ANNOTATED BIBLIOGRAPHY OF DATA SOURCES

Lower Gallatin TMDL Planning Area

Prepared for:

GREATER GALLATIN WATERSHED COUNCIL
P.O. Box 751
Bozeman, MT 59771

And

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
P.O. Box 200901
Helena, MT 59620-0901

Prepared by:

PBS&J
3810 Valley Commons Drive, Suite 4
Bozeman, MT 59718

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This annotated bibliography presents a brief review of newly obtained documents containing relevant water quality information in the Lower Gallatin TMDL Planning Area. Reports and data were obtained between March 20th and May 12th 2007 through contacts with the various agencies engaged in water quality related work in the Greater Gallatin area. Additional information from universities and other organizations was also obtained during this timeframe.

In this document, a list of reports reviewed is presented, followed by a brief review of the information as categorized by the general data types: chemistry, sediment/habitat, biology, maps/photos and general background information. A total of 20 reports were reviewed during this project. Selected communications with natural resource professionals obtained during this data inventory are included following this review.

In general, reports which have been previously reviewed by the Montana Department of Environmental Quality (MDEQ) as part of their Sufficient Credible Data and Beneficial Use Determination (SCDBUD) process were not re-reviewed during this process, though the information was compiled into the accompanying databases, which include extensive water quality datasets from the USGS National Water Information System (NWIS), the U.S. Environmental Protection Agency STORET database and other relevant data sources. A list of all the documents cited in the MDEQ SCDBUD files is presented at the end of this document.

This annotated bibliography is accompanied by both an **Existing Data Compilation database**, which includes a description of the existing water quality data types and data sites throughout the watershed, and the **Source Quantification database**, which highlights sources of data that appear to be relevant for future TMDL monitoring and assessment efforts. This annotated bibliography is also accompanied by the **Lower Gallatin Watershed Characterization Report,** which summarizes general watershed conditions.

Electronic Deliverables:

Barndt, S., and S. Bay. 2004. Bear Creek Fish Investigations, 2003: Population and Habitat Surveys. Gallatin National Forest, Bozeman Ranger District, January 30, 2004.

Byorth, P.A. 2000. Gallatin River Drainage Trout Population Surveys: July 1994 - June 1999, Project 3302. Montana Fish, Wildlife and Parks, Bozeman, Montana.

Byorth, P.A., and T. Weiss. 2002. Madison - Gallatin Fisheries Annual Monitoring Report: 2001. Montana Fish, Wildlife and Parks, Bozeman, Montana.

Byorth, P.A., and T. Weiss. 2003. Madison - Gallatin Fisheries Annual Monitoring Report: 2002. Montana Fish, Wildlife and Parks, Bozeman, Montana.

Greenup, Mary Taylor. 2003. Spatial investigation of ground water nitrate-nitrogen and coliform bacteria in the Gallatin local water quality district, Gallatin County, MT, Montana State University, Bozeman, MT.

NRCS. 2001. Attachment D: East Gallatin Inventory and Assessment Data Summary.

Story, M., and C. Taylor. 2004. Bear Creek Sediment, Turbidity and Discharge Monitoring Report, April-August 2003. Gallatin National Forest, January 12, 2004.

Story, M. 2007. Bozeman Municipal Watershed (BMW) Water Quality Issue, March 5, 2007. Gallatin National Forest, Bozeman, Montana.

Story, M. 2007. Draft Chapter 3 and 4 North Bridger Grazing Allotments, March 2, 2007. Gallatin National Forest, Bozeman, Montana.

Tohtz, J., and T. Weiss. 2006. Fisheries Investigations in the Madison and Gallatin River Basins: Annual Report for 2005. Federal Aid Project F-113-R-5. Montana Fish, Wildlife and Parks, Bozeman, Montana.

Weiss, T., and P. Byorth. 2000. Urban Fish Ponds Fisheries Investigations: Madison / Gallatin District, July 1994 - June 1999. Montana Fish, Wildlife and Parks, Bozeman, Montana.

Hard Copy Deliverables:

Kendy, E. 2001. Magnitude, extent, and potential sources of nitrate in ground water in the Gallatin Local Water Quality District, southwestern, Montana, 1997-98, Water-Resources Investigations Report 01-4037, U. S. Geological Survey, Denver, Colorado, 66 p.

Available on the Internet:

GNF. 2005. Bridger Bowl Special Use Permit and Master Development Plan Final Environmental Impact Statement. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=projects/bridger_bowl.

GNF. 2006. Bangtail Mountains Road Decommissioning Project Environmental Assessment. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=projects/bangtail_mountains.

GNF. 2006. Gallatin National Forest Travel Plan FEIS. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=/projects/travel_planning.

Hargrave, P., Kerschen, M., McDonald, C., Metesh, J.J., Norbeck, P.M., Wintergerst, R.. 2000. Abandoned-inactive mines program, Gallatin National Forest, Administered Lands. Montana Bureau of Mines and Geology: Open File Report 418, 199 p. Available on the Internet at: http://www.mbmg.mtech.edu/pdf-open-files/MBMG418_Gallatin.pdf.

Available at the Gallatin Local Water Quality District:

Bozeman Watershed Council. 2004. Sourdough Creek Watershed Assessment, Bozeman, Montana, 93 p.

Deal, K. 1998. Analysis of septic system failure in Gallatin County, Montana. MSU Extension Service, Bozeman, Montana, 46 p.

English, A. and C. Baker. 2004. Wetland and Riparian Resource Assessment of the Gallatin Valley and Bozeman Creek Watershed, Gallatin County, Montana. Gallatin Local Water Quality District. Bozeman, MT. Prepared for the Montana Department of Environmental Quality. June 2004.

McIlroy, Susan Kay. 2004. Identifying Linkages Between Aquatic Habitat, Geomorphology, and Land Use in Sourdough Creek Watershed. Montana State University Master's Thesis 125 p.

