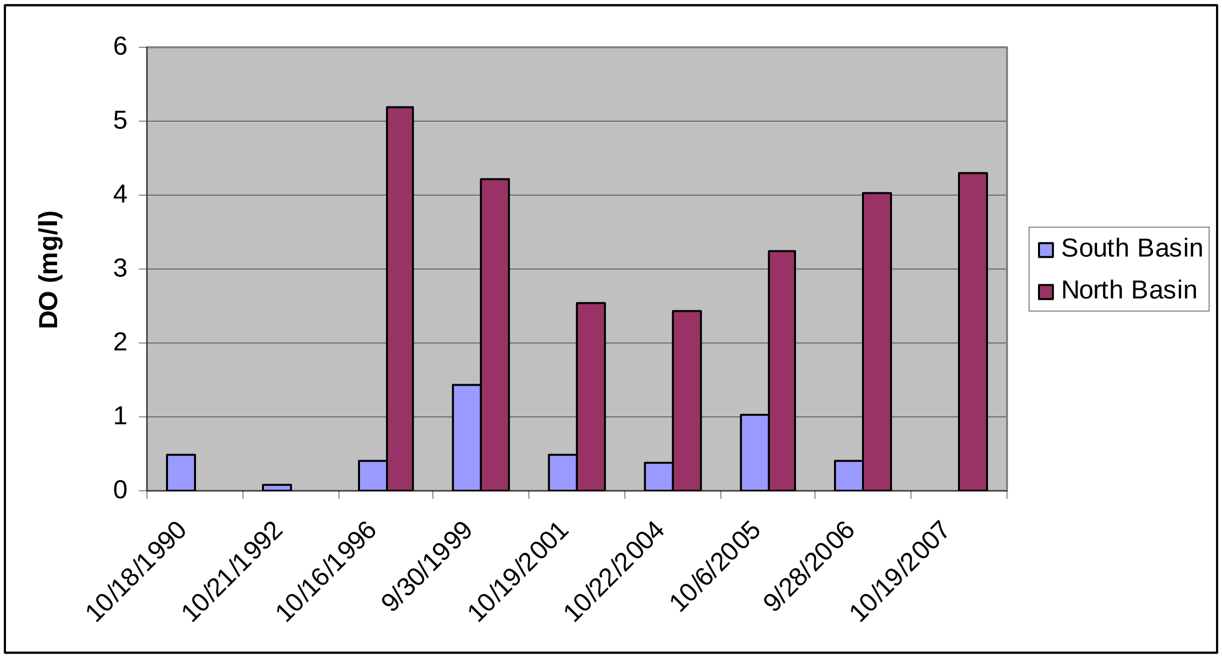


Table 2. ***Dissolved Oxygen Concentrations and Percent Saturation in the North and South Basins of Swan Lake, 1990 to 2007.***

Date	North Basin mg/l	North Basin % Sat	South Basin mg/l	South Basin % Sat
10/18/90	NA	NA	0.5	NA
10/21/92	NA	NA	0.07	NA
10/16/96	5.2	NA	0.4	NA
9/30/99	4.21	NA	1.42	NA
10/19/01	2.53	21.1	0.49	2.6
10/22/04	2.43	22.3	0.37	3.5
10/6/05	3.24	30	1.03	9.5
9/28/06	4.03	36.8	0.4	3.4
9/27/07	4.31	40.0	NC	NC

NC: Not collected; NA: Not available

2.1.1.2 Spatial Extent of the Low Dissolved Oxygen Areas (DO)

Status of Primary Target 1

The spatial extent of low DO concentration throughout Swan Lake were evaluated by SEC in 2004, 2005 and 2006 by measuring the DO concentration at 1 meter off the bottom of the lake at approximately 100 locations primarily in the North and South Basins in October of each year, prior to fall turnover. These DO concentrations were plotted geographically using ArcGIS and contours representing each DO increment (5 down to 0 mg/L) were approximated using a krieging utility so that the spatial extent of each increment could be calculated. Krieging is a statistical technique used to estimate the value of a variable at unobserved locations from observations of its value at nearby locations.

As shown in **Tables 3** though **5,** the spatial extent of DO concentrations less than 5 mg/l has increased from 1678 acres in 2004, to 2445 acres in 2005, to 2975 acres in 2006. Areas of critically low DO concentrations below 2 mg/l have also increased, from 190 acres in 2004 to 458 acres in 2005, but then decreased slightly in 2006 to 369 acres. Swan Lake is approximately 3,270 acres in size, so in 2006 when the spatial extent of the less than 5 mg/l area was at its largest, it represented about 9 percent of the total lake area. The apparent increase in area with DO concentrations less than 5 mg/l should be viewed with caution. The extent to which number and location of sampling points and algorithm of the krieging program can influence the results of the analysis is currently unknown. Nevertheless, the magnitude of the increase suggests that this portion of Primary Target 1 for Swan Lake is not currently being met.

Table 3. ***Spatial Extent of Low DO Concentrations in Swan Lake, 2004.***

DO Level (mg/l)	South Basin (acres)	North Basin (acres)
0 - 1	30.4	0
1 - 2	159.2	0
2 - 3	298.3	0.5
3 - 4	470.1	18.8
4 - 5	643.9	57.2
Total area < 5 mg/l	1678	

Table 4. ***Spatial Extent of Low DO Concentrations in Swan Lake, 2005.***

DO Level (mg/l)	South Basin (acres)	North Basin (acres)
0 - 1	155.2	0
1 - 2	302.9	0
2 - 3	466.6	0
3 - 4	623.9	50.6
4 - 5	725.3	120.5
Total area < 5 mg/l	2445	

Table 5. ***Spatial Extent of Low DO Concentrations in Swan Lake, 2006.***

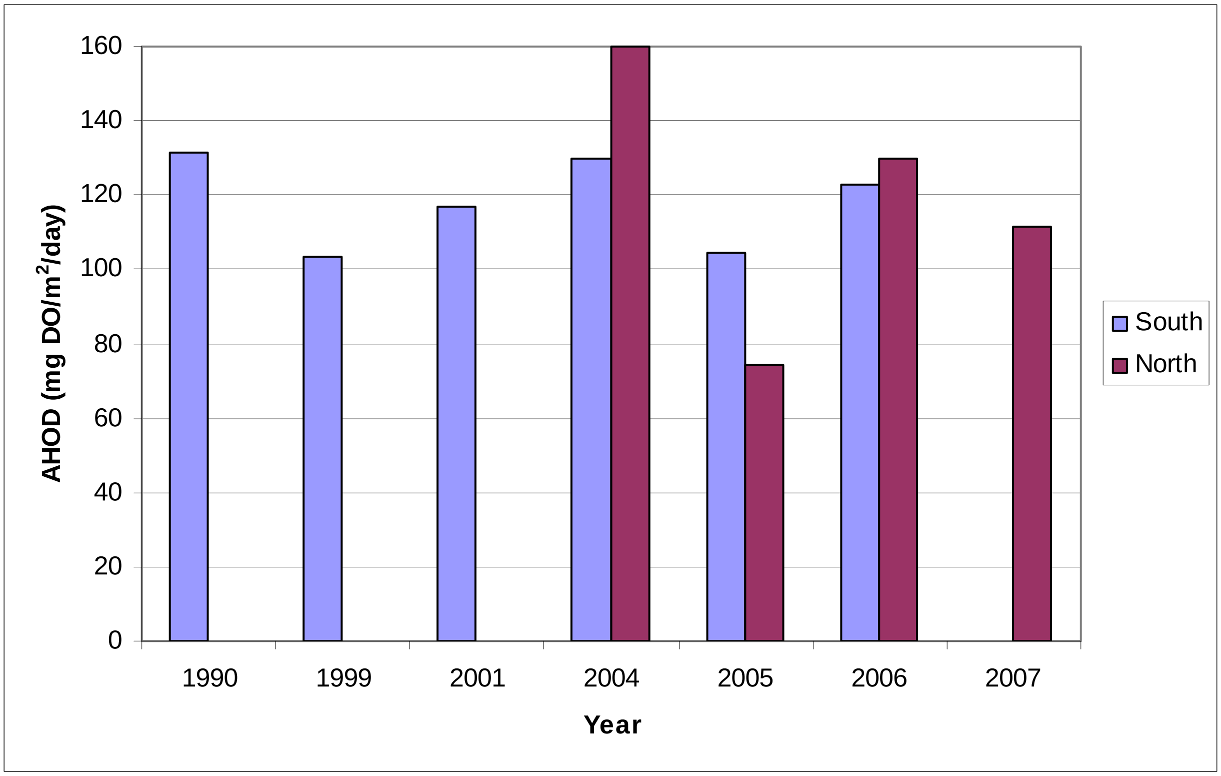
DO Level (mg/l)	South Basin (acres)	North Basin (acres)
0 - 1	67.7	0
1 - 2	301.1	0
2 - 3	563.5	0
3 - 4	804.4	39.9
4 - 5	1062	136.5
Total area < 5 mg/l	2975	

2.1.1.3 Areal Hypolimnetic Oxygen Deficit (AHOD)

Although it was not identified as a target variable in the TMDL document, Areal Hypolimnetic Oxygen Deficit (AHOD), was identified by the TMDL TAG as a useful tool for tracking oxygen levels in Swan Lake with the data that are typically collecting by the Swan Lake monitoring program.

