MUDDY CREEK THE FULL STORY





1936

1960s



1990s

Compiled for Greenfields Irrigation District By Alan Rollo, Great Falls, Montana January 31, 2020

Page 1 of 5

ACKNOWLEDGEMENTS

This document was produced and funded at the request of the Greenfields Irrigation District. The data contained in this document was obtained from <u>many</u> other studies; documents; Muddy Creek Task Force meeting minutes; correspondence and personal information. The primary document used for the older information was the November 1979 "Muddy Creek Special Water Quality Report" compiled by Systems Technology, Inc. 1 tried very hard to ensure all information included in this document is factual but if some material is found not to be accurate, please contact me immediately.

To be clear about the Muddy Creek story, the origins of the severe Muddy Creek erosion problem <u>did not</u> occur overnight and the reasons for the erosion were the product of many. That is why this document <u>should not</u> be used to place the blame for the erosion problem on anyone or any group. So when looking for real long-term solutions, realize it will take time and lots of hard work through a team approach.

Both the Muddy Creek Task Forces (MCTF) formed, one in the 1980s and the other in the 1990s, accomplished many great projects – through very different approaches. Each MCTF was comprised of many hard-working groups and individuals with the sole purpose of finding reasonable cooperative solutions to this major erosion problem. Although the reduction of sediment from Muddy Creek may not be completely resolved, the collaborative efforts to-date are commendable. And that hard work has actually made a difference with a documented reduction of sediment by 80% towards the goal of a healthy stream.

TABLE OF CONTENTS

1.0	Muddy Creek Introduction	4
2.0	Muddy Creek Sequential Historical Summary	6
3.0	Muddy Creek History – Ice age to 1960s	7
4.0	Muddy Creek 1970s Studies Phase	12
5.0	Muddy Creek 1980s More Studies and Action Phase	17
6.0	Muddy Creek 1990s Second Call for Actions Phase	26
7.0	Muddy Creek 2000s Continued Projects Phase	41
8.0	Sun River & Muddy Creek Watershed maps	51
9.0	Muddy Creek – Other Key Documents	57
10.0	Muddy Creek Pictorial History	66
11.0	Muddy Creek Referenced Documents	80

---- LIST OF FIGURES ----

Figure 1	Sun River Watershed with Muddy Creek location map	51
Figure 2	Muddy Creek Watershed topo map	52
Figure 3	Muddy Creek Watershed aerial map	52
Figure 4	Muddy Creek Watershed aerial map with GID boundary	53
Figure 5	Muddy Creek Watershed worst eroding reach aerial map	53
Figure 6	Muddy Creek Watershed projects location map	54
Figure 7	Reach #1 Grade Control pictures to projects location map	55
Figure 8-13	Left out intentionally – for future use	
Figure 14	Fairfield Bench Geology	61
Figure 15	Groundwater Flow Direction	62
Figure 16	Barb Design	63
Figure 17	Ramp Design	64

--- LIST OF TABLES ----

Chart 1.	Flow Data for Muddy Creek Project	58
Chart 2.	Sediment Data for Muddy Creek Project	59
Chart 3.	USGS Muddy Creek at Vaughn Peak Flow Chart	60

--- LIST OF CHARTS ----

Table 1.	1980s Cash and In-Kind Allocation to the Muddy Creek Project	25
Table 2.	1990s Cash and In-Kind Allocation to the Muddy Creek Project	40
Table 3.	2000s Cash and In-Kind Allocation to the Muddy Creek Project	50
Table 4.	Summary of Cash and In-Kind Allocation to the Muddy Creek Project	65

Muddy Creek

MUDDY CREEK BASIC FACTS: Muddy Creek is a tributary of the Sun River in the Upper Missouri River Basin, with the Creek drainage headwaters east and north of Freezout Lake. The Creek flows 42 miles generally eastward to Power, then turns south until it joins the Sun River at Vaughn, 15 miles upstream from the Sun-Missouri confluence at Great Falls, Montana. The Creek travels through Teton and Cascade Counties draining approximately 314 square miles (200,000 acres) of agricultural land which has been developed since the early 1920's from rangeland and dryland farming into primarily irrigated cropland. There are five major tributaries flowing into Muddy Creek and when all combined total more than 30 miles of streams that flow into Muddy Creek. The elevation goes from 3,880 feet to 3,350 feet at its mouth for an overall slope of 13 feet per mile. Precipitation averages 11-12 inches per year with 80% of the yearly precipitation falling between April to September. Mid-summer thunderstorms can produce intense runoff that causes major erosion to occur. The highly erodible soils in this area, deposited during the glacial era, is a noteworthy reason there is an erosion problem in this drainage.

MUDDY CREEK EVOLUTION:



After the 1936 Muddy Creek picture shown on the left, early land use changes included aggressive grazing and irrigation along the Creek banks. Those were the first human caused negative impacts to this small stream. Additional erosion problems started to occur after Reclamation developed the GID, when significant amounts of tailwater entered the Creek. The results from all causes were devastating as shown in the picture to the right.



Greenfields Irrigation District (GID), adjacent to and west of the Creek, now supports approximately 83,000 irrigated acres of which 51,000 acres are in the Muddy Creek watershed. Irrigation return flows increased the annual flow of the Creek by a factor of ten, from the original yearly flow of 10,000 acre-feet to approximately 100,000 acre-feet. The increased flows in the Creek contributed to the extensive erosion of the fine-grained alluvium and at times annually transported over 200,000 tons of sediment into the Sun River. Approximately 80 percent of the Sun River's sediment load comes from the Creek which makes up only 17 percent of the Sun River watershed. Due to the bank movement, several acres of farmland adjacent to the Creek were lost every year. This sediment load transported by the Creek have severely impacted water quality in both the Sun and Missouri Rivers in the Great Falls area.



Over time, the Muddy Creek erosion has caused significant controversy and had become a way of life in the basin - with battle lines drawn over the cause, what fixes should be made, and who should pay for the fixes. Even with the significant irrigation improvements accomplished in the 1980s reducing the amount of tail water entering Muddy Creek, the huge amounts of sediment continued to leave the area. Then in the 1990s the real "tug-of-war" radically changed when the second Muddy Creek Task Force (MCTF) was organized bringing the conflicting parties into a group, working as a team to voluntarily resolve one of the worst nonpoint source pollution problems in Montana. The group ascertained innovative and proactive ways to tackle a problem that had stagnated for many years.