Schmitz, D., S. Ammondt, M. Blank, and D.T. Patten. 2006. Using Historic Aerial Photography and Paleoflood Hydrology to Assess Long-Term Ecological Response to Two Montana Dam Removals. 10 p.

Chemistry Data

Kendy, E. 2001. Magnitude, extent, and potential sources of nitrate in ground water in the Gallatin Local Water Quality District, southwestern, Montana, 1997-98, Water-Resources Investigations Report 01-4037, U. S. Geological Survey, Denver, Colorado, 66 p.

This report describes the magnitude, extent, and potential sources of nitrate in ground water in the Gallatin Local Water Quality District (GLWQD). Based on 96 samples from 1998, nitrate concentrations in ground water ranged from <0.05 to 13 mg/L. The median nitrate concentration found basin-fill deposits was "less than about 3 mg/L". Sources of nitrates in ground water cited in this document include silviculture, atmospheric deposition, livestock, fertilizer, soil organic nitrogen, and septic-system effluent. Fertilizers and soil organic nitrogen were thought to be the biggest source of nitrate to ground water in the GLWQD. Irrigation was noted to facilitate the movement of nitrogen from fertilizers to groundwater. This study also examined water-quality data from three subdivisions and concluded that domestic septic effluent did not appear to be a major source of nitrate to ground water in the GLWQD, though there were approximately 7,000 septic system served residences in the GLWQD in 1998.

Greenup, Mary Taylor. 2003. Spatial investigation of ground water nitrate-nitrogen and coliform bacteria in the Gallatin local water quality district, Gallatin County, MT. Master's thesis, Montana State University, Bozeman, MT.

This study involved the compilation of ground water quality data, primarily for nitrate-nitrogen and coliform bacteria in the Gallatin Local Water Quality District (GLWQD). This study used existing data, most of which was collected by the USGS. This study found that the West Gallatin Alluvial aquifer has the lowest levels of both nitrate-nitrogen and coliform bacteria, presumably due to the greatest capacity for dilution. The western flanks of the Bridger Range and the northern front of the Gallatin Range were identified as potential problem areas with a tendency for nitrate-nitrogen levels higher than expected from normal background levels. This pattern corresponds with the Quaternary-Tertiary Basin Fill aquifer. The finding suggests that continual loading of nitrate-nitrogen in these areas may pose future health risks due to limited dilution rates.

Deal, K. 1998. Analysis of septic system failure in Gallatin County, Montana. MSU Extension Service, Bozeman, Montana, 46 p.

This report summarizes information collected during interviews with local engineers, installers, pumpers and homeowners to determine what factors contribute to septic system failure in the Gallatin Valley. In general, septic system failure occurs when the soil within the adsorption field no longer accept effluent from the septic tanks at the same rate at which it is general. In the Gallatin Valley, reasons for failure discovered during this study include equipment failure (pipes settling and breaking, etc.), poor site evaluation and/or design, and homeowner neglect or ignorance. This study noted that there are 160 different soil types in the Gallatin Valley and tight clay soils found at some locations were cited as one factor leading to failure. Specific locations of concern cited include Bridger Canyon, Four Corners, Gallatin Gateway and Bear Canyon. Gravelly soils and shallow groundwater may potentially lead to problems in the Four Corners and Gallatin Gateway area, while steep slopes are a concern in Bridger Canyon and clayey soils are a concern in Bear Canyon.

Hargrave, P., Kerschen, M., McDonald, C., Metesh, J.J., Norbeck, P.M., Wintergerst, R. 2000. Abandoned-inactive mines program, Gallatin National Forest, Administered Lands. Montana Bureau of Mines and Geology: Open File Report 418, 199 p.

There are 462 mine and mill sites on or near the Gallatin National Forest within the Madison, Gallatin, upper Yellowstone, Yellowstone Headwaters, and Clarks Fork of the Yellowstone drainages. Of these, 9 were determined to have a potential to have adverse effects on soil or water quality on GNF-administered land. The Johnson Canyon site on the west slope of the Bridger Range is the only site in the Lower and East Gallatin TPA that was identified as a site with potential environmental problems impacting GNF-administered lands. (Note: this is also called Mill Canyon). Of the four water samples taken at the Johnson Gulch adits, only the field pH of the adit discharge did not meet water-quality criteria. The flow was very low and only contacted the waste dump for a short distance. The zinc levels doubled downstream (from 32µg/L to 76.3µg/L), but both measurements were well below the standards for zinc. The lab pH was 7.6, while the field pH was 5.98. The other pH measurements were approximately 6.5 for the field and 7.6 for the lab. Except for local effects, these sites showed little effect on the environment. Runoff was minimal and probably only seasonally significant. Zinc levels in the waste were the most obvious problem, but they were not reflected in the water analyses.

In the hydrology and hydrogeology section of this report, it was noted that about 110,000 acres are irrigated with water diverted from the Gallatin River above Logan.

Blue Ribbons of the Big Sky Country APO. 1979. Final Report and Water Quality Management Plan.

Only the introduction of this report was available. It outlined the scope of this $475,000 study, which was funded by the U.S. Environmental Protection Agency under provision of Section 208 of the Clean Water Act.

Sediment/Habitat Data

Story, M., and C. Taylor. 2004. Bear Creek Sediment, Turbidity and Discharge Monitoring Report, April-August 2003. Gallatin National Forest, January 12, 2004.

This report is cited in the SCDBUD files and is reviewed briefly here due to its relevance in the TMDL process. This study includes discharge (cfs), turbidity (NTU), suspended sediment (mg/L), and bedload sediment (tons/day) measurements performed at eight sites on Bear Creek in 2003. The results are presented in a table as averages and graphically over the sampling timeframe (April 16, 2003 through August 19, 2003). Suspended sediment and bedload sediment loads were calculated in tons/year and in tons/mile^2/year. The complete dataset is included in the appendix of the report, which was obtained in electronic format.