For purposes of this analysis, AHOD was calculated separately for the north and south portions of the lake. Results of the analysis are presented in **Figure 2.** At this time, no trend in AHOD values is apparent from the existing data.

Figure 2. ***Areal Hypolimnetic Oxygen Deficit (AHOD) for North and South Portions of Swan Lake, 1990 to 2007.***



2.1.2 Primary Target 2

No increasing trend of nutrient and chlorophyll a concentrations, no increasing trophic state index trends, and no decreasing trend in Secchi Depth values in Swan Lake.

According to the TMDL document (DEQ 2005) the rationale for this target is as follows:

> [Meeting this target] *will prevent or minimize algae blooms within the lake and therefore provide protection for cold-water fish and aquatic life beneficial uses, and will further avoid potential POC loading associated with increased algal growth. It will also protect lake aesthetics and help ensure that turbidity remains within the range of naturally occurring levels as defined under State Law.*

2008 Primary Target 2 Status

Swan Ecosystem Center collected total phosphorous and chlorophyll *a* data from Swan Lake on five occasions in 2004 (**Table 6**), and periphyton (attached algae) chlorophyll a concentrations from four near shore locations in August 2004 (**Table 7**). Limited additional data may be available from the Flathead Basin Commission's volunteer lake monitoring program. The available data are not sufficient for trend identification. Since early 2007, DEQ has been collecting nutrient, chlorophyll *a*, and Secchi depth data in Swan Lake. The study is scheduled to continue into late 2008. When the results of this study are available, the status of Primary Target 2 will be evaluated.

The average chlorophyll *a* and total phosphorous values from the 2004 SEC study were used to calculate the trophic state index (TSI) for Swan Lake (**Table 6**). The TSI provides a measure of the potential productivity of a lake and is calculated separately for chlorophyll *a* and total phosphorous concentrations. A TSI value of less than 40 indicates an oligotrophic (nutrient poor) lake; while a value between 40 and 60 indicates a mesotrophic (moderately enriched) lake. Based on the 2004 SEC data, Swan Lake appears to be at the upper end of the oligotrophic range, with TSI values more indicative of oligotrophic status when calculated using chlorophyll *a* than with total phosphorous.

Table 6. ***2004 Chlorophyll a and Total Phosphorous, North and South Basins of Swan Lake.***

Date	Chlorophyll a (ug/l)		Total Phosphorous (ug/l)	
	North Basin	South Basin	North Basin	South Basin
5/28	0.928	0.84	5.082	11.262
6/21	1.902	2.378	6.423	6.719
7/27	0.951	0.555	5.895	14.544
8/27	0.555	0.634	32.488	15.532
9/16	1.03	0.872	19.448	10.291
Average	**1.07**	**1.06**	**13.87**	**11.70**
TSI	**31.3**	**31.2**	**42.1**	**39.6**
Trophic State	**Oligotrophic**	**Oligotrophic**	**Mesotrophic**	**Oligotrophic**

Table 7. ***Periphyton Chlorophyll a Concentrations, Swan Lake, August 27, 2004.***

Location	Periphyton Chlorophyll a (mg/cm^2)
Abbartec Dock	1.202
South Basin	1.268
Rockhouse	1.242
Dock Bay East	0.144

2.1.3 Secondary Target 1

No increasing trend in phosphorous, nitrogen, TSS and organic carbon loads associated with human impacts entering Swan Lake from the Swan River.

> *This secondary target directly addresses POC and nutrient loading and will help ensure that Swan Lake Primary Targets are met…This secondary target is focused on the Swan River, since this is the primary pollutant loading source to Swan Lake.*

2008 Secondary Target 2 Status

No loading data collected after the completion of the Swan TMDL document were located for this report. However, since early 2007, DEQ has been collecting phosphorus, nitrogen, TSS and organic carbon loading data at Porcupine Bridge on the Swan River to evaluate loading to Swan Lake. The study is scheduled to continue into late 2008. When the results of this study are available, the status of Secondary Target 1 will be evaluated.

2.1.4 Secondary Target 2

Application of Montana Adapted Forestry BMPs at stream crossings and near stream road segments. Specific target objectives include:

- Applying Best Management Practices (BMPs) to the extent practical to the top 70 sediment-producing sites identified in TMDL document. These are locations where the estimated sediment load is greater than approximately 3 tons/year and thus where BMP upgrades are likely to produce significant sediment load reductions. Any newly identified road crossings with sediment loading values similar to these top 70 sites will also have BMPs applied to the extent practical. Alternatively, proper road decommissioning is a viable approach to permanently reduce the sediment load from any of these top 70 sites or any locations where a road crosses or is near a stream.
- Applying BMPs to all new road segments. BMP application rates in the Swan Lake Watershed should, at a minimum, be consistent with overall forest practices audit results for BMP compliance in Montana.

According to the TMDL document (DEQ 2005) the rationale for this target is as follows:

> *Erosion from roads, particularly at stream crossings and where roadsa are adjacent to a stream, isa major source of fine sediment loading and elevated levels of suspended sediment/solids to receiving waterbodies during runoff or storm events… The sediment load from roads is also a source of increased nutrient loading, mainly phosphorous, and particulate organic carbon to a lesser extent. Therefore, this target also represents an important approach to minimizing nutrient loading to Swan Lake and perhaps even Flathead Lake.*

2008 Secondary Target 2 Status

In 2006, SEC facilitated restoration on two roads that are close together in the Cold Creek drainage. This road complex represented the largest known chronic source of sediment in the Swan Watershed. The TAG determined that the repair of these roads will likely curtail approximately 60 tons of sediment per year, assuming the base erosion rate of 30 tons/year that was used in the TMDL. The project involved road #9568, which included four point sources in close proximity. One of these (SWC125) was second on the TMDL stream crossing priority list. The other three were also all identified as sediment sources in the TMDL. Additionally, the Cold Lakes trailhead road # 9599, which was not assessed in the TMDL, was rehabilitated, having been identified by the Flathead National Forest as the highest road restoration priority in the Swan. The road had been a problem for years and was eroding badly.

An additional SEC-facilitated road restoration project is scheduled for the summer of 2008, but had not yet been implemented at the time of this report. The project entails reducing sediment delivery along Elk Creek Road #9591 beginning at the junction with Kraft Creek Road #561 and heading north for seven miles to the junction with Road #10291. This will entail addressing 12 known sites identified as priority sediment sources in the TMDL. The repair of the TMDL sites will reduce sediment loading by an estimated 33.55 tons per year. This is Phase II of a multi-year effort that began in 2006 to repair all TMDL sites in the Cold, Elk and Glacier creek basins. These basins are critical for native species, yet they have high road densities in mixed ownership, including national forest, Plum Creek Timberlands and privately owned lands. This road receives considerably more public use than the original road design was intended to support. TMDL road delivery sites to be addressed include SWC numbers 75, 77, 81-88, 90, 91.

As part of the road restoration prioritization process, SEC revisited the top 10 sediment producing road locations identified in the TMDL. One of these, SWC125, was restored in the Cold Creek project described above. Three more, SWC 21, 159, and 78, have been brought up to BMP standards by the Flathead National Forest since the TMDL was completed. Once the Elk Creek project has been competed, 8 of the top 70 sediment producing sediment producing road sources will have been restored along with several additional sites, resulting in a reduction in sediment loading of an estimated 130 tons/year.

Plum Creek Timber Company has been also been addressing road sediment delivery problems on lands in the Swan watershed under its management. Although the company has not evaluated TMDL delivery sites specifically, they have studied three Swan sub-watersheds by inventorying sediment delivery in the mid-1990s and then again in 2005 to quantify the effectiveness of ongoing road sediment reduction efforts. Within the Swan Watershed, Plum Creek studied the Goat/Squeezer, Piper, and Cedar Creek watersheds, and found sediment load reductions of 27%, 71%, and 25%, respectively, for an average sediment reduction by road length of 33%.

The extent to which other organization in the Swan have addressed road-based sediment sources is currently unknown, as is the extent to which new sources have been created and BMPs utilized.

2.1.5 Secondary Target 3

No reductions in overall average riparian canopy density and no increases in the spatial extent of the riparian zone in which canopy density is less than 50% based on a comparison to the aerial photo assessment that was conducted for the TMDL based on 1997 aerial photography.