After just a few years of hard work in the 1990s, there were many successes with the Muddy Creek project, through collaboration skills and new techniques. This teamwork resulted in an 80% reduction of sediment from Muddy Creek into the Sun River. This document will describe how these changes took place over time.



MAPS DEPICTING DRAINAGE LOCATIONS



Location of Muddy Creek Watershed within the Sun River Watershed

Muddy Creek SEQUENTIAL HISTORICAL SUMMARY

The following summary helps lay out the general sequence of events used in this document to tell the Muddy Creek story.

<u>MUDDY CREEK BEGINNING</u>: In "glacial days" this area was under Lake Great Falls. So, when the lake drained, a very deep sediment deposition/erosive soils was left behind. When the early settlers reached this area, there was very little erosion because Muddy Creek only flowed in response to precipitation events - not the problem it has become today. These early settlers started changing how Muddy Creek was used which was an early contribution to the erosion problem. Early 1900s, Reclamation started developing Greenfields Irrigation District (GID). When local landowners opposed parts of the project, GID was scaled back leaving extra irrigation "tail-water" to be dumped into the Muddy Creek drainage. By the 1960s, Muddy Creek had become a huge issue for local landowners and water quality in the Sun and Missouri Rivers.

<u>1970s ~ STUDIES PHASE</u>: The 1970s was considered the study phase as lots of work went into evaluation of the Muddy Creek erosion problem, causes and best solutions on how to reduce the sediment loads entering Sun and Missouri Rivers. Most of those ideas were VERY expensive and would have had limited benefits. So even though there was a strong desire by many hard-working people to implement some or all of the proposed plans - no on-the-ground projects were accomplished during this period.

<u>1980s CALL FOR ACTION PHASE and MORE STUDIES</u>: In 1979 a Muddy Creek Task Force (MCTF) was organized by Teton and Cascade Conservation Districts to dust off previous options and consider any new possibilities to control erosion. During this timeframe, there was several irrigation water management projects installed including GID's Rehabilitation & Betterment (R&B) program but no instream work. Those irrigation projects did help reduce total amount of tail-water entering Muddy Creek but it was not enough to measurably reduce the erosion.

<u>1990s SECOND CALL FOR ACTION PHASE</u>: Since the 1980s attempts to slow the erosion had limited success, in 1992 the local landowners requested help from State of Montana. A new MCTF was established in 1992 as a means of discussing how the erosion problem could be resolved. The MCTF pursued funds to hire a coordinator and look into "out-of-box" solutions that all parties could get behind. The palatable solution had to be financially feasible and measurably reduce erosion. The group began to implement an action plan in 1993. Team work over the next ten years reduced the annual sediment load into the Sun River from average 200,000 tons per year to 27,000 tons – an 80% reduction.

<u>2000s CONTNUED ACTIONS PHASE</u>: After the huge success of erosion reduction in the 1990s, the MCTF found it almost impossible to acquire the necessary funds to continue with the instream erosion control projects. So, the group focused on acquiring funds to install water management projects to help reduce flows into Muddy Creek. These water management projects have proven to be beneficial but not with great results as what was hoped for. Now in 2020, the Sun River Watershed Group (SRWG) continues to pursue funds for Muddy Creek erosion control projects using a multiprong approach through instream projects and water management.

Muddy Creek HISTORY – Ice Age through 1960s

NOTE: Other than data with specific references, this chapter of the report used "Muddy Creek Special Water Quality Project" compiled by Systems Technology, Inc., November 1979.

Early Days - Did Muddy Creek always look like it does today? Isn't that why it is called Muddy Creek? To answer those questions and many more we need to go back as far as the ice age when the face of earth dramatically changed. First point to understand about the Muddy Creek drainage is that in "glacial days" this area was under "Lake Great Falls". When the lake drained, a very deep fine-grained alluvium sediment deposition was left behind as described in *"Geology of the Vaughn Quadrangle, Montana";* USGS, 1961. Also, it was presumed that this Creek contributed some sediment to the Sun River – but it was insignificant because the stream went dry after spring runoff.

1805 - On June 14, 1805 Lewis writes in his journal he had reached the Sun River which was a handsome stream with its waters clear. <u>*"The Journals of Lewis and Clark – 1804-1806"*; Meriwether Lewis and William Clark, 1804-1806. With the Sun River running so clear, it was likely that Muddy Creek did not contribute the sediment loads it does today.</u>

Late 1800s – The book <u>"Boots and Shovels – A History of the Greenfields Irrigation District, Division of the Sun River</u> <u>Project, Fairfield, Montana"</u>; The Fairfield Sun Time, 1978 describes a history of the area. It noted that the early settlers could not rely upon Muddy Creek as a source of water since it dried up in late summer and drought years.

1889 – <u>USGS surveyed Sun River drainage</u> identifying lands rich for irrigation, 10 possible reservoir sites, and 3 canal lines. Three identified reservoir sites were built for today's Greenfields Irrigation District (GID). A Benton Lake site was also surveyed to be supplied with Sun River water. <u>*"Eleventh Annual Report of the USGS – 1889-1890 – Part II – Irrigation"*; USGS, 1891.</u>

1890 – <u>Great Falls/Canada Railroad and Great</u> <u>Northern Railway installation</u> included lines along Muddy Creek as shown in these railroad maps. The web site <u>"Montana Museum of</u> <u>Railroad History"</u> is an excellent source of data and maps that describes railroads in detail.

Maps downloaded from Railroad of Montana, Dale Jones ightarrow

<u>Muddy Creek segments were straightened</u> to simplify construction while building the railroad. The aerial view shown in right picture illustrates one of the sites where the-"railroad" moved Muddy Creek. With low flows during that timeframe, this channel change probably was not an issue. But when the flows became dramatically higher, the straightened channels became a problem as Muddy Creek tried to meander.







1903 – Charles Fitch of the United States Reclamation Service conducted Reclamation's first reconnaissance of this region. Surveyor, Fitch estimated that almost 395,000 acres of land could be irrigated in this region. <u>*"Sun River"*</u> **Project"**; Bureau of Reclamation, Robert Autobee, 1995.