The study was conducted to assess the impact of motorized recreation use on water quality. Sources of sediment cited in the report include streambank sloughing due to livestock grazing, a trail which parallels and crosses the stream, and a large “semi-active” landslide along the west side of Bear Canyon. At the lower sites, stormflow from roads and residences, agricultural impacts (concentrated cattle grazing), irrigation return flows, and fine textured streambanks were cited as sources of sediment. It was concluded that stream fording during motorized recreation activities and agricultural activities lead to increased sediment loads in Bear Creek.

Barndt, S., and S. Bay. 2004. Bear Creek Fish Investigations, 2003: Population and Habitat Surveys. Gallatin National Forest, Bozeman Ranger District, January 30, 2004.

This report is cited in the SCDBUD files and is reviewed briefly here. Fish populations and habitat were assessed at four sites, with sites corresponding with sites 1, 3, and 5 established during the sediment study (Story and Taylor 2004), while the forth site (LaMotte School) falling in-between sediment sites 7 and 8. Habitat measures included pools/km, mean residual pool depth, total pool area, pools as a percent of reach length, percent of unstable banks, percent of undercut banks, large woody debris/mile, and a visual estimate of substrate surface fines <2mm. This report concluded that fine sediment levels are high enough to potentially limit trout populations, through reduced spawning success or other mechanisms in Bear Creek, though they did not detect an apparent population density effect during this assessment. With the exception of site 5, trout densities in Bear Creek are comparable to or higher than other streams on the GNF.

It was noted that local geology appeared to predispose streambanks to natural instability that was easily exacerbated by even low levels of disturbance. Site 1 had the largest amounts of both unstable and undercut banks, but the unstable banks were common at the other three sites as well. At sites 1 and 3, streambanks were destabilized by localized, moderate to low cattle impacts. Additionally, a trail crossing through site 1 caused localized instability. At site 5, unstable banks were increased by channel adjustments resulting from channel modification at an old lumbermill upstream. At the LaMotte site, intensive cattle use of the riparian area locally destabilized banks, both by hoof shear and vegetation removal. As a result of these sediment sources, the amounts of surface fines <2 mm (visually estimated) in potential trout spawning areas were greater than 25%. Furthermore, these amounts were inversely related to stream energy (lowest at site 5 and highest at site 1). As with the report by Story and Taylor (2004), livestock grazing and the use/location/maintenance or roads and trails were cited as sources of sediment and factors leading to fish habitat degradation.

Story, M. 2007. Bozeman Municipal Watershed (BMW) Water Quality Issue, March 5, 2007. Gallatin National Forest, Bozeman, Montana.

This draft report section includes an analysis of the impact of “fuel treatments” in Hyalite Creek, Bozeman Creek and Leverich Creek watersheds. It indicates that the proposed actions have the potential to increase sediment and nutrient loads and presents an assessment of sediment yield to these streams. In addition, this report indicated that the Gallatin National Forest has a sediment standard of 0-26% fine substrate sediment (<6.3mm) in “A” streams (containing sensitive species and/or Blue Ribbon fisheries) and 0-30% fine sediment in “B” streams (all other streams), with a annual sediment delivery of no more than >30% of reference for “A” streams and >50% for “B” streams.

The average water yield for the Hyalite drainage at the Forest boundary is 47,000 acre feet per year. Of this, 1.8% is attributed to water yield increase due to timber harvest and roads. The Hyalite Creek watershed includes approximately 30 miles of roads (in the Gallatin NF Travel Plan), with 20 miles scheduled to be decommissioned in the next 5-10 years. Hyalite Creek is a very stable A2/A3, B3/B4, and C3/C4 steam type with boulder/cobble /gravel stream substrate with generally stable coarse textured streambanks and considerable resistance to erosion and stream channel source sediment. During 1991 and 1992, Hyalite Creek was monitored at Langor Campground and near the Forest boundary from mid-April through June to refine a pre-timber sale baseline. Suspended sediment averaged 9 and 17 mg/l (range from 0.5 to 57 mg/L), while bedload sediment averaged 0.8 and 2.4 tons/day (range from 0.0054 to 38.4 tons per day). Hyalite Creek water quality is slightly better since the 1992 monitoring since virtually no timber harvest has occurred and several miles of road have been closed and/or decommissioned.

Since Hyalite Creek is listed as impaired due to nutrients, information on grazing presented in this report was reviewed. The only grazing allotment in the BMW area is the Hyalite Canyon allotment. This allotment was put into a new management plan in 1998 (USFS, 1998). The allotment plan consolidated the Hyalite and West Hyalite Allotments, eliminated the South Cottonwood allotment, and brought the allotment into compliance with Forest Plan standards. The revised AMP includes 382 AUMs under a three-pasture rest rotation grazing system in 3 pastures (Langhor, Lick/Wildhorse, and Moser/Buckskin). A riparian exclosure fence of approximately 1/2 mile in length has been constructed to eliminate the riparian utilization issues in Lick Creek. Previous to AMP revision, Buckskin riparian grazing was been virtually eliminated with the implementation of livestock grazing best management practices and adherence to riparian utilization standards. The increased riparian buffering from the new pastures and exclusion fencing has increased sediment infiltration and has reduced water quality effects to very minor and probably un-measurable.

On Bozeman Creek, Gallatin NF monitoring indicated that annual sediment yields averaged 25.6 tons/mile^2/year from 1978 through 1980. Since that time the amount of timber harvest activity in Bozeman Creek has declined and average annual sediment yields are lower, currently estimated at 12.8 tons/mile^2/year. Current sediment yields, evaluated with the R1/R4 model, and accounting for all existing roads and harvest units, indicated that Bozeman Creek sediment yields are about 12% above a pristine baseline which is well within the Gallatin NF sediment standard for a Class A stream of 30% over natural.