According to the TMDL document (DEQ 2004) the rationale for this target is as follows:

> *Riparian health is a valuable indicator of streambank stability and shade potential and overall beneficial use support. Healthy vegetation on and near streambanks and*

in floodplains reduces the potential for increased sediment and nutrient loads to Swan Lake and to the tributaries of concern. Reduced canopy cover can also lead to undesirable increases in temperature. This vegetation indicator not only links to all pollutants of concern, it also provides and easy methodology for identifying areas on-the-ground where landowner participation in water quality protection can be encouraged and where water quality protection measures can be applied.

2008 Secondary Target 3 Status

No follow up aerial photo assessment has been conducted to evaluate changes in riparian canopy coverage in the Swan Lake Watershed.

2.2 Goat Creek

In 1996, the entire length of Goat Creek appeared on the Montana 303d list for partial support of aquatic life and cold water fish because of organic enrichment and low dissolved oxygen, siltation and other habitat other habitat alteration, and flow alteration. For the 2002 revisions to the 303d list, the causes of impairment were changed. From the headwaters to the confluence with Squeezer Creek, causes of impairment were listed as nutrients and suspended solids, and below the Squeezer Creek confluence, the causes of impairment were listed as siltation and other habitat alterations (**Table 8**).

The data review completed for the TMDL resulted in several changes to the 2002 listing decision. DEQ determined that the lower reach of Goat Creek, from Squeezer Creek to the mouth, was fully supporting it's beneficial uses and thus no TMDL was required for this reach. In the upper section of Goat Creek above the Squeezer Creek confluence, DEQ determined that nutrients concentrations were not resulting in impairment to the stream, and that a TMDL was necessary only for suspended solids. The 303(d) status of Goat Creek has not changed since the completion of the TMDL (**Table 8**).

Table 8. ***303(d) Status of Goat Creek.***

Reach	1996 Use Support Conditions	1996 Probable Cause of Impairment	2002 Use Support Conditions	2002 Probable Cause of Impairment	2006 Use Support Conditions	2006 Probable Cause of Impairment
Headwaters to Squeezer Creek	Partial Support for aquatic life and cold water fish	Organic enrichment/DO, Siltation and Other Habitat Alteration, Flow Alteration	Partial Support for aquatic life and cold water fish	Nutrients, Suspended Solids	Partial Support for aquatic life and cold water fish	Suspended Solids
Squeezer to Mouth	Partial Support for aquatic life and cold water fish	Organic enrichment/DO, Siltation and Other Habitat Alteration, Flow Alteration	Partial Support for aquatic life and cold water fish	Siltation and Other Habitat Alteration	Fully supporting beneficial uses	None

In the *Water Quality Protection Plan and TMDLs for the Swan Lake Watershed* (DEQ 2004), DEQ proposed that a 33% reduction in reduction in suspended sediment loads during peak flow conditions was necessary to return the stream to full support of its aquatic life and cold water fish beneficial uses. The reduction is to be based on a comparison to 1997 loading data. To track progress towards meeting water quality goals, DEQ established two primary targets for Goat Creek:

2.2.1 Goat Creek Primary Target 1

Total Suspended Sediment of less than 30 mg/l during peak flow conditions

According to the TMDL document (DEQ 2005) the rationale for this target is as follows:

> *This target is based on the fact that streams in the Swan Lake drainage with limited or no human impact appear to have peak flow TSS values in the 15 to 20 mg/l range, representing an indication of the range of naturally occurring conditions…Recent TSS data from 2004 suggest that Goat Creek may currently satisfy this target condition. Another year of representative peak flow data with TSS results less than 20 mg/l, or two more similar years with results less than 30 mg/l may suggest that this target is currently satisfied in Goat Creek. Compliance with this target allows for consideration of duration and magnitude of any sample results greater than 30 mg/l.*

2008 Primary Target 1 Status

The Montana Department of Natural Resource Conservation (DNRC) supplied discharge and TSS data from 2004 and 2005 that were not included in the TMDL document. The target of 30 mg/l TSS was exceeded in five of the DNRC sampling events, twice in 2005 and three times in 2004 (**Table 9**). Hydrologists with DNRC reported noticing an increase in bedload movement in Goat Creek during this time period, which may be responsible for the seemingly elevated TSS concentrations. The cause of the increase in bedload movement is unknown. Based on the available data, Goat Creek does not appear to be meeting its target for TSS concentrations at this time.

2.2.2 Goat Creek Primary Target 2

Macroinvertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols.

According to the TMDL document (DEQ 2005) the rationale for this target is as follows

> *This standard water quality target is consistency applied to all waterbodies in Montana, and provides a direct indication of beneficial use support for aquatic life.*

Table 9. ***Discharge and TSS Data From Goat Creek, June 2004 Through March 2005.***

Date	Stage	Flow (cfs)	TSS (mg/l)
5/11/04	0.99	61.76	3
5/13/04	0.89	50.137	**48**
5/17/04	0.79	37.592	3
5/20/04	0.86	44.852	**41**
5/24/04	0.92	55.355	1
5/26/04	0.89	35.329	**41**
6/1/04	1.07	71.389	2
6/3/04	1.03	67.974	1
6/12/04	1.01	57.461	2
6/15/04	1.04	55.253	1
6/23/04	0.97	51.587	1
6/28/04	0.96	53.528	2
3/16/05	0.45	NC	<1
4/12/05	0.64	NC	<1
4/27/05	1.02	60.704	5
5/5/05	0.79	36.038	2
5/8/05	1.1	76.955	11
5/12/05	1.04	70.5	6
5/17/05	1.36	113.529	**32**
5/19/05	1.24	94.499	7
5/22/05	1.11	72.435	2
5/24/05	1.04	66.334	2
6/4/05	2.3	239.332	**166**
6/9/05	1.5	122.044	11
6/12/05	1.4	105.424	5
6/24/05	1.28	70.697	3

Data collected upstream of Squeezer Creek confluence.

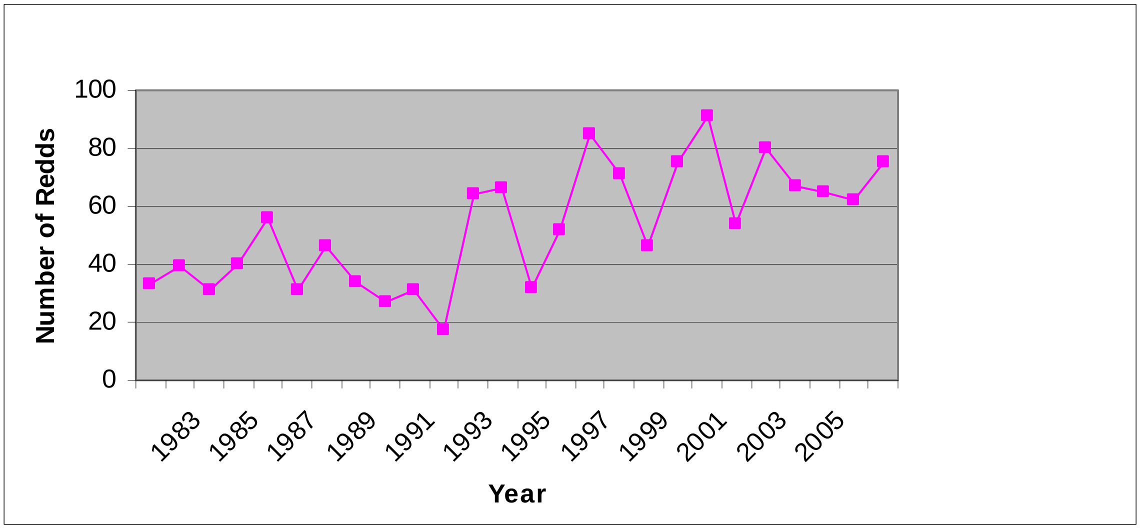
2008 Primary Target 2 Status

At the time of this report, no macroinvertebrate data from Goat Creek were available beyond what had been included in the TMDL document. The TMDL presented macroinvertebrate results from one site on Goat Creek from 1991. Standard DEQ metrics indicated full support of beneficial uses.

2.2.3 Bull Trout Redd Counts

Montana Fish, Wildlife, and Parks has been conducting counts of bull trout spawning redds since 1982. Although Bull Trout Redd counts are not a formal target in the TMDL for Goat Creek, they provide a possible proxy for aquatic life and cold water fish beneficial uses. The number of bull trout redds increased from 33 in 1982 to a high of 91 in 2001, and then declined slightly to 75 in 2007. Overall, the trend appears to be positive, with in the number of bull trout redds in Goat Creek more than doubling during the period of record (**Figure 3**).