1903-1906 – <u>Reclamation evaluated several reservoir</u> and canal options that included Benton Lake and Muddy Creek areas. <u>*"Sun River Project"*</u>; Bureau of Reclamation, Robert Autobee, 1995.

1906 - <u>Reclamation was given authorization by Congress to develop the Sun River Project</u> which included the Greenfields Division. From 1913 to 1936, work took place on the Greenfields Division's distribution system. First water was delivered in 1920. The Division's drainage system was completed in 1958. <u>"Sun River Project"</u>; Bureau of <u>Reclamation, Robert Autobee, 1995.</u>

1900s reference to early proposed irrigation by USGS and BoR are in the <u>"Water Resources Survey – Cascade County,</u> <u>Montana"</u>; State Engineers Office, June 1961. It describes this area's early proposed irrigation stating:

The initial irrigation system provided for the storage of Sun River water at Gibson Dam, the Willow Creek Reservoir on Willow Creek, Pishkun Reservoir north of the Sun River, Muddy Creek Reservoir on Muddy Creek near Power and Benton Lake Reservoir eight miles north of Great Falls. The lands to be irrigated, in addition to the present Greenfields District, were east of the District along the Sun River and the Teton River area to the north. Later opposition developed from the homesteaders on dry-land farms and all of the plan, except the Greenfields District, was given up. The withdrawn lands were restored to public entry. With the reduction in acreage, the use of Muddy Creek Reservoir and Benton Lake Reservoir was abandoned.

1914 – <u>Milwaukee railroad contractor installing bridge</u> across Muddy Creek near Vaughn runs into trouble when designs call for 13 feet depth for bridge pilings but due to "dirt conditions" have to double that depth. <u>*"A Pictorial History of the Sun River Valley"*</u>; Sun River Valley Historical Society, February 1989; pages 56-57.

1914-1916 – <u>Local landowners adamantly opposed</u> being added to the Greenfields Division. <u>"Sun River Project";</u> <u>Bureau of Reclamation, Robert Autobee, 1995.</u> With scaling back the irrigation project, the Muddy Creek Reservoir near Power and additional irrigated lands were eliminated. This modification is a possible reason why excess water now enters Muddy Creek from Greenfields Irrigation District (GID).

1925 - <u>Muddy Creek, 1925</u>. Photo courtesy of Charles Penwell of brush and foliage along Muddy Creek can be found in <u>"A Pictorial History of the Sun River Valley";</u> Sun <u>River Valley Historical Society, February 1989</u>. The book goes on to say there were many diamond willows, basket willows, dogwood willows, yellow currents, buffalo berries, wild roses and some cottonwood trees.

1930s – <u>Muddy Creek, 1936</u>. Photo courtesy of Joyce Wohgelmuth. As landowners started settling along Muddy Creek, lush riparian vegetation and willows were removed as shown in lower right photo. This allowed for heavy livestock use of the riparian corridor to forage for grass and get water. The next not so wise move was landowners started irrigating along the highly erodible creek banks which really increased erosion as shown in photo lower right. Below chart estimates early Muddy Creek flows - approximately 30 cfs in spring, going dry in fall so sediment contributions into the Sun River were minimal.







1930s - <u>Sun River Valley Ditch Company</u> (SRVDC) that was constructed in 1868 to supply water to a flour mill on Mill Coulee was extended and enlarged in following years to include other farms down the valley. This ditch was then allowed to drain into Muddy Creek just north of Vaughn. <u>*"Water Resources Survey – Cascade County, Montana";*</u> <u>State Engineers Office, June 1961.</u>



Also playing a role in the Muddy Creek erosion is the excess tailwater from the SRVDC. When the ditch was expanded it also intercepted many drainages, with all of its runoff emptying into Muddy Creek just north of Vaughn.





1942 – <u>"Reconnaissance Report on Sun River Basin – Sub-</u> Basin Report No. 13"; Bureau of Reclamation, June 1942. REPORT HIGHLIGHT – This report was a thorough evaluation of where/if additional storage and irrigated lands was possible in the Sun River Basin. The report describes the flows of Muddy Creek is made up almost entirely of return flow and waste from the GID. It goes on to state that the return flow in Muddy Creek has been increasing constantly in the past few years. It describes the Muddy Creek Reservoir site that was proposed near Power but will probably not be utilized because no land was classed as arable.



1946 - <u>Missouri River water quality survey</u> (NO COPY FOUND) referenced in the <u>*"Pollution Studies of the Missouri River*</u> *in the Great Falls Area"*, Montana State Board of Health Report, November 26, 1957.

1953, June 4 – <u>Muddy Creek flows reached 7,600 cfs at Vaughn</u> with what was considered a 100-year flood event as documented by USGS. <u>*"USGS Annual Peak Streamflow for Station 06088500";* USGS, June 30, 1997</u>. REPORT HIGHLIGHT: USGS report on maximum annual flows at stream gage at Muddy Creek at Vaughn from 1925 – 1996.

1956 - <u>"Reconnaissance Report – Sun-Teton Division"</u>; Bureau of Reclamation, March 1956. REPORT HIGHLIGHT – This report was a follow-up evaluation of where/if additional storage and irrigated lands was possible in the Sun and Teton River Basins. The Power area projects were dismissed because soils were considered non-irrigable, dispersion of arable tracts and high per-acre cost to develop.

1957 – <u>"Pollution Studies of the Missouri River in the Great Falls Area"</u>, Montana State Board of Health Report, <u>November 26, 1957</u>. REPORT HIGHLIGHT - This investigation primarily focused on obtaining data on the water quality in the Missouri River downstream of Great Falls. The report also documented conditions of the Sun River right before entering the Missouri River with heavy turbidity levels that render the Sun River practically void of plant and animal life.

1958 - <u>"Memorandum of Understanding between the Bureau of Sport Fisheries & Wildlife and the Bureau of</u> **Reclamation"**; April 28, 1958. REPORT HIGHLIGHT: Agreement to allow use of Muddy Creek water for Benton Lake.