Average annual water yield for the Bozeman Creek drainage is about 21,400 acre feet. Approximately 210 acre feet or about 1% of this total is increased water yield associated with the existing timber harvest units and roads. Bozeman Creek alternates between Rosgen B3 and C3 channel types in the lower reaches above and below the City of Bozeman water diversion. The riffle dominated B3 channel type has moderate entrenchment, cobble dominated 2-4% gradient. The riffle/pool C3 channel type is slightly entrenched, cobble dominated, 1-2% gradient. A few C4 channel segments occur in the upper part of the Bozeman Creek watershed. Riparian vegetation is vigorous, partially due to absence of cattle grazing. The City of Bozeman has substantial and senior water rights to Bozeman Creek. Since Mystic Lake Reservoir was breached in the early 1980's, no water storage in the drainage occurs. The City of Bozeman could increase late season water supply by construction of an impoundment for which the City has reserved storage rights with the Montana DNRC.

Story, M. 2007. Draft Chapter 3 and 4 North Bridger Grazing Allotments, March 2, 2007. Gallatin National Forest, Bozeman, Montana.

These two chapters, which are currently in draft format, describe the North Bridger grazing allotments, which are located on the northern end of the Bridger Mountain Range within the Shields River, Upper Missouri River and Gallatin River sub-basins. The information in this report specifically relevant to the Lower Gallatin TPA process is for Pass Creek, Mill Creek and Quagle Creek in the Dry Creek Watershed (Pass Creek and Lower Dry Creek 6^{th} code HUCs), which includes the Blacktail and Mill Creek grazing allotments, and North Cottonwood Creek in the North Cottonwood grazing allotment, which is in the Smith Creek 6^{th} code HUC (the NHD layer shows North Cottonwood Creek flowing into Reese Creek). The upper Dry Creek 6^{th} code HUC, which includes the Blacktail grazing allotment, was not assessed since there is not a perennial stream within the grazing allotment. The mainstem of Dry Creek is not located on National Forest lands.

Proper Functioning Condition (PFC) riparian assessments were performed at 7 sites within the Pass Creek, Lower Dry Creek, and Smith Creek 6^{th} code HUCs in 2004-2006 and stream channel assessment were performed at 6 sites. Six out of 7 sites were found to be in PFC, while the other site was rated as “functional-at-risk” with and upward trend. Rosgen stream types of A2, A3, B4 and B6 were noted. Eleven stream channel monitoring reaches were selected in the North

Bridger allotments and assessed for the first time in 2005 to monitor the effectiveness of the proposed grazing standards and to gather baseline information. Low gradient stream reaches with limited rock content were selected. These are stream channel types that are susceptible to livestock related impacts. While none of these streams are in the Dry Creek watershed or the lower Gallatin TPA, data may be useful as "regional" conditions. Measurement parameters included bankfull widths, residual pool depths, and streambed substrate particle size distributions. General discussions were presented for assessments performed in the Pass Creek (Pass Creek 6th code HUC), Mill Creek and Quagle Creek (Lower Dry Creek 6th code HUC) and North Cottonwood Creek (Smith Creek 6th code HUC).

GNF. 2006. Bangtail Mountains Road Decommissioning Project Environmental Assessment. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=projects/bangtail_mountains.

Chapter 3 of this report includes a discussion of water resources in the Bangtail Mountains, including Stone Creek, which is a tributary of Bridger Creek, and Jackson Creek. Jackson Creek and Bridger Creek are listed for nutrient impairments, while Stone Creek is listed for sediment impairments.

In the Bangtail Mountains, stream channel types are primarily A2, A3, B2, and B3 with fair to good streambank stability. Steam composition is generally gravel/cobble/small boulder with some lower gradient, finer textured depositional sections on the larger streams near the Forest Boundary (Stone Creek and Jackson Creek). Sections of lower gradient streams are affected by livestock grazing, including parts of Jackson Creek. Much of the Bangtail range was actively roaded and logged in the 1980's and up to the mid-1990's before completion of the BSL land exchange. It is estimated that timber harvest in Jackson Creek included about 1,050 acres by 1980, an additional 600 acres by 1988, and 598 acres by 1998.

Sediment yields were evaluated using the R1/R4 sediment model (Cline et.al., 1981). Total sediment yields have been measured in Stone Creek at 42.1 and 39.5 tons/mi2/year which was used to approximate a Livingston Group baseline sediment yield of 40 tons/mi2/year. There are approximately 24.5 miles of existing roads in the Jackson Creek watershed, with an estimated sediment load of 196 tons/year, which is 43% over natural. Following road decommissioning, Jackson Creek would have 14.2 miles of road and an estimated sediment yield of 171 tons/year, which is 25% over natural.

GNF. 2005. Bridger Bowl Special Use Permit and Master Development Plan Final Environmental Impact Statement. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=projects/bridger_bowl.

Chapter 3 (The Affected Environment) and Chapter 4 (Environmental Consequences) were briefly reviewed for information relevant to Bridger Creek, since Maynard Creek and Slushman's Creek within the Bridger Bowl Ski Area flow into Bridger Creek. This report noted the sediment yield to Upper Bridger Creek, Slushman Creek and Maynard Creek has been increased due to road building and timber harvest, while ski runs have increased the sediment yield to Maynard Creek. There are two impoundments within the study are, with one used for snowmaking.

GNF. 2006. Gallatin National Forest Travel Plan FEIS. Gallatin National Forest, Bozeman Ranger District, Gallatin County, Montana. Available on the Internet at: http://www.fs.fed.us/r1/gallatin/?page=/projects/travel_planning.

Chapter 3 Issue 7 (Fisheries) and Chapter 3 Issue 20 (Watershed) were reviewed for relevant information on listed stream segments. In the Fisheries section, the Travel Plan notes that annual sediment delivery for Gallatin National Forest Class A streams (30% over natural) is being exceeded in Bear Canyon and the Bangtails, though road decommissioning work is being done in the Bangtails to bring them into complains. It also notes that culverts that act as fish passage barriers have fragmented habitat, which, in some cases, has lead to the preservation of native species by preventing the immigration of non-native species. There are only 3 genetically pure populations of westslope cutthroat trout on the Gallatin National Forest. The GNF has prioritized culverts for replacement on cutthroat streams where restoring fish passage will connect cutthroat populations, while culverts barriers will be maintained in some areas to prevent immigration of non-native species.