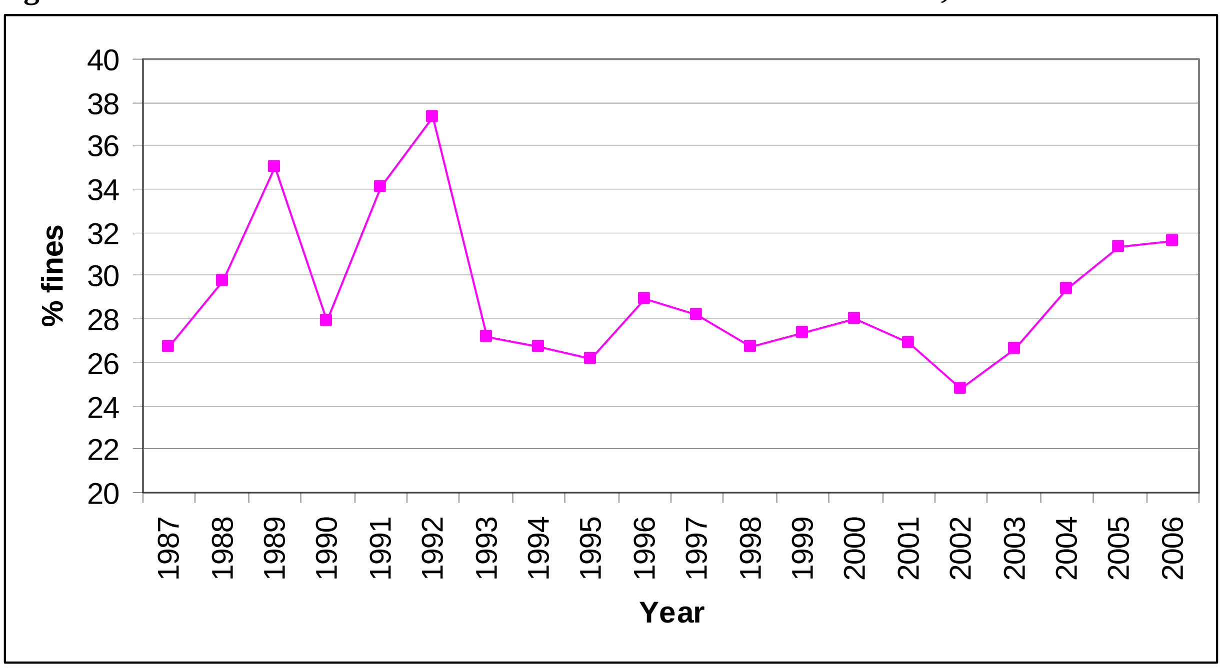
Figure 3. ***Bull Trout Redds in Goat Creek, 1982 to 2007.***



2.2.4 McNeil Core Percent Fines <6.35 mm

Montana Fish, Wildlife, and Parks has been conducting McNeil core sampling since 1987. Although McNeil core counts are not a formal target in the TMDL for Goat Creek, they, like bull trout redd counts, provide a possible proxy for aquatic life and cold water fish beneficial uses. Percent fines <6.35 mm in Goat Creek were 26.7 in 1987, fluctuated widely to a high of 37.3 in 1992, and then became relatively stable in the mid to high 20s throughout most of the remaining period of record, with a slight increase to the low 30s since 2000 (**Figure 4**). For purposes of comparison, a McNeil core percent fines target was set at <35% as part of the Jim Creek TMDL. Percent fines in Goat Creek have been below this target since 1992.

Figure 4. McNeil Core Count Percent Fines <6.35 mm in Goat Creek, 1987 to 2006.



2.3 Jim Creek

In 1996, the entire length of Jim Creek appeared on the Montana 303d list as threatened for support of aquatic life and cold water fish by siltation and other habitat alteration. For the 2002 revisions to the 303d list, the upper segment of the stream, above the confluence of the west fork of Jim Creek, was de-listed, while the listing status of the reach below the west fork was changed to partial support of the aquatic life and cold water fish beneficial uses due to siltation (**Table 10**). The data review completed for the TMDL confirmed the 2002 listing decision, which remains unchanged on the 2006 303d list, the most recent list completed by DEQ.

Table 10. ***303(d) Status of Jim Creek.***

Reach	1996 Use Support Conditions	1996 Probable Cause of Impairment	2002 Use Support Conditions	2002 Probable Cause of Impairment	2006 Use Support Conditions	2006 Probable Cause of Impairment
Headwaters to West Fork	Threatened for aquatic life and cold water fish	Siltation and Other Habitat Alteration	No impairment indentified	No probable causes identified	No impairment indentified	No probable causes identified
West Fork to Mouth	Threatened for aquatic life and cold water fish	Siltation and Other Habitat Alteration	Partial Support for aquatic life and cold water fish	Sediment (Siltation)	Partial Support for aquatic life and cold water fish	Sediment (Siltation)

In the *Water Quality Protection Plan and TMDLs for the Swan Lake Watershed* (DEQ 2004), DEQ proposed a 10% reduction in fine sediment loading to spawning gravels in Jim Creek as necessary to return the stream to full support of its aquatic life and cold water fish beneficial uses. To track progress towards meeting water quality goals, DEQ established three primary targets for Jim Creek:

2.3.1 Jim Creek Primary Target 1

McNeil core substrate fine sediment (<6.35 mm) levels of no more than 35%

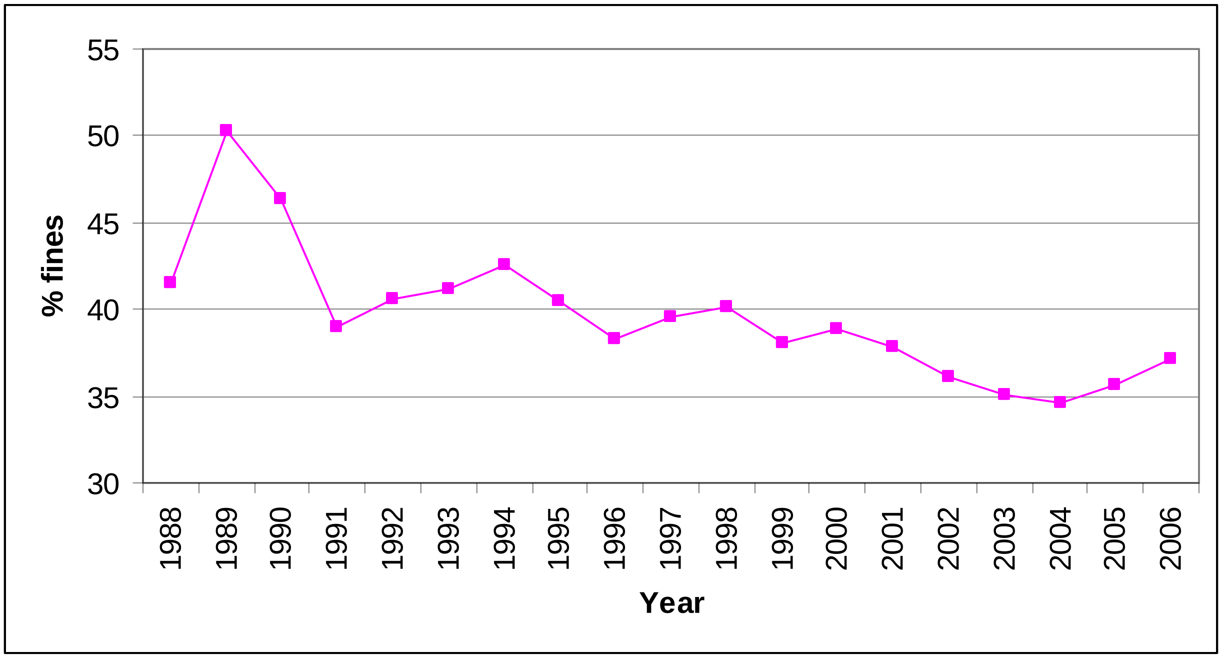
According to the TMDL document (DEQ 2005) the rationale for this target is as follows:

> *This target is directly linked to the sediment impairment described by the siltation causes of the 2002 303(d) list. Elevated levels of fine sediment from human activities reduce fry emergence and are therefore a direct indicator if impairment conditions*

2008 Primary Target 1 Status

Montana Fish, Wildlife, and Parks has been conducting McNeil core sampling in Jim Creek since 1988. Percent fines <6.35 mm in Jim Creek were 41.5 in 1988, rising to 50.3 in 1989, and then declined throughout most of the period of record to a low of 34.6 in 2004. Percent fines then rose slightly in 2005 and 2006. In every year except 2004, percent fines <6.35 mm in Jim Creek have exceeded the TMDL target of <35% (**Figure 5**).

Figure 5. McNeil Core Count Percent Fines <6.35 mm in Jim Creek, 1988 to 2006.



2.3.2 Jim Creek Primary Target 2

Pools and Large Woody Debris: 50% pools with cover and at least 50 pieces of large woody debris (LWD) per 1,000 feet of channel.