1960s - As GID grew to current size of over 83,000 acres so did the number of irrigated acres that drained into Muddy Creek. By the 1960s, approximately 50,000 of the 83,000 plus irrigated acres drained into Muddy Creek. This excess water increased the Muddy Creek flows by tenfold reaching approximately 90,000 acre-feet annually. There was a short period when Muddy Creek flows reached 600 cfs.





In the 1960's, the erosion reached its worst levels, with lateral migration moving large amounts of sediment downstream into the Sun and Missouri Rivers. This extra water in Muddy Creek began to change its characteristics. This also meant many productive privately-owned acres eroded into the Sun River. The State of Montana now considered Muddy Creek one of its worst non-point source pollution problems in the state. The problem had become such a significant issue that area landowners were demanding action.









1961 – <u>"Geology of the Vaughn Quadrangle, Montana"; USGS, 1961.</u> REPORT HIGHLIGHT: Geology for this region including Muddy Creek soils. Glacial lake deposit and reworked glacial lake deposit (Holocene and Pleistocene) — Grayish-brown, yellowish-brown, and pale orange silt interbedded with very fine-grained sand and clay. Lake deposits are horizontally bedded and may be laminated. Unit also contains grayishorange, yellowish-brown, and pale orange silt and colluvial deposits reworked from glacial lake deposits, chiefly as sheetwash alluvium, and fine-grained deltaic deposits along Muddy Creek. Most of the unit represents deposits of Glacial Lake Great Falls.

1961 - *"Water Resources Survey – Cascade County, Montana";* State Engineers Office, June 1961. Summary of irrigated lands in Cascade County, Montana including Greenfields Irrigation District.

1962 - <u>"Water Resources Survey – Teton County, Montana"</u>; State Engineers Office, June 1962. Summary of irrigated lands in Teton County, Montana including Greenfields Irrigation District.

1966 - *"Water Quality Control Study – Sun-Teton Unit, Montana*; Federal Water Pollution Control Administration, July, <u>1966</u>. REPORT HIGHLIGHT: Bureau of Reclamation requested the Federal Water Pollution Control Administration participate with planning for possible construction of three more dams on the Sun River. The study concluded the most practical solution to the major turbidity problem is to improve irrigation practices and initiate other methods of soil conservation to keep soil erosion to a minimum.

1967 – <u>"Muddy Creek Study"</u>, Bureau of Reclamation, 1967. REPORT HIGHLIGHT: Investigation primarily focused on obtaining estimates of salt pick-up from the irrigated bench lands. It also provided some flow data and field observations of sediment problems which identified the extremely high flows of irrigation return waters accompanied with rain storm event water was contributing to the Muddy Creek sediment problem.

End of reports and data for 1960s.

Beginning - GRANTS and IN-KIND PROJECTS FUNDING

WHEN (FY)	GRANT PROJECT and SPONSOR	GRANT AMOUNT	IN-KIND MATCH	FISCAL AGENT	PROJECT PURPOSE
UNKNOWN					

Muddy Creek 1970s STUDIES PHASE

NOTE: Starting in the 1970s, Muddy Creek publicity grew as the erosion increased to became one of Montana's worse non-point source pollution problems - contributing huge amounts of sediment into the Sun and Missouri Rivers. The following highlights the studies and activities during that period:

1970 – <u>"Sun River Sediment Problem"</u>, Bureau of Reclamation, 1970. REPORT HIGHLIGHT: This study generally describes the problems of erosion in the Muddy Creek channel. It identifies the lower reach from Gordan to Vaughn as in serious condition. It states the need of a preliminary investigation to determine possible corrective measures.

1972 - <u>"Water Pollution Control in Cascade County"</u>, Montana Department of Health and Environmental Sciences, <u>December 1972</u>. REPORT HIGHLIGHT: Although majority of the report focused on classification of streams and sewage discharges it does reference effects of farming practices on water quality have only been determined in one area which was Greenfields Bench irrigation project which returns water to Muddy Creek. It states "immediate action is needed to prevent further erosion by the creek and subsequent degradation of Sun River water quality by turbidity and sediment".

1972 – <u>*"Muddy Creek: A Pollution Study"*</u>, Proceedings of the Montana Academy of Sciences 32: 58-65, Eugene Johnson. SUMMARY: Purpose of this study was to investigate the extremely silt laden stream, Muddy Creek, at Vaughn, Montana, along with the detrimental effect it produces in the Sun River and the Missouri River.

1974 – <u>*"Information on Muddy Creek Erosion Problem"*</u> Sun-Teton Division; Pick-Sloan Missouri River Program; Montana; April 1974. REPORT INTRODUCTION: The purpose of this information summary is to present information pertaining to and resulting from an appraisal study of possible solutions to the silt-deposition problem from Muddy Creek into the Sun River. The information contained herein represents a summary of the findings to date, recognizing the fact that many problems remain to be solved. The investigation leading to this summary were conducted under various ongoing programs as workloads and funding permitted. Muddy Creek Dam and Reservoir site, a principal feature of the study, was first considered in a sub-basin report dated June 1942, which covered the Missouri River area above Great Falls.



1974 - <u>"Water Quality Inventory and Management Plan - Missouri-Sun-Smith River Basin, Montana"; Water</u>

<u>Quality Bureau, Environmental Sciences Division, Montana Department of Health and Environmental Sciences;</u> <u>August 1974</u>. REPORT INTRODUCTION: Report presents information relative to the water quality and water quality inventory and management in the Missouri-Sun-Smith basin. It identifies Muddy Creek as the cause of water quality issues in the Sun and Missouri Rivers "because of high sediment loads due principally to poor irrigation practices in the Muddy Creek drainage".

1975 – <u>"Montana Water Resources Development";</u> Corps of Engineers, 1975 describes the results/damages of the 1964 flood as a reason to relocate the Muddy Creek channel near Vaughn and construction of a levee.

1976 – <u>"Water Quantity and Quality of the Sun River from Gibson Dam to</u> Vaughn, 1973-1974"; Montana Department of Fish and Game; May 5, 1976. INTRODUCTION: Study of the Sun River from Gibson Dam to Vaughn was conducted from April to September 1973 and from April to October, 1974. The report identifies the need to control return flows into Muddy Creek as primary tool to reduce erosion.