In the Watershed section, sediment modeling was performed using erosion coefficients were developed for the five primary geological types on the GNF: hard crystalline, Tertiary volcanic, Livingston volcanic, hard sedimentary and Cretaceous sedimentary. Based on the local geology, these erosion coefficients were used to model natural sediment loads. Sediment loads were also calculated for motorized trails, non-motorized trails, trails, roads, timber and fire, and a percent over natural was presented.

McIlroy, Susan Kay. 2004. Identifying Linkages Between Aquatic Habitat, Geomorphology, and Land Use in Sourdough Creek Watershed. Montana State University Master's Thesis 125 p.

This study examined channel morphology and riparian features in the upper and lower Sourdough Creek watershed, including large woody debris frequency, pool length, substrate particle size distributions, streambank characteristics, sinuosity and riparian canopy cover. This study was used to help develop the Bozeman Watershed Council's Sourdough Creek Watershed Assessment. In the lower watershed, this study found that increased sinuosity was connected to an increase in large woody debris and pool length and recommended that land-use practices that reduce sinuosity be avoided. This study also suggested that the upper watershed may be a suitable location for the re-introduction of westslope cutthroat trout since there are barriers at the municipal diversion dam, Mystic Lake, a culvert of the South Fork and a waterfall complex on the South Fork.

Schmitz, D., S. Ammondt, M. Blank, and D.T. Patten. 2006. Using Historic Aerial Photography and Paleoflood Hydrology to Assess Long-Term Ecological Response to Two Montana Dam Removals. 10 p.

Mystic lake dam on Sourdough Creek was built in 1901 and removed in 1985. A discharge of 141-211 cfs was estimated for “overbank” flow conditions, while the 100 year flood event was estimated at 671 cfs. This study concluded that there was no change in the downstream system following the removal of Mystic Lake Dam in 1985.

Anderson, W.C. et al. 1977. Inventory of Sediment Pollution on Private Lands in the Blue Ribbons of the Big Sky APO.

This study evaluated private lands in several watersheds, including the Bozeman Creek, Bridger Creek, Camp Creek, Dry Creek, Godfrey Creek, Rocky Creek, Smith Creek and West Gallatin River watersheds using the Universal Soil Loss Equation. This report summarized the acreages under various land use practices in each of these watersheds and provided a description of the soil types. Soil erosion problems due to gullies in cropland areas and unvegetated roadside areas were cited. Road construction for subdivisions and logging was cited as a direct source of sediment pollution to streams. Stream channel assessments performed along 165.2 miles in conjunction with this study documented 16.8 miles of channel altered by straightening for roads and railroads, 12.2 miles of stream bank erosion related to livestock grazing and miscellaneous other agricultural activities, and 37.4 miles of eroding stream channel due to natural conditions.

Blue Ribbons of the Big Sky Country APO. 1977. A study in Stream Reach inventory and Channel Stability Evaluation for the Blue Ribbons APO Study Area, October 19, 1977.

This assessment used the Phankuck stream stability evaluation to assess stream stability on several streams, including Bozeman Creek, Bridger Creek, Bear Creek, Camp Creek, Cottonwood Creek, Dry Creek, Godfrey Creek, Hyalite Creek, Rocky Creek, Reese Creek, Smith Creek, Stone Creek and the East and West Gallatin River. The results of this study indicated that land use practices contribute significantly to stream conditions, particularly on alluvial fans in areas where land use practices such as agriculture are more intensive.

Story, M. 1995. 1993 Water Quality Monitoring Summary: Gallatin National Forest.

This report provided an overview of water quality monitoring results from 1993 specifically related to grazing allotments. The Lick Creek pasture of the Hyalite C&H allotment had not been grazed prior to the assessment on July 20th. While extensive growth was noted at the time of this assessment, this report recommended changing the grazing rotation to a 3 pasture system.

Biology Data

Byorth, P.A. 2000. Gallatin River Drainage Trout Population Surveys: July 1994 - June 1999, Project 3302. Montana Fish, Wildlife and Parks, Bozeman, Montana.

This report summarizes fish population trends in the East and West Gallatin Rivers between 1994 and 1999. On the West Gallatin River, monitoring conducted at the Williams Bridge Section near Gallatin Gateway indicated that rainbow trout and brown trout populations were stable based on data from 1977, 1990 and 1997. The report noted that water temperatures remain relatively cool in this section and winters are somewhat less severe than in the canyon. On the mainstem of the Gallatin River downstream of the confluence of the East and West Gallatin, monitoring was conducted at the Logan Section in 1999. Brown trout predominated along this 4.3 mile monitoring section. The East Gallatin River was assessed above (upper Hoffman) and below (lower Hoffman) the Bozeman Municipal Sewage Treatment Plant. The East Gallatin was noted to have much higher chemical productivity than the West Gallatin, resulting in higher density fish populations and faster growth rates. Monitoring between 1994 and 1998 indicated rainbow trout and brown trout populations were stable, with brown trout populations comprising 10 to 25% of the standing crop.

Development, angling pressure, and the whirling disease parasite were cited as threats to the fishery in the Gallatin watershed. Whirling disease was not detected in the Hoffman section on the East Gallatin River in 1998, though subsequent testing has indicated its presence on the East, West and mainstem Gallatin Rivers.

Weiss, T., and P. Byorth. 2000. Urban Fish Ponds Fisheries Investigations: Madison / Gallatin District, July 1994 - June 1999. Montana Fish, Wildlife and Parks, Bozeman, Montana.