According to the TMDL document (DEQ 2005) the rationale for this target is as follows:

> *Woody debris is an important component for fisheries and aquatic life habitat. A significant lack of woody debris can provide a basis for an impairment determination due to loss of aquatic habitat. Woody debris also helps establish streambed stability, dissipates energy, and directly influences sediment storage (Rosgen, 1996). The Jim Creek stream assessment revealed the LWD and pool numbers with cover in the area of Reach 24 were significantly reduced when compared to parts of this and other streams that were apparently less impacted by riparian harvest. The percent pools with cover and number of LWD in other reaches assessed with similar stream type conditions were grater than 50% and 50 respectively. Targets of 50% and 50 were chosen to provide some allowance for variability between streams.*

2008 Primary Target 2 Status

At the time of this report, no pool or LWD data from Jim Creek were available beyond what had been included in the TMDL document. Selected data from the TMDL are presented in **Table 11**. As summarized above, Jim Creek was meeting its LWD and pool targets when the data were reviewed for the TMDL except in Reach 24.

Table 11. *Selected LWD and Pool Data from the Swan TMDL.*

Location	LWD (single/1000 ft)	LWD (Aggregates/1000ft)	Percent Pools with cover
Reach 5L	96	6	67
Reach 5U	78	23	NC
Reach 11	186	129	83
Reach 24	13	0	19

2.3.3 Jim Creek Primary Target 3

Macro invertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols.

According to the TMDL document (DEQ 2005) the rationale for this target is as follows

> *This standard water quality target is consistency applied to all waterbodies in Montana, and provides a direct indication of beneficial use support for aquatic life.*

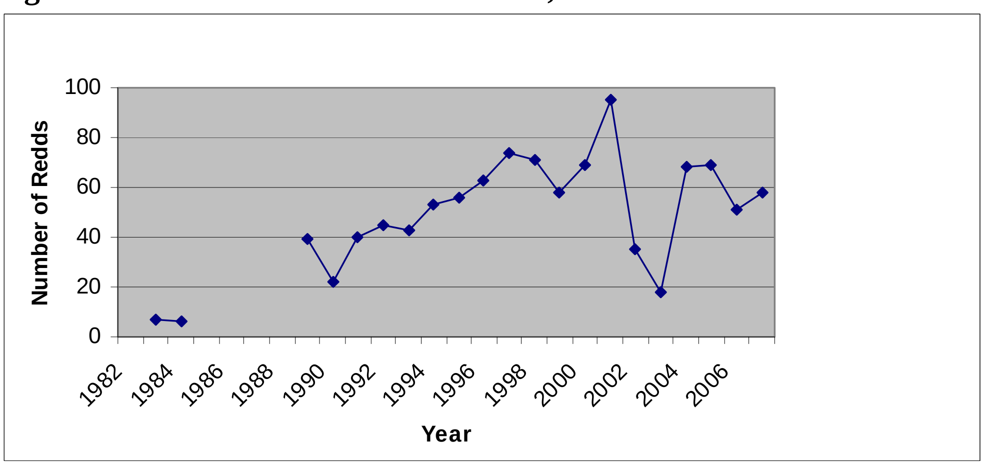
2008 Target 2 Status

At the time of this report, no macroinvertebrate data from Jim Creek were available beyond what had been included in the TMDL document. The TMDL presented macroinvertebrate results from one site on Jim Creek from 1991. Standard DEQ metrics indicated full support of beneficial uses.

2.3.4 Jim Creek Bull Trout Redd Counts

Montana Fish, Wildlife, & Parks has been conducting counts of bull trout spawning redds in Jim Creek since 1983, except for 1985 to 88. Although bull trout redd counts are not a formal target in the TMDL for Jim Creek, they provide a possible proxy for aquatic life and cold water fish beneficial uses. The number of bull trout redds increased from 7 in 1983 to a high of 95 in 2001, declining precipitously in 2002 and 2003, and then climbing again for several years. The most recent count was 58 in 2007. Overall, the trend appears to be positive, with more than a eight-fold increase in the number of bull trout redds in Goat Creek between 1983 and 2007 (**Figure 6**).

Figure 6. *Bull Trout Redds in Jim Creek, 1982 to 2007.*



2.4 Additional SEC Data Collection

2.4.1 Temperature Monitoring

As recommended in the TMDL document, SEC has been monitoring temperature in the Swan River and several critical bull trout streams since 2005. Although no stream in the Swan appears on the 303(d) list as impaired by high temperatures, the data were considered important for establishing baseline conditions. Temperature was monitored continuously via temperature data loggers according to standard DEQ protocols. Monitoring locations are presented in **Table 12.**

To evaluate the temperature monitoring results, the Swan TMDL Implementation TAG recommended three metrics: 1) maximum temperature, 2) maximum weekly average temperature, and 3) maximum weekly maximum temperature. Maximum temperature is the warmest temperature of the monitoring period. Maximum weekly average temperature (MWAT) is the mean of the average daily temperature in the warmest seven consecutive days in the monitoring period. Maximum weekly maximum temperature (MWMT) is the mean of the peak daily temperatures of the warmest seven consecutive days in the monitoring period. Although no formal temperature standards have been adopted in Montana for these measures of temperature, the TAG suggested a maximum MWMT of 15^{o} C and a maximum MWAT of 12^{o} C in the tributary streams as a general guideline for support of bull trout.

Data from 2005 and 2006 (**Tables 13** and **14**) indicate potentially lower temperatures than were found in 2007 (**Table 15**); however, at most of these locations the first day of the monitoring period was the warmest, suggesting that the peak stream temperatures may have occurred before the loggers were deployed in these years. In 2007, all of the streams except Lion Creek exceeded the MWAT and MWMT guidelines. No temperature thresholds have been established for the Swan River.

Table 12. ***Summary of Swan River and Tributary Temperature Monitoring Locations***

Location Name	Latitude	Longitude
Swan River Porcupine Bridge	47 53 222	113 51 652
Swan River Salmon Prairie Bridge	47 37 747	113 47 089
Swan River Kraft Creek Bridge	47 27 793	113 41 113
Goat Creek	47 44 946	113 49 707
Lion Creek	47 40 841	113 48 911
Cold Creek	47 34 826	113 45 406
Elk Creek	47 32 332	113 44 393
Glacier Creek	47 31 756	113 43 293

Table 13. ***Swan Watershed Temperature Data, 2005 (^{o}C)***

Location	Monitoring Period	Max Temp	Date of Max Temp	MWAT	MWMT
Cold Creek	7/28/05 to 3/24/07	16.11	8/6	12.67	15.23
Elk Creek	8/21/05 to 3/22/07	14.55	8/21	11.15	13.19

PBSJ

Table 14. *Swan Watershed Temperature Data, 2006 (°C)*

Location	Monitoring Period	Max Temp	Date of Max Temp	MWAT	MWMT
Cold Creek	7/25 to 10/6	16.25	7/25	13.23	15.35
Elk Creek	7/22 to 10/6	16.06	7/24	13.36	15.77
Glacier Creek	7/25 to 10/6	21.87	7/25	18.22	21.87
Goat Creek	7/28 to 10/6	15.15	7/28	10.89	14.63
Lion Creek	7/23 to 11/16	14.36	8/8	11.41	14.36
Swan – Porcupine Bridge	7/28 to 10/6	17.23	7/28	14.70	16.23
Swan – Salmon Prairie Bridge	7/27 to 10/7	21.51	7/28	17.27	19.64
Swan – Kraft Creek Bridge	7/23 to 10/7	25.43	7/28	22.03	24.96

Table 15. *Swan Watershed Temperature Data, 2007 (°C)*

Location	Monitoring Period	Max Temp	Date of Max Temp	MWAT	MWMT
Cold Creek	7/6 to 10/8	17.49	7/28	14.51	17.49
Elk Creek	7/6 to 10/8	17.13	7/28	14.06	17.13
Glacier Creek	7/6 to 10/8	22.08	7/28	18.60	22.08
Goat Creek	7/6 to 10/8	15.56	7/14	12.07	15.56
Lion Creek	7/6 to 10/8	14.58	7/28	11.79	14.58
Swan – Porcupine Bridge	7/6 to 10/8	26.06	7/28	22.52	26.06
Swan – Salmon Prairie Bridge	7/6 to 10/8	22.39	7/28	19.28	22.39
Swan – Kraft Creek Bridge	7/6 to 10/8	19.82	7/14	17.71	19.82

2.4.2 Swan River Aerial Photo and Channel Assessment

The Swan TMDL TAG, in consultation with DEQ, determined that documenting existing conditions in the Swan Watershed was a high priority. The Swan Watershed is relatively undeveloped at this time, but the rate of growth is increasing, and the TAG wanted to establish baseline conditions so that the impact of this growth on streams in the watershed could be evaluated over time. To accomplish this, in 2004 SEC conducted an aerial photo assessment of the Swan River and several tributary streams and a follow-up on the ground assessment in 2005 to document existing conditions.

2.4.2.1 Aerial Photo Assessment

Aerial photos were obtained from the Flathead National Forest, and with assistance from the Forest Service, they were ortho-rectified using Mosaic software. The photos were oriented and grouped into sections that could be inserted as image files into ArcMap GIS drawings.