1976 – "Proposed Rehabilitation and Betterment Program for Greenfields Irrigation District", Bureau of

<u>Reclamation, June 1976</u>. REPORT HIGHLIGHT: As a result of past studies conducted by the Bureau of Reclamation, an R&B program for GID is proposed which includes the lining of approximately 4.7 miles of main canals and 131.4 miles of laterals; the replacement of approximately 5 miles of open laterals with closed conduit; the installation of automatic control and telemetric equipment for control of water at Gibson and Pishkun Dams and at strategic points on the irrigation system; and the repair, updating, and replacing of various structures and measuring devices. Diagram below shows some of the proposed projects on GID that would benefit Muddy Creek.



1977 – "Montana Water Quality Bibliography 1974 – Summer 1977"; Statewide 208 Planning; Montana Department of Health and Environmental Sciences; 1977. INTRODUCTION: This work updates information about water quality in Montana to mid-1977. Also stated that Muddy Creek is clearly, major problem of concern as a contributor of high sediment loads entering the lower Sun River. **1978** – <u>"Corps Supplemental Environmental Statement"</u>; Sun River Flood Protection Project, Great Falls, Montana; U.S. Army Engineer District; January 1978. HIGHLIGHT: Primary purpose of the environmental review was to consider a levee in the Great Falls area to address public concern of the 1975 flood impacts. The report also discusses fisheries impacts because of the heavy silt load entering the Sun River from Muddy Creek.

1978 – <u>"Statewide Water Quality Management Plan"</u>; Statewide 208 Water Quality Management Planning Project; Montana Department of Health and Environmental Sciences; 1978. BACKGROUND: Plan identifies significant sources of water pollutants in each state. It states Muddy Creek as one of the major nonpoint source problems in the entire statewide area.

1978 – <u>"Enterprise Costs for Irrigated Crops – Fairfield Bench in Teton County"</u>; Cooperative Extension Service, <u>February 1978.</u> The report was a summary of production inputs to produce irrigated crops. This study was part of a larger irrigation water management project on the Fairfield Bench.

1978 – <u>Muddy Creek Landowners' Association formed</u> by 30 landowners frustrated over continued loss of farmland along Muddy Creek.

1979 – "Biological Conditions of the Sun River and Muddy Creek", Montana Department of Health and

Environmental Sciences; 1979. The study revealed large concentrations of algal nutrients (nitrogen and phosphorus) in the Sun and Muddy waters.





1979 - <u>Muddy Creek Task Force</u> was organized by Teton and Cascade Conservation Districts. First order of business was to compile useful historic data and identify viable options to resolve the Muddy Creek erosion problem.



The MCTF supported Cascade and Teton Conservation Districts to contract Systems Technology, Inc for \$5,570 to accomplish the Muddy Creek study.

1979 – <u>*"Muddy Creek Special Water Quality Project"*; Systems Technology, Inc; November 1979</u>. Teton and Cascade Conservation Districts hired Systems Technology to complete a report of relevant Muddy Creek data and provide recommended solutions to the erosion problem. The report solutions were as follows:



1. <u>On-Farm Management</u> - of improved water and stream corridor management, and increased ASCS cost-sharing and SCS technical assistance. This included more efficient water use systems, stream riprap and minimum use streambank corridors.

2. <u>Surplus Canal Water Diversion</u> - excess canal water could be diverted into Freezeout Lake as a surge system.

 <u>Muddy Creek Stabilization</u> - using proven erosion control measures such as, riparian vegetation protection, tree plantings, riprap, and rock drops.

4. <u>Interceptor Canal</u> - to parallel the Creek and intercept Fairfield Bench irrigation return flows. Such a canal would be constructed on the west side of Muddy Creek and be 14 miles long.

5. <u>Greenfields Irrigation District</u> - modifications to the present water delivery system in automating reservoir water releases and measuring each field delivery as well as hydroelectric generation on canals.

6. <u>Educational Program</u> - involving local residents and farmers and promoting participation of federal and state agencies.

7. <u>Funding Search</u> - pursuing state and federal funding sources for both on-farm and stream protection measures.





1979, November 7 – Montana Association of Conservation Districts (MACD) passes resolution at their annual meeting supporting the pursuit of collaboration and federal funding for the Muddy Creek project.

1979 – <u>*"Muddy Creek Property Owner Affects from Sediment Waters"*; Unknown author, December 6, 1979. REPORT HIGHLIGHT: Summarizes financial impacts to landowners that live along Muddy Creek.</u>

1979 – <u>"Evaluation of Channel Erosion Structures for Muddy Creek"</u>; Corps of Engineers, 1979. REPORT HIGHLIGHT: The Corps looked at using stone revetments, stone-filled soil interceptor trenches and reopening old meanders to reduce channel slope. For 45 stream miles the cost would have been \$14.4 million.

End of reports and data for 1970s.

WHEN (FY)	GRANT PROGRAM and SPONSOR	GRANT AMOUNT	IN-KIND MATCH	FISCAL AGENT	PROJECT PURPOSE	
UNKNOWN						

1970s Funds Expended for Projects

Muddy Creek

1980s – MORE STUDIES & CALL FOR ACTION PHASE

NOTE: Other than data with specific references, this section of the report used primarily "Muddy Creek Special Water Quality Project" report compiled by Systems Technology, Inc., November 1979 AND "Muddy Creek Special Water Project" report compiled by John Andrews, January 1985

<u>Charts below</u> show where started in 1980 with amount of sediment and flow in Muddy Creek. Through primarily on-farm irrigation practices and irrigation delivery system improvements there was flow improvements by the end of the 1980s as shown in end of this chapter on 1980s chart.



1980 – <u>"Technical Assistance Report – Muddy Creek Task Force";</u> Dr. Arthur Hornsby, Environmental Protection Agency, 1980</u>. REPORT HIGHLIGHT: At the request of U.S. Senator Max Baucus, Dr. Hornsby with several other agencies staff participated in a Muddy Creek tour and Muddy Creek Task Force meeting to review the preliminary studies already conducted and recommend the direction of future efforts of the Muddy Creek Task Force. The summary of his report states what is needed now is a mechanism to evaluate all available data, including scientific literature which might be applicable to this particular setting, to develop (1) an action plan, (2) a strong sense of priorities, and (3) an implementation strategy.</u>

1980 - <u>"Statewide 208 Newsletter to Achieve and Preserve Clean Waters – Issue #21"; Montana Department of Health</u> and Environmental Sciences, March-April 1980. Newsletter highlighted under special projects how the Muddy Creek effort just keeps rollin' along.