This report reviewed fishery management of several ponds. It noted that Glen Lake outlets to the East Gallatin River near Manely Bridge, while Bozeman Pond also empties to the East Gallatin. Both ponds are spring fed gravel borrow pits.

Byorth, P.A., and T. Weiss. 2002. Madison - Gallatin Fisheries Annual Monitoring Report: 2001. Montana Fish, Wildlife and Parks, Bozeman, Montana.

This report summarizes fish population trends in the East and West Gallatin Rivers during 2001 and builds on the report by Byorth (2000). On the West Gallatin River, monitoring conducted at the Williams Bridge Section near Gallatin Gateway indicated that rainbow trout and brown trout populations were at or near record highs in each size group. On the East Gallatin River, which was assessed above (upper Hoffman) and below (lower Hoffman) the Bozeman Municipal Sewage Treatment Plant, population densities peaked in 1998-2000, and decreased in 2001, which the authors hypothesized was due to persistent drought. This report indicated that the combined influences irrigation withdrawals, urban development, the presence of the parasite that causes whirling disease, ***warm water temperatures*** and ***sedimentation*** appear to restrict trout populations in the mainstem of the Gallatin River downstream of the confluence of the East and West forks.

This report discussed two stream relocation projects recently completed in the Gallatin Valley and an assessment of a culvert on Camp Creek. Nash Spring Creek, which is a tributary of Sourdough Creek, was monitored a two sites to assess the effect of stream channel relocation. It was noted that the relocated reach may provide greater habitat diversity, since it was found to support the various trout species (rainbow, brown, brook) in higher numbers, while the unimpacted reach may represent a more stable "climax" fish community where brown trout out-compete other fish species. East Catron Creek, which runs through farm land that is rapidly being converted by urban development, was monitored to assess the effect of channel relocation on trout populations. The results were inconclusive, though additional monitoring was recommended. Camp Creek was assessed upstream and downstream of a culvert on Highway 84. Based on the results on recent monitoring, it was surmised that the culvert was not a barrier, though there is an 18 inch drop at the culvert outfall. It was noted that the Camp Creek basin is comprised of deep soils, which provides an abundant source of fine sediment.

This report included a brief description of Arctic grayling and Westslope Cutthroat trout populations in the Hyalite Creek watershed. Emerald Lake, at the headwaters of the East Fork Hyalite Creek, supports an Arctic grayling population. This fish were "certainly" stocked. Arctic grayling are also found in Hyalite Reservoir. Westslope cutthroat trout are restricted to a tributary of Middle (Hyalite) Creek below Hyalite Reservoir. During a conversation with FWP Fisheries Biologist Mike Vaughn, he noted that there are only two genetically pure populations of westslope Cutthroat trout in the watershed, with the second population in the West Fork of Wilson Creek. He also noted that Arctic grayling were re-introduced into the lower Gallatin, and possibly the East Gallatin, though it doesn't appear that the re-introductions were successful (Mike Vaughn, personal communication, March 27, 2007).

Byorth, P.A., and T. Weiss. 2003. Madison - Gallatin Fisheries Annual Monitoring Report: 2002. Montana Fish, Wildlife and Parks, Bozeman, Montana.

This report summarizes fish population trends in the East and West Gallatin Rivers during 2002 and builds on reports by Byorth (2000) and Byorth and Weiss (2002). This report noted that the presence of the parasite that causes whirling disease has been documented in the East Gallatin and that the intensity of infection of rainbow trout is increasing. It surmised that infection rates are likely to impact rainbow trout populations in the near future.

In 2001, the Thompson Section was re-established on the East Gallatin River. This section is between Penwell Bridge and the mouth of Trout Creek. Streamflow in the East Gallatin increases in this section due to ***groundwater inputs***. This reach was heavily impacted by channelization and agricultural practices historically. Trout densities were lower than at the Hoffman section, which is approximately 7 miles upstream. There was a lack of juvenile rainbow and brown trout and ***water quality*** was cited as a possible cause limiting reproductive success. Trout populations decreased between 2001 and 2002 on the East Gallatin, likely due to drought related conditions.

Tohtz, J., and T. Weiss. 2006. Fisheries Investigations in the Madison and Gallatin River Basins: Annual Report for 2005. Federal Aid Project F-113-R-5. Montana Fish, Wildlife and Parks, Bozeman, Montana.

This report summarizes fish population trends in the East and West Gallatin Rivers during 2005 and builds on reports by Byorth (2000) and Byorth and Weiss (2002 and 2003). One the mainstem of the Gallatin River, trout populations appeared to be stable in the Logan section. On the East Gallatin River, rainbow trout abundance has decreased since the onset of whirling disease. Continuing drought was also cited as a factor. Drought may exacerbate the whirling disease problem, since low stream flows may concentrate the *M. cerebralis* spores in less water, especially in the spring. Rainbow trout populations have decreased steadily since 1999, while Brown trout populations have remained relatively stable. It was noted that effluent discharge from the Waste Water Treatment Plant can significantly affect streamflows in the East Gallatin River during low flow periods in late summer, which have been exacerbated by drought in recent years.

Spawner counts were performed for Yellowstone cutthroat trout and Arctic grayling in Hyalite Reservoir. In 2002, the USFS added log structures to the West Fork Hyalite Creek to enhance fish habitat. The number of spawning fish of both species has increased significantly in this stream since 2003. It was noted the Yellowstone cutthroat trout are stocked annually to the reservoir. Arctic grayling have never been legally stocked and the original introduction is unexplained. The population is naturally self-sustaining at this time.

Clay, J. 1996. Godfrey Creek Periphyton Assessment.

This report summarizes periphyton data collected the West Fork Godfrey Creek, East Fork Godfrey Creek, and Godfrey Creek at Churchill on July 20th, 1995. Data indicate relatively good biological integrity on the two tributary streams, while biological integrity on the mainstem of Godfrey Creek was considered poor due to heavy siltation. However, sample notes indicate that the Godfrey Creek sample may have been stored improperly, which may have negatively affected the results.