Using the ortho-rectified photos, the mainstem of the Swan River was divided into 20 reaches based upon sinuosity and channel type (single channel vs. braided). In each reach, the following characteristics were measured: length of reach segment (if braided, an attempt was made to identify a main channel so the overall segment length could be determined), sinuosity, belt meander width, and bankfull width (**Table 16**). Meander belt width could not be determined in heavily braided reaches.

As a permanent record of the Swan River's 2004 condition, GIS shapefiles were created to outline bridges, structures (houses, sheds, barns, etc.), rip-rap, sediment sources, and cleared ground that were visible in the photos. The shapefile of cleared ground was created by outlining all the areas where vegetation had obviously been removed. The open area may not be associated with development but the lack of vegetation may contribute to increased run-off and increased sediment/nutrients (herbicides, pesticides, fertilizers).

Structures and bridges are count data (e.g, there are three structures along Segment 1), rip-rap is a length measurement (e.g., there is 246 feet of rip-rap along Segment 20), and sediment and cleared ground are area measurements. There were usually many plots of cleared ground along each stream segment so the area of each polygon is shown. But there is also a total area column which is the summation of all the area of cleared ground along each segment. Cross sections established in 2004 were also delineated in the shapefiles. GIS layers are on file at SEC.

Table 16. ***Physical Parameters for the 20 Swan River Segments.***

Reach #	Length (ft)	Sinuosity	Braided/Single Channel	Bankfull Width (ft)						October 2004 cross sections
				1	2	3	4	5	Av	
1	13,538	1.1	S	54	45	45	31	60	47	None
2	8,203	1.2	B	NA	NA	NA	NA	NA	NA	N
3	9,618	1.1	S	40	53	65	74	55	57	M,L
4	6,463	1.1	S	44	47	52	45	54	48	None
5	10,047	1.3	S	53	41	47	66	62	54	None
6	12,123	1.1	B	45	49	47	49	55	49	None
7	14,696	1.2	S	50	51	46	60	51	52	None
8	52,866	1.3	B+	NA	NA	NA	NA	NA	NA	J,I
9	11,543	1.1	S	115	92	126	107	104	109	H
10	15,007	1.1	B	171	96	140	93	123	125	G
11	11,158	1.1	S	99	117	105	108	130	112	None
12	5,734	1.1	B	147	111	158	137	NA	138	None
13	14,768	1.1	S	129	116	102	146	121	123	None
14	4,030	1.3	B	134	116	NA	NA	NA	125	None
15	9,985	1.2	S	145	121	135	121	110	131	D
16	42,126	1.3	B+	NA	NA	NA	NA	NA	NA	C
17	10,071	1.2	B	136	131	129	135	120	130	None
18	9,058	1.4	S	127	136	132	139	126	132	A
19	10,758	1.8	B	126	127	132	118	131	127	None
20	23,367	1.5	S	127	140	149	145	134	139	None

Green rows are braided stretches; B+ reaches are severely braided.

2.4.2.2 Swan River Channel Assessment

During the summer of 2005, permanent cross sections were established in ten of the twenty reaches established in the aerial photo assessment (A, C, D, G, H, I, J, L, M, and N). In addition to the cross sections (which are on-file at SEC) the following data were collected at each site: bankfull width, average bankfull depth, flood-prone width, gradient, Wolman pebble count, riffle stability index, Pfankuch rating, and GPS coordinates and photos of cross section locations. This information was also gathered at four sites each on Goat and Jim Creeks, and three sites on Elk Creek.

Results are summarized in **Tables 17** through **20.** As the primary purpose of these data is to track changes over time by comparing them to similar data collected in the future, no analysis of them is presented at this time. It is anticipated that the study will be repeated in 5 to 10 year intervals to evaluate trends in channel and near-stream conditions.

Table 17. ***Bankfull and Floodprone widths, Average Bankfull Depths, W/D Ratio, Entrenchment Ratio, and Gradients (feet).***

Cross Section	Bankfull Width	Average Bankfull Depth	W/D ratio	Measured Floodprone width	Max Floodprone Width	Entrenchmnt Ratio	Gradient
Goat 1	33.6	1.62	20.76	97.91	134.4	2.91	0.002
Goat 2	45.24	0.75	59.95	194.54	180.96	4.30	0.017
Goat 3	25.83	1.21	21.36	96.64	103.32	3.74	0.023
Goat 4	17.42	1.47	11.84	27.9	69.68	1.60	0.036
Jim 1	39.21	1.97	19.95	209.55	156.84	5.34	0.012
Jim 2	22.77	1.58	14.41	58.04	91.08	2.55	0.012
Jim 3	28.06	1.76	15.94	43.1	112.24	1.54	0.055
Jim 4	29.4	2.13	13.81	274.41	117.6	9.33	0.022
Elk 1	47.28	1.68	28.16	169.24	189.12	3.58	0.005
Elk 2	42.28	1.29	32.70	59.7	169.12	1.41	0.011
Elk 3	37.3	1.14	32.77	53.46	149.2	1.43	0.004
Section A	166.05	3.37	49.32	402.23*	664.2	4.00	0.002
Section C	321.22	1.96	163.73	761.73*	1284.88	4.00	0.0014
Section D	115.35	2.26	50.95	664.71	461.4	5.76	0.002
Section G	129.79	2.06	63.08	847.61	519.16	6.53	0.005
Section H	96.49	1.78	54.32	117.15	385.96	1.21	0.004
Section I	70.63	2.12	33.25	660	282.52	9.34	0.003
Section J	117.08	1.53	76.34	1213.34	468.32	3.53	0.005
Section L	57.9	1.51	38.27	166.94	231.6	2.88	0.005
Section M	80.86	2.05	39.51	170.7	323.44	2.11	0.002
Section N	45.18	1.72	26.30	112.72	180.72	2.49	0.002

Since the greatest defining entrenchment ratio is 4.0 (above which all streams are classified as type DA), maximum floodprone width is 4 times bankfull width. The actual floodplain may be wider than this but the width ceases to matter for classification purposes. A few of the measured floodprone widths did not extent far enough for the ground to exceed floodprone elevation but they had exceeded maximum floodprone width. Measured floodprone widths with asterisks were incomplete; they neither spanned enough ground to finally exceed the floodprone elevation nor did they exceed the maximum floodprone width. All measurements are in feet.

Table 18. ***D84 Values for Each Cross-section as Determined from Wolman Pebble Count Data.***

Cross Section	D84
Goat1	33
Goat2	63
Goat3	176
Goat4	130
Jim1	25
Jim2	85
Jim3	480
Jim4	69
Elk1	118
Elk2	185
Elk3	203
SectionA	81
SectionC	87
SectionD	74
SectionG	153
SectionH	121
SectionI	58
SectionJ	52
SectionL	102
SectionM	103
SectionN	53

Table 19. ***Riffle Stability Index (RSI)***

Cross Section	Geometric Mean Size	RSI
Goat 1	111.80	99.14
Goat 2	113.61	97.59
Goat 3	150.31	79.88
Swan A	59.78	74.22
Swan C	111.08	94.21
Swan D	156.02	98.28
Swan G	140.23	80.52
Swan H	101.80	77.23
Swan I	103.11	95.82
Swan J	115.85	98.14
Swan L	105.30	85.68
Swan M	98.27	83.29
Swan N	74.20	96.25

Not collected in Jim or Elk Creeks.

Table 20. ***Pfankuch Channel Stability Evaluation Scores.***

Cross Section	Landform Slope	Mass Wasting	Debris Jam Potential	Vegetative Bank Protection	Channel Capacity	Bank Rock Content	Obstructions to flow	Cutting	Depositional Patterns	Rock Angularity	Brightness	Consolidation of Particles	Bottom Size Distribution	Scouring & Deposition	Aquatic Vegetation	Total	Status
Swan A	6	9	2	3	4	6	2	16	4	3	1	4	4	6	1	**71**	Good
Swan C	8	3	8	3	4	6	6	12	8	2	1	4	8	12	2	**87**	Fair
Swan D	8	6	2	3	4	4	2	12	8	3	1	4	4	6	1	**68**	Good
Swan G	6	6	8	3	4	4	4	12	12	3	1	4	4	12	1	**84**	Fair
Swan H	2	3	8	3	4	6	4	8	4	3	1	4	4	6	1	**61**	Good
Swan I	2	3	8	3	4	6	4	8	12	3	1	4	8	6	1	**73**	Good
Swan J	2	3	8	3	4	6	6	12	12	3	1	4	8	12	1	**85**	Fair
Swan L	2	3	8	3	4	8	6	12	8	2	1	4	8	12	2	**83**	Fair
Swan N	2	3	8	3	4	8	6	12	8	2	1	4	8	12	2	**83**	Fair
Swan M	4	3	4	3	4	8	4	8	4	2	1	4	4	6	1	**60**	Good
Goat 1	8	9	6	3	3	8	6	12	8	4	3	6	16	24	3	**119**	Poor
Goat 2	4	6	6	3	4	6	4	8	8	3	3	5	12	18	3	**93**	Fair
Goat 3	6	6	8	3	3	4	4	4	4	3	2	4	8	12	NA	**71**	Good
Goat 4	2	3	2	3	2	2	2	4	4	3	1	4	8	6	NA	**46**	Good
Jim 1	2	3	8	3	3	8	2	4	4	2	1	4	4	6	1	**55**	Good
Jim 2	4	3	8	3	2	8	2	4	4	2	1	4	4	12	1	**62**	Good
Jim 3	4	3	8	6	3	2	2	8	4	2	1	4	4	6	1	**58**	Good
Jim 4	4	6	6	6	2	8	6	8	12	1	1	6	12	18	3	**99**	Fair
Elk 1	4	6	4	3	4	6	4	8	4	2	2	6	12	12	3	**80**	Fair
Elk 2	4	3	4	3	4	2	2	4	4	2	1	4	8	6	3	**54**	Good
Elk 3	4	3	6	3	4	2	4	4	4	2	1	4	8	6	3	**58**	Good