1980 – <u>MCTF hires Muddy Creek coordinator</u>. MCTF selected John Andrews for the position and the employment was through the Cascade Conservation District.

1980 - <u>Muddy Creek Special Project</u> – The Cascade Conservation District was <u>awarded \$5,000</u> from the DNRC 223 grant program to support MCTF coordinator salary and miscellaneous expenses.

1980 – <u>"Upper Missouri River Basin Level B Study"</u>, Missouri River Basin Commission, April 1980. STUDY HIGHLIGHT: Objective was to develop a 15-20-year plan coordinating water and related land use management. It also identified one of the major water quality problems in state occurs on Muddy Creek where excessive erosion and sedimentation degrade water quality.

1980 – <u>"Appraisal of the Problem and Strategy for Federal Agency Action on Muddy Creek", SCS Technical Field</u> <u>Committee, 1980</u>. REPORT HIGHLIGHT: Provide a strategy for coordinated federal agency action to solve the Muddy Creek erosion problem.

1980 - <u>"Simulation of Water-Quality Data at Selected Stream Sites in the Missouri River Basin, Montana"; USGS</u> <u>Report 80-76, September 1980</u>. REPORT HIGHLIGHT: Describes statistical water quality data evaluation.

1980 – <u>Muddy Creek Executive Board established</u> bylaws on October 22, 1980. Member organizations included Cascade Conservation District (CCD), Teton Conservation District (TCD), Muddy Creek Landowners Association, Cascade County ASCS committee, and Teton County ASCS committee. The Board's objectives were to improve agricultural practices and control runoff and erosion, in order to reach project goals of reducing sediment, improving water quality and preserving the natural resources of the Muddy Creek area.

1980, October 22 – <u>Formal cooperative agreement</u> signed by Cascade Conservation District, Teton Conservation District, Muddy Creek Landowners Association, Cascade ASCS County Committee & Teton ASCS County Committee.

1980 - <u>"Statewide 208 Newsletter to Achieve and Preserve Clean Waters – Issue #23"; Montana Department of Health</u> and Environmental Sciences, October 1980. Newsletter highlighted that Muddy Creek will not meet 1983 goals and project funding.

1980 - *"Trip Report – Special Water Quality Study on Muddy Creek, Montana, October 20-24, 1980"*; John Hedlund, <u>SCS, November 7, 1980</u>. REPORT HIGHLIGHT: Assesses need for "Interim USDA On-Farm Progress Report".

1980 – *Fairfield Bench Wells Water Quality Monitoring* – The State of Montana <u>awarded \$9,800</u> from the Old West Regional Commission to support bi-weekly sampling of 25 wells on the Fairfield Bench for nitrates and pesticides.

1980 - <u>*"Water Quality Sampling of Domestic Wells";* John Andrews, August 1980. REPORT HIGHLIGHT: Summarized wells data sampled in August 1980. Analysis of well data <u>did not</u> show a relationship between nitrogen levels and well water levels, pre-irrigation season or during irrigation. Of the 24 sites sampled there were four wells exceeding nitrate standards.</u>

1980 – <u>On-Farm Irrigation Improvements</u> – The Cascade Conservation District was <u>awarded \$200,000</u> from the Old West Regional Commission to augment an ASCA/ACP cost-share program for land leveling, ditch lining and sprinkler water lines. Over 100 producers were allowed up to \$3,500 of these funds to match the ASCS funds.





1980-1983 - <u>Muddy Creek Special Project</u> – The Cascade Conservation District was <u>awarded \$95,000</u> from the DHES "208 grant program" to focus on improving water quality in Muddy Creek. As part of the project focus, the funds helped support MCTF coordinator salary.

1980-1984 – <u>On-Farm Irrigation Improvements</u> – Producers in this area were <u>awarded \$1,016,000</u> from the ASCA/ACP cost-share program for land leveling, ditch lining and sprinkler water lines.

- Over 100 producers received up to \$3,500 of these ASCS funds to install irrigation improvement projects.

1981 – <u>Muddy Creek filmed</u> by unknown individual to document erosion during heavy rains. NO COPY FOUND.

1981 – <u>"Nitrates in Wells of the Greenfields Irrigation</u> District Fairfield, Montana", Kit C. Walther, Environmental Specialist, Water Quality Bureau, Department of Health and Environmental Sciences, April 20, 1981. REPORT HIGHLIGHT: Study of nitrate concentrations in groundwater of the Greenfield Bench east of Fairfield which 8 of the 24 sites monitored had exceedances of the 10 mg/l levels that are too high for infants to drink.

1981 – <u>"Muddy Creek Erosion Problem – A Coordinated</u>

Strategy for Federal Action", (SCS, BoR, Corps, EPA), April <u>1981.</u> REPORT HIGHLIGHT: Describes alternative <u>on-farm</u> solutions which federal programs could offer to help resolve the Muddy Creek erosion problem, proposes further analysis of alternative structural measures and describes the scope of work for feasibility grade level study. Report was geared for Montana Congressional delegation to introduce legislation to obtain federal funding for Muddy Creek projects. Below charts include estimated costs for preferred projects and projected water savings if those projects were implemented.

			-
Table 2To	tal Costs for Mudd	ly Creek Improvemer	ts
Activity	Total Cost	Federal	Other
		- dollars	
Onfarm management financial assistance	19,000,000	12,467,750	6,532,250
Onfarm management technical assistance	2,395,000	2,395,000	-0-
Information and education	370,000	370,000	-0-
Surge relief canal	10,000,000	10,000,000	-0-
Muddy Creek stabilization	-0-	-0-	-0-
Environmental studies and monitoring	201,500	31,500	170,000
Hydrology study	63,900	63,900	-0-
TOTAL	22 020 400	25 220 150	6 702 250





1981 – <u>Teton County Irrigation Demonstration Project.</u> Teton Conservation District was <u>awarded \$24,228</u> through a CDs Earmarked Revenue Funds administered by the DNRC. The project's primary purpose was to improve on-farm irrigation practices by automating water turnouts on flood irrigation. Three farmers participated on 155 acres with in-kind contributions of \$23,052.