Spawn, R. 1997. Benthic Macroinvertebrate Rapid Bioassessment of Godfrey Creek, Gallatin County, Montana 1995.

This report described Godfrey Creek as a 10-mile long spring-fed creek. This assessment included three sites: West Fork Godfrey Creek, East Fork Godfrey Creek, and Godfrey Creek at Churchill and concluded that habitat condition improved between 1989 and 1995. However, the biological condition of the benthic macroinvertebrate community was described as severely degraded. Organic pollution was suggested as a potential source of poor water quality.

Wells, J.D. 1977. 208 Fisheries Study. Submitted to Blue Ribbons of the Big Sky Country Areawide Planning Organization.

This study summarized the effect of land use practices on trout populations in Rocky Creek, as well as the relationship between stream flow and trout populations in the Gallatin River. On Rocky Creek, 1400 feet of stream was channelized by road construction in 1967 and the channelized section was found to be nearly devoid of vegetation cover. On the Gallatin River in 1976, which was the second of two high water years, a low flow of 189 cfs was recorded in early September between the Irving and Manhattan bridges. This study found that irrigation diversions between the Williams and Shedds bridges account for the majority of the diverted water. In addition, a maximum water temperature of 70ºF was documented between the Irving and Manhattan bridges.

Bridger Canyon Property Owners Association. 2001. Biological Integrity of Bridger Creek Based on Periphyton and Macroinvertebrate Community Structure. Prepared by Confluence Consulting, Inc.

This study was conducted upstream and downstream of a proposed septic drain field. Macroinvertebrate, periphyton samples were collected during three monitoring events: July 2000, December 2000, and April 2001. In general, macroinvertebrate and periphyton data indicated “good to excellent” conditions in Bridger Creek near Bridger Bowl. However, the results of this report suggest Maynard Creek is a source of nutrients to Bridger Creek. Water chemistry results remained below detection limits in most samples, except for nitrate+nitrite and Total Kjeldahl Nitrogen at station 1b in April of 2001. Note that detection limits for water chemistry samples were higher than typically employed by Montana DEQ.

Bollman. 2002. An Analysis of the Aquatic Invertebrates and Habitat of Camp Creek, Gallatin County, Montana: August 2001. Prepared for the Montana Department of Environmental Quality. Prepared by Rithron Associates, April 2002.

This report describes two macroinvertebrate samples collected from Camp Creek in 2001. Results suggested that water quality impairment limits biotic potential at both sites, potentially due to fine sediment deposition, nutrient enrichment and elevated water temperatures.

Maps/Photos

NRCS. 2001. Attachment D: East Gallatin Inventory and Assessment Data Summary.

The NRCS conducted a study of 5.4 miles of East Gallatin River comparing channel migration and riparian buffer widths using aerial photos from 1937, 1954, 1979, 1990, and 2001. Stream reach assessments were performed and bank erosion, human alterations and natural features were recorded with GPS. Out of 12 reaches assessed, 1 was rated "sustainable", 6 were rated "at-risk" and 5 were rated "not sustainable".

General Background Information

Bozeman Watershed Council. 2004. Sourdough Creek Watershed Assessment, Bozeman, Montana, 93 p.

This assessment noted that water quality in the upper Sourdough Creek watershed may be improving as logged areas recover, though there would be a high potential for sediment delivery if the area was ever affected by a sever fire. In the lower watershed, potential impacts to water quality include non-point source sediment inputs, septic systems, stormwater runoff and golf course runoff. Sourdough Creek provides the water supply for Bozeman, serving approximately 28,000 people. This assessment included the collection of general stream reach characteristics and a fish habitat assessment along 14 reaches of Sourdough Creek.

Selected Communications during Data Inventory Efforts

March 27th – April 16th, 2007

MFWP

Mike Vaughn, Fisheries Biologist, MFWP, 994-4042, 3/27

> Joel Tohtz was former biologist for the area and Pat Byorth before that. Could not find a reference reach on Camp Creek during recent reconnaissance. Spring creek restoration and bank stabilization activities are occurring on private lands. Grayling were re-introduced to the lower Gallatin (and possibly East Gallatin), but it doesn't appear to be successful. Historically, the Gallatin watershed was a westslope Cutthroat trout fishery. Only two pure strands of WCT remain in the watershed, with one on the West Fork Wilson Creek above some sort of barrier. Whitefish in Lower/East Gallatin appear to have been impacted by whirling disease, as are rainbow trout. The East Gallatin fishery is trending towards a brown trout fishery. Potentially too few trout on main Gallatin River between Manhattan and Logan to make accurate population estimate. The river is dumping its bedload as it comes out of the canyon, leading to a shift channel.

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DNRC

Scott Compton, DNRC Regional Office, 556-4503, scompton@mt.gov, 4/2, 4/10 and 4/11

> Has been measuring streamflow and temperature on West Gallatin River at several headgates with the water commissioner in cooperation with the Association of Gallatin Agricultural Irrigators (AGAI) between Sheds Bridge and Belgrade. Reported that there are enough water rights to de-water the river at Belgrade, but the irrigators are interested in maintaining some streamflow and the only flows there are maintained though voluntary donations.

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DNRC

Tom Hughes, DNRC State Lands, thughes@mt.gov, 4/5

> "I don't have any data that we have collected other that a wetland delineation that I did. I did an evaluation of the creek to determine our options for restoration but have not recorded anything. Revegetation is really all we plan to do to narrow the channel width so that sediment will flush through the reach on the state tract. If a fishery could be established, we may consider cutting off a long meander loop to increase the overall gradient of the stream to flush sediment more efficiently. I did not see any fish barriers at the interstate and highway culverts. I have antidotal information that years ago a trout fishery existed. Let me know if you have any questions."