2.5 Flathead National Forest PIBO Monitoring

The Flathead National Forest has been assisting with TMDL implementation in the Swan Watershed since the completion of the TMDL document. As part of this effort, the Forest is conducting stream monitoring at 50 assessment locations in the Swan Valley according to protocols defined by the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). Assessment reaches are being reassessed every five years on a rotating basis to track their long-term health. Results of these assessments will be included in future updates of this report.

2.6 Plum Creek Timber Company Research Summary

Plum Creek Timber Company (PCTC) has assisted SEC with TMDL implementation in the Swan Watershed since the project began and prepared the following summary of relevant monitoring and research efforts for inclusion in this report.

2.6.1 Plum Creek Aquatic Monitoring and Research

Since 2000, Plum Creek has implemented the Native Fish Habitat Conservation Plan (NFHCP) on company lands in the Swan River Basin, and elsewhere in western Montana. The NFHCP is a 30-year agreement with the US Fish and Wildlife Service under the federal Endangered Species Act, and is designed to conserve habitat for bull trout, westslope cutthroat trout, Columbia River redband rainbow trout, and two species of native whitefish. Biological goals of the Plan are to maintain or improve the “4 Cs” essential to trout conservation: cold, clean, complex, and connected habitats.

The NFHCP has 55 individual commitments mostly related to reducing sedimentation from company roads, providing effective buffers along streams during harvest operations, grazing management practices, and riparian restoration. Adaptive management under the NFHCP is guided by research and monitoring data collected on both implementation and effectiveness of the plan. A description of monitoring and research undertaken in the Swan as part of the NFHCP adaptive management program are described below.

2.6.1.1 Road Sediment Production

Accuracy of road erosion modeling in western Montana (including Swan TMDL modeling) is poor because empirical data on road erosion rates in our predominant parent materials (glacial till and Belt Supergroup) has not been collected. Under the NFHCP, Plum Creek and the University of Montana measured road erosion at 20 randomly-selected plots throughout western Montana over a three-year period: 2002-2004. One of these plots was located in the Whitetail Creek drainage, which is in the northwestern corner of the Swan River basin. This research was published in the Journal of the American Water Resources Association (Sugden, B.D., and S. Woods. 2008. 2007. Sediment production from forest roads in western Montana. JAWRA 43(1):193-206). This research found that measured road erosion rates in these two soil types is about ten-times lower than what was modeled in the Swan TMDL.

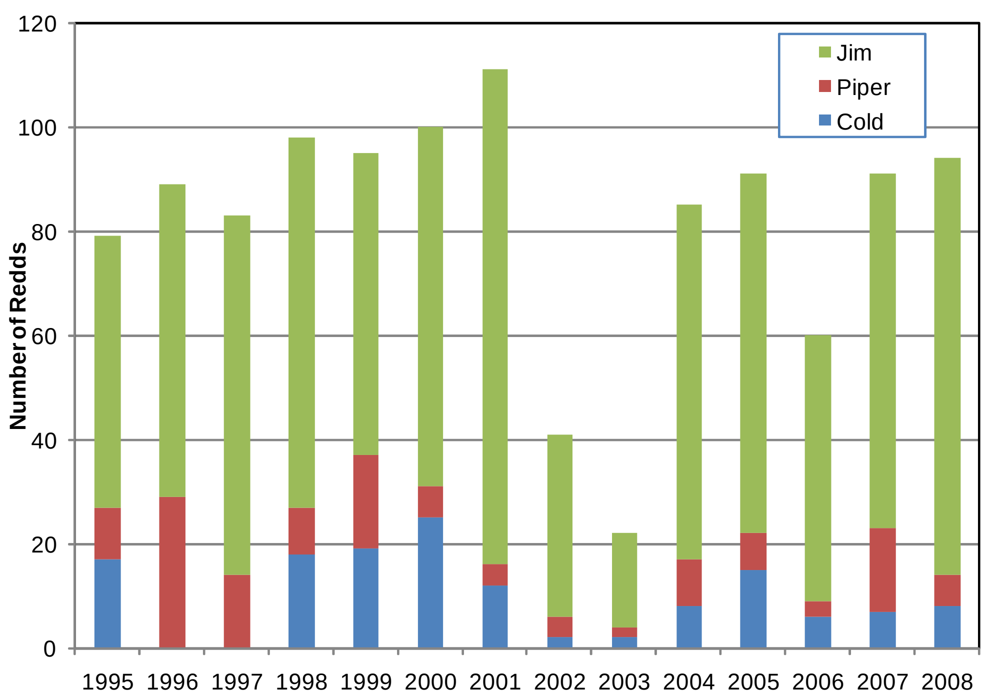
2.6.1.2 Riparian Buffer Strip Effectiveness for Protecting Stream Temperatures

Under the NFHCP and Montana Streamside Management Zone (SMZ), timbered buffers need to be retained when harvesting adjacent to streams. The width of these buffers is dependent on several factors, including the steepness of the adjacent hillslope and confinement of the stream channel. Buffer widths typically range from 50-150 feet on each side of the stream, depending on the site-specific factors. The effectiveness of these buffers for temperature control was evaluated at 30 sites in western Montana between 1999 and 2004. Three of these sites were in the Swan, including two sites on Cold Creek and one on Lion Creek. Continuous stream temperature data was collected for at least one summer before timber harvest and one summer after. Effectiveness of the buffer on stream temperature was evaluated the relationship between upstream and downstream temperature after the harvest. This research found that the NFHCP and Montana SMZ law are highly effective at preventing stream temperature changes as a result of timber harvest. In the three Swan study sites, no stream temperature increases were detected.

2.6.1.3 Bull Trout Redd Counts

Since 1995, Plum Creek has inventoried bull trout spawning nests (redds) in three Swan tributaries: Cold Creek, Jim Creek, and Piper Creek. These counts supplement those done by Montana FWP in Elk, Goat, Squeezer and Lion Creeks. Over the monitoring period, Cold Creek has averaged 12 redds per year, Piper 10, and Jim 62. These data are reported annually to Montana FWP.

Figure 7: ***Redd Counts for Swan Tributaries Monitored by Plum Creek***



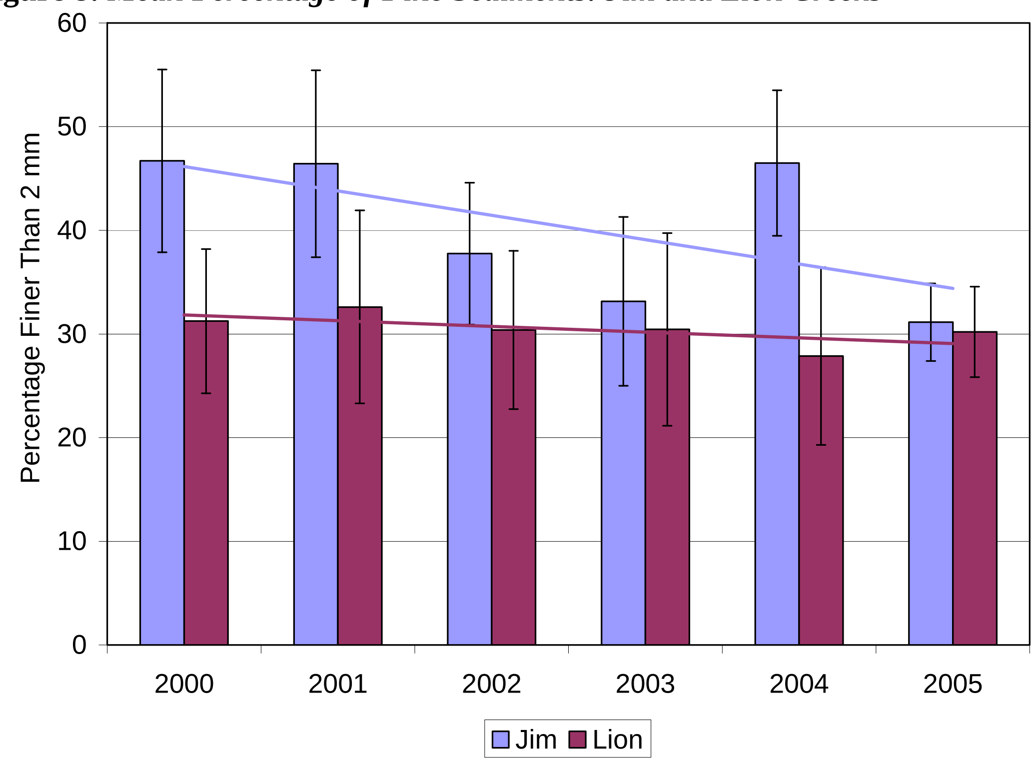
2.6.1.4 Large Woody Debris Movement in Streams