1981 – *"Irrigation Demonstration Project annual report",* Montana Extension Service, Bauder and Cullen, 1981. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1981 – <u>"Agreement on the Management and Administration of Montana's Environmental Programs FY 1982", Water</u> Quality Bureau, Department of Health and Environmental Sciences, September 1981. REPORT HIGHLIGHT: Address many environmental programs in Montana. It highlights the "infamous Muddy Creek of the Sun River is Montana's showcase sediment problem". **1981** – <u>Muddy Creek special funds allocation</u> – Bureau of Reclamation <u>authorized \$250,000</u> to be used for stream stabilization pilot project on Muddy Creek, but then Reclamation cancelled project. Reclamation reasoning was those federal funds could not be spent on private lands. MCTF felt the funds were moved to a different project.

1981–1982 – <u>Muddy Creek Special Project</u> – The Cascade and Teton Conservation Districts were <u>awarded \$300,000</u> through Renewable Resources Development Program administered by the DNRC. The project's primary purpose was to install improved agricultural practices to reduce irrigation return flow into Muddy Creek.

1982 - <u>Muddy Creek Special Project</u> – The Teton Conservation District was <u>awarded \$4,500</u> to assist with MCTF coordinator salary.

1982 – <u>"Managing Fertilizer and Irrigation Water on the Fairfield Bench to Minimize Nitrate Leaching Below the Root</u> **Zone**", Montana Extension Service, Bauder, 1982. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>*"Irrigation Scheduling in the Greenfields Irrigation District"*, Montana Extension Service, Bauder and Jones, 1982</u>. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>*"Irrigation Nitrogen Demonstration Plots"*</u>, Montana Extension Service, Bauder, 1982</u>. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>"CONSUMPT, A New Approach to Irrigation Scheduling"</u>, Montana Extension Service, Bauder, 1982. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>"Scheduling Irrigation with Evaporation Pans"</u>, Montana Extension Service, Bauder and Jones, 1982. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>"Geological and Materials Report; Three Damsites and Two Surge Relief Canal Alignments"; Greenfields</u> Division; Muddy Creek Study; by Lovell M. Parish; February, 1982. REPORT HIGHLIGHT: Irrigation wastewater discharges from Greenfields Irrigation District, when combined with storm runoff, have caused serious erosion problems along lower reaches of Muddy Creek. This report presents geological data pertinent to three damsites and two surge relief canal alignments visited during the field reconnaissance. Below shows the proposed project sites.



1982 – <u>"Nutrients in Muddy Creek and Wastewater Drains of the Greenfields Irrigation District", Kit C. Walther,</u> Environmental Specialist, Water Quality Bureau, Department of Health and Environmental Sciences, March, 1982. REPORT HIGHLIGHT: April to October 1980 study of nutrient sources into major irrigation drains and dryland tributaries to Muddy Creek.

1982 – "Muddy Creek Study – Plan Formulation Review Document", U.S. Bureau of Reclamation, July 1982.

- NO COPY FOUND.

1982 <u>– "Montana Water Quality – 1982"</u>, Water Quality Bureau, Department of Health and Environmental Sciences, July 1982. REPORT HIGHLIGHT: Addresses many water quality issues across the entire state of Montana. In the lists of water quality impaired streams, it flags Muddy Creek as one them.

1982 – <u>"Water Quality Inventory and Management Plan – Missouri-Sun-Smith River Basin, Montana"</u>; Water Quality Bureau, Environmental Sciences Division, Montana Department of Health and Environmental Sciences; 1982. INTRODUCTION: This report presents information relative to the water quality and water quality inventory and management in the Missouri-Sun-Smith basin. It identifies soils erosion as a major problem in the Muddy Creek drainage.

1982 – <u>*"Fairfield Bench Water Control Reports"*, Montana State University, Civil Engineering Class, Hertzog, 1982</u>. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1982 – <u>Muddy Creek Watershed Protection (Northeast</u> <u>Unit)</u> federal financial assistance proposal for <u>\$800,000</u> submitted to Soil Conservation Service (SCS) by Cascade CD, Teton CD and GID. The project objective was to promote better irrigation water management by providing a cost-share program focused on water saving practices on approximately 10,000 acres on lands located in northeast area of the Muddy Creek drainage. Practices included concrete ditch lining, conversion to sprinkler irrigation systems, land leveling, and flood irrigation automation components.



1983 - <u>Muddy Creek Special Project</u> – Teton Conservation District <u>awarded \$2,500</u>, assist with MCTF coordinator salary.

1983 – <u>*"The Influence of Screen Size on Washtub Evaporation"*, Montana Extension Service, Westesen and Ismail, <u>1983</u>. REPORT HIGHLIGHT: To improve on-farm irrigation practices.</u>

1983 – *"Special Report on Muddy Creek Study, Montana"*, U.S. Bureau of Reclamation, Billings, Montana, December <u>1983</u>. REPORT HIGHLIGHT: Presented results of past studies, short review of all alternatives considered and a more detailed analysis of a dam near Power. The reduction of sediment loads into the Sun River were only estimated at 60,700 tons/30% at an estimated project cost then of \$22 million with annual operations of \$35,000. See below map for proposed projects.



1983 – <u>"Evaluation of the Ground-water Contribution to</u> Muddy Creek from the Greenfields Irrigation District - Report

#113", Montana Bureau of Mines and Geology, December 31, <u>1983</u>. REPORT HIGHLIGHT: Over three irrigation seasons MBMG investigated characteristics of the ground-water system to see if excess irrigation runoff could be controlled. To effectively track all water entering the Muddy Creek drainage, installed for surface water were 15 flumes, weirs, and other channel controls and 19 wells for groundwater. As shown in right chart for some of flow data, this very extensive project identified exactly where and how much water was entering the Muddy Creek drainage.