City of Bozeman

Dustin Johnson, City of Bozeman Engineer, Bozeman stormwater plan, 582-2280, 3/30

> The City of Bozeman is currently working on Phase II Stormwater Compliance. This is the second year and they will be monitoring 2-4 locations annually during 1 storm event from now on. The permit from the DEQ is for 5 years and they need to provide an annual report. One water quality monitoring site is on Rouse and discharges into Bozeman Creek. There are several subdivisions built prior to 1980 that have stormwater issues, while newer subdivisions have to meet more stringent requirements. As part of master plan, the city also plans to identify flood concerns, including the Farmers Canal. The Master Plan will be posted online when it is completed. Have added modified inlets to a pipe at the corner of Rouse and Main to trap runoff contaminants. Plan to be labeling storm drains to indicate water flows to Bozeman Creek. Pipes from the roofs on downtown buildings (Baxter) discharge rainwater directly into Bozeman Creek.

City of Bozeman

Tom Adams, superintendent, City of Bozeman Waste Water Treatment Plant, 586-9159, Tadams@Bozeman.net, 4/4 and 4/6

> 4/4: Are currently in the process of building a new facility that will be a switch from chlorination disinfection to UV disinfection. It will be completed in late 2009 or early 2010. They have been a partner with the USGS for the gage on the East Gallatin located just upstream of the plant and have been monitoring flow for the past 4-5 years. Discharge from the plant fluctuates all the time, falling when the ~11,000 MSU students leave for the summer. They don't have any storage capacity and discharge averages 5 million gallons per day, with a plant capacity of 5.8 million gallons per day. In their permit, there are caps for pathogens and other inputs, but not nutrients.
>
> 4/6: When East Gallatin hits low flows of 15-17 cfs (15 million gallons/day) in August of drought years, the effluent discharge is a substantial portion ("a third") of the total flow, coming out at 5 million gallons per day (~7.5 cfs). Once the BNR plant comes online in 2010, the nutrient load from the plant will greatly decrease. Currently monitoring nutrients in the outfall as part of their permit, though there is not a concentration cap. Will provide nutrient and flow data at the outfall for the past 2 years. Future monitoring strategies should consider that the nutrient load from the plant will be going down in 2010.

NRCS

Tom Pick, NRCS Water Quality Specialist, State Office, 587-6947, 4/16

> Indicated that the NRCS is not involved in water quality monitoring. They do PFC assessments with landowners enrolled in conservation/implementation programs, but this information is considered confidential under the 2002 Farm Act. In the past, many cars have been pulled out of the East Gallatin. The channel may still be adjusting to flooding in the 1980's and is somewhat incised, with high scarps downstream of Belgrade. The East Gallatin also gets "murky" easily. When the riparian buffer is removed, the silt loam soils on top of gravels make for naturally unstable banks. Reported that they did a study in the 1989-90 time-period where they walked the entire East Gallatin and mapped riprap/car bodies, culverts, and headgates. Have been working with diaries to get fences along streams. Reported that Godfrey, Yellowdog and Camp Creeks were the areas of high dairy concentration historically. Noted that weeds are a problem and that the spraying of weeds negatively effects woody vegetation regeneration. Willows would naturally comprise the East Gallatin River corridor. Also noted that deer browse of woody vegetation in the Gallatin Valley is very high and can reduce woody vegetation development (up to a certain age). The NRCS is involved with some conservation easements with the GVLT and with the Wetland Reserve Program. Also noted that the trend in irrigation in the valley is to place ditch water in pipes and to use sprinkler irrigation.

NRCS

Wendy Williams, NRCS Field Office, 522-4000, 4/12

> Did a study of 5.4 miles of East Gallatin River comparing aerial photos from 1937, 1954, 1979, 1990, and 2001. Have orthorectified historic photos and infrared imagery. Digitized streams and riparian buffer and mapped channel migration and loss of riparian vegetation. Also mapped erosion, human alterations, and natural features. Report is available online at http://gallatincd.mt.nacdnet.org/.

Gallatin CD

Marcie Murnion-Learn, 522-4011, 4/5

> Reported there is an electronic map of stream and ditch network that is currently under review and it will be available on the website once it is finalized. It has perennial streams (river, stream, springs) and ditches.

GNF

Mark Story, Hydrologist GNF, 522-8573, mtstory@fs.fed.us, 4/5

> The GNF has mostly collected streamflow, suspended sediment and bedload data, along with performing some sediment modeling.

GNF

Bruce Roberts, Fisheries Biologist, GNF, broberts@fs.fed.us, 522-2544, 4/5

> Reported westslope cutthroat trout populations in Wildhorse Creek (tributary of Hyalite Creek), West Fork Wilson Creek, and a population of a "handful" of fish discovered in Leverich Creek in 2006. Indicated most data was in hard copy format. There is some McNeil core sample data, but he didn't collect any of it. Indicated that there is some fishery data in the Sourdough Creek Watershed Assessment report.

MSU

Chris Guy, USGS-BRD, Cooperative Fishery Unit, MSU, 994-3491, cguy@montana.edu, 4/5

> "I take the Fisheries Management Class out on Bridger Creek each fall. I have three years of fish and habitat data."

MSU

Dan Gustafson, 994-2771, aquatic ecologist, dlg@rapid.msu.montana.edu, 4/1

> "I have hundreds of samples from the Gallatin drainage from the early 1980's up to yesterday (*Capnia confusa* and *Taenionema pacificum* were emerging in numbers from the Lower Gallatin, the East Gallatin is no longer suitable for most stonefiles). My samples are not computerized and I am not prepared to do much with them at this time. It should be pretty obvious that most Gallatin drainage streams start out in very good shape and get degraded more or less heading downstream. Mud and manure loading and water withdraw are the most frequent problems I see. For me, the most interesting faunal change beyond the lost of sensitive species is the addition of some lowland species- with enough mud, warming and regulation our local trout streams become suitable for many species that normally occur only far downstream. Insects can make this jump on there own, while other aquatic creatures need to be transported by humans."

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