Large woody debris (LWD) in streams is important for creating complex fish habitat (pools, hiding cover, etc.). It is delivered to streams from windthrow, bank erosion, and sometimes deliberately through stream enhancement projects. In developing the NFHCP, Plum Creek used a model to evaluate how different stream buffer designs would provide for a continuous and adequate supply of LWD to streams. A key modeling assumption is how fast existing LWD moves out of streams, either through decay or simply being washed downstream. The only available existing data on LWD “depletion” was from streams in western Washington and coastal Alaska. To address this information gap, Plum Creek collaborated with the National Council for Air and Stream Improvement (NCASI) and Oregon State University (OSU). OSU tagged wood in three streams in the Swan in 1999 (Upper Squeezer, Piper, and Goat Creeks). In 2002, Plum Creek tagged wood in four additional streams: Woodward, South Woodward, and Lower Squeezer Creeks, as well as a reach on the Swan River. These reaches were re-surveyed in 2007, and data analysis is pending.

2.6.1.5 Spawning Gravel Quality

Under the NFCHP, two streams in the Swan are monitored for spawning gravel quality – Lion Creek and Jim Creek. Lion Creek is considered a reference streams by which trends in Jim Creek can be evaluated. This sampling done in even-numbered years during the summer by coring spawning gravels with a McNeil Sampler. These samples are then sieved to determine the fraction of the gravel that is composed of fine sediment. Data are reported by every five years in conjunction with NFHCP reporting. The figure below shows the mean percentage of fines (<2 mm) by year. Error bars show the 95% confidence interval about the mean.

Figure 8: ***Mean Percentage of Fine Sediments: Jim and Lion Creeks***



2.6.1.6 Riparian Stand Conditions

As part of the NFHCP, Plum Creek is tracking riparian stand conditions over time. In 2000, one thousand permanent long-term cruise plots were established on company land across western Montana. Sixty of these plots are located in the Swan in the Woodward, Fatty, Squeezer, Dog, and Cold Creek watersheds, as well as along the Swan River. These plots will be re-cruised in 2010.

3.0 SUMMARY AND RECOMMENDATIONS

3.1 Swan Lake TMDL Target Status

3.1.1 Primary Target 1

No decreasing percent saturation of dissolved oxygen (DO) in the bottom waters of Swan Lake and no increase in the spatial extent of the low DO area in the lake.

Status: Although no trend is apparent in the available percent saturation data, there is no indication that low DO concentrations in the lake have worsened, and thus the first half of Target 1 appears to have been met in recent years. In contrast, the spatial extent of the DO deficit appears to have increased; however it is unclear whether the increase is a function of variability in the data or reflects an actual degradation of water quality.

3.1.2 Primary Target 2

No increasing trend of nutrient and chlorophyll *a* concentrations, no increasing trophic state index trends, and no decreasing trend in Secchi Depth values in Swan Lake.

Status: Available data are insufficient for evaluating this target; however, a soon to be completed study by DEQ will provide more data and this target can then be evaluated.

3.1.3 Secondary Target 1

No increasing trend in phosphorous, nitrogen, TSS and organic carbon loads associated with human impacts entering Swan Lake from the Swan River.

Status: Available data are insufficient for evaluating this target; however, a soon to be completed study by DEQ will provide more data and this target can then be evaluated.

3.1.4 Secondary Target 2

Application of Montana Adapted Forestry BMPs at stream crossings and near stream road segments.

Status: By the fall of 2008 when the Elk Creek road restoration project has been competed, 8 of the top 70 sediment producing road crossing that were identified in the TMDL will have been addressed by SEC and it's project partners, resulting in an estimated sediment load reduction of 130 tons/year. Plum Creek Timber Company has estimated that sediment loading from roads under its management has been reduced by approximately 33%. The extent to which other organization in the Swan have addressed road-based sediment sources is currently unknown, as is the extent to which new sources have been created and BMPs utilized.

3.1.5 Secondary Target 3

No reductions in overall average riparian canopy density and no increases in the spatial extent of the riparian zone in which canopy density is less than 50% based on a comparison to the aerial photo assessment that was conducted for the TMDL based on 1997 aerial photography.

Status: No follow up aerial photo assessment as been conducted to evaluate changes in riparian canopy coverage in the Swan Lake Watershed.

3.2 Goat Creek TMDL Target Status

3.2.1 Target 1

Total Suspended Sediment of less than 30 mg/l during peak flow conditions.

Status: In 2004 and 2005, the target was exceeded 5 times in monitoring conducted by DNRC. Based on the available data, Goat Creek does not appear to be meeting its target for TSS concentrations at this time.

3.2.2 Target 2

Macroinvertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols.

Status: At the time of this report, no macroinvertebrate data from Goat Creek were available beyond what had been included in the TMDL document.

3.3 Jim Creek TMDL Target Status

3.3.1 Target 1

McNeil core substrate fine sediment (<6.35 mm) levels of no more than 35%.

Status: Montana Fish, Wildlife, and Parks has been conducting McNeil core sampling in Jim Creek since 1988. Percent fines <6.35 mm in Jim Creek were 41.5 in 1988, rising to 50.3 in 1989, and then declined throughout most of the period of record to a low of 34.6 in 2004. Percent fines then rose slightly in 2005 and 2006. In every year except 2004, percent fines <6.35 mm in Jim Creek have exceeded the TMDL target of <35%.

3.3.2 Target 2

Pools and Large Woody Debris: 50% pools with cover and at least 50 pieces of large woody debris (LWD) per 1,000 feet of channel.

Status: At the time of this report, no pool or LWD data from Jim Creek were available beyond what was included in the TMDL document.

3.3.3 Target 3

Macroinvertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols.

Status: At the time of this report, no macroinvertebrate data from Jim Creek were available beyond what was included in the TMDL document.

3.4 Recommendations

Based on the available data and target compliance summary presented in this report, the following recommendation for future data collection and other TMDL implementation activities are presented to facilitate discussion and project planning among TAG members.

- Trends data requirement analysis: For all data that is to be used for trends analysis - including DO concentrations in Swan Lake, area of low DO concentrations, AHOD, in-lake nutrient, secchi, and chlorophyll concentrations – the TAG should conduct an analysis of the quantity and characteristics of data that would make trend detection possible. Similar analysis has been conducted for other DEQ-funded TMDL implementation projects in Montana (Clark Fork River VNRP, for example).
- Continued monitoring of Swan Lake DO metrics – profiles, spatial extent of DO deficit, and AHOD.
- The in-lake and loading data that is being collected by DEQ's multi-year Swan project should be obtained and incorporated into a future draft of this report. This represents the most comprehensive study of Swan Lake since the Flathead Lake Biological Station's study in the early 1990s and the two studies together would allow for an evaluation of Swan Lake Primary Target 2 and secondary Target 1.
- Macroinvertebrate data should be collected from Jim and Goat Creeks to evaluate the macro targets for these streams
- Pool and LWD data should be collected from Jim Creek to evaluate the TMDL targets for these parameters.
- Final temperature targets should be agreed upon by the TAG for Swan River and the tributaries in which temperature monitoring is being conducted. Where temperatures exceed these targets, the TAG should investigate potential causes of the elevated temperatures.
- Continue road BMP implementation and sediment load reductions efforts.

- A formal system should be adopted for tracking improvements to the road network and for indentifying potential new sources of road sediment that were not evaluated in the TMDL.
- Collaborate with Flathead National Forest on PIBO monitoring and use PIBO data to track TMDL progress on 303(d)-listed streams and long-term stream health throughout the watershed.
- Continue education and outreach.
- A data library should be established at SEC to house all of the data collected by the Swan TMDL Implementation Project. Although the data have been uploaded to the state's STORET database, this system is not practical for all of the data that have been collected (shapefiles and cross sections, for example), and is difficult for non-agency personnel to access.

4.0 REFERENCES

Montana Department of Environmental Quality. 2004. *Water Quality Protection Plan and TMDLs for the Swan Lake Watershed.* June 2004. Helena, MT.

Sugden, B.D., and S. Woods. 2008. 2007. Journal of the American Water Resources Association: Sediment production from forest roads in western Montana. JAWRA 43(1):193-206.