1983 – <u>*"Irrigation Scheduling in the Greenfields Irrigation District"*, Montana Extension Service, Bauder and Hertzog, 1983</u>. REPORT HIGHLIGHT: To improve on-farm irrigation practices.

1983-1984 - <u>Muddy Creek Special Project</u> – The Cascade and Teton Conservation Districts were <u>awarded \$10,000</u> from the Bureau of Reclamation to assist with MCTF coordinator salary for a four-month period.

1983-1985 – <u>Muddy Creek Watershed Protection and</u> <u>Irrigation Improvement</u> project through Montana's Water Development Grant Program submitted by Cascade and Teton CDs. The state legislature <u>awarded</u> <u>them \$100,000</u> to reduce wastewater into Muddy Creek by improving irrigation practices. Automating flood irrigation was one of the projects, as shown, right.



1984 – <u>"Muddy Creek Special Water Project", Renewable Resources Development Grant Summaries, Cascade</u> <u>Conservation District, January 1984.</u> This report was written to reflect all of the studies from agencies involved in the RRD grant program.

1984 – <u>"The Effects of Muddy Creek on the Biology of the Lower Sun River"</u>, Water Quality Bureau, Department of Health and Environmental Sciences, January 1984. REPORT HIGHLIGHT: Identifies Muddy Creek as Montana's worst water quality problem. Findings of the study states during the peak of the irrigation season when the sediment contribution is much larger, conditions for aquatic life will be the worst, at times extending the impact zone all the way to the Missouri River at Great Falls.

1984-1985 – <u>Muddy Creek assessment project through DHES "205J Program.</u>" <u>\$7,700 was awarded</u> for baseline inventory on approximately 35 miles of Muddy Creek.

1984-1994 – <u>Muddy Creek Watershed Protection (Northeast Unit)</u> Soil Conservation Service (SCS) federal financial assistance for \$874,000</u>. The project promoted better irrigation water management by providing a cost-share program focused on water saving practices on approximately 10,000 acres on lands located in northeast area of the Muddy Creek drainage. Practices included concrete ditch lining, conversion to sprinkler irrigation systems, land leveling, and flood irrigation automation components. Approximately \$600,000 for 40 farmers at rate of 30-50% producer cost-share and remaining to SCS for administering the program.</u>

Unknown date - <u>"Muddy Creek Study", U.S. Bureau of Reclamation, Billings, Montana,</u> Unknown date. REPORT HIGHLIGHT: This was conducted by the BoR while GID was going through a Rehabilitation and Betterment (R&B) project. The intent of the study was to address concerns of storm related water discharges into Muddy Creek. It identified two methods for reducing those discharges: 1) surge-relief canal and 2) reservoir. **1985** – <u>*"Muddy Creek Special Water Project Final Report"*, John Andrews, January 1985</u>. REPORT HIGHLIGHT: Project accomplishments to-date and proposed projects in the future.



1985 – <u>"Stream Inventory: Muddy Creek Drainage, Cascade and Teton Counties"</u>, John Andrews, January 1985. REPORT HIGHLIGHT: Summarized baseline conditions through a physical inventory of streambanks and channel survey of Muddy Creek in November and December 1984.

1978 – **1985** – BoR Rehabilitation & Betterment (R&B) Program to improve GID's infrastructure and water delivery system. GID <u>spent \$8.3 million</u> installing concrete lining, pipes, and automation on 40 miles of canals. A key result of that R&B project was approximate annual <u>reduction of 20,000 acre-feet of water</u> entering Muddy Creek.



1986 – <u>*"Muddy Creek Special Water Project Report"*, Water Development Program grant, Cascade Conservation District, November 20, 1986</u>. REPORT HIGHLIGHT: Accomplishments to-date <u>with the \$100,000 grant.</u> **1986** – <u>"Muddy Creek Diversion"</u>, Soil Conservation Service, November 18, 1986. REPORT HIGHLIGHT: Was in reference to a request to divert water from Muddy Creek to irrigate lands north of Manchester and outletting at Black Horse Lake. This basic one-page report stated the 3,000 acres that the <u>project be served does not have soils suited to be irrigated</u>. Project closed.

1987 – <u>Agricultural Riparian Area Rehabilitation Project grant</u>, Montana Department of Natural Resources and Conservation, July 1987. This grant provided funding to conservation districts to complete <u>planning</u> for rehabilitation projects on the Sun River and three other streams in Montana. <u>Grant was \$100,000</u> with match of \$20,000 from DNRC, \$5,300 DNRC 223 grant, \$6,428 from DHES, and \$25,000 in-kind from SCS, DHES, and DNRC.

1987 – <u>"Sun River Corridor Inventory Report", SCS, April 1987</u>. Cascade, Teton, and Lewis & Clark CDs requested MT DHES to inventory Sun River physical features. REPORT HIGHLIGHT: Describes that increase of silts from the Muddy Creek erosion is partially responsible in the change of fishery population and water quality in the lower Sun River.

1988 – <u>"Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation</u> Drainage in the Sun River Area, West-Central Montana, 1986-87", USGS Report #87-4244, U.S. Geological Survey, 1988. REPORT HIGHLIGHT: Describes concentrations of selected inorganic and organic constituents in water, bottom sediment and biota. The report mentions return flows into Muddy Creek have caused substantial sediment problems but these flows have decreased in recent years because of the GID Rehabilitation and Betterment Program.

1989 - <u>"A Pictorial History of the Sun River Valley"</u>; Sun River Valley Historical Society, February 1989. The book documents the history of the Sun River Valley.

<u>"Estimates of Monthly Streamflow Characteristics at Selected Sites in the Upper Missouri River Basin, Montana, Base</u> <u>Period Water Years 1937-1986"</u>; USGS report #89-4082, U.S. Geological Survey, 1989. REPORT HIGHLIGHT: Describes flow data for multiple years including those in Muddy Creek.

End of reports and data for 1980s.

1980s GRANTS and IN-KIND PROJECTS FUNDING

WHEN (FY)	GRANT PROGRAM and SPONSOR	GRANT	IN-KIND	FISCAL	PROJECT PURPOSE
		AMOUNT	MATCH	AGENT	
1980	Muddy Creek –223 grant (DNRC)	5,000	unknown	Cascade CD	MCTF coordinator salary & miscellaneous
1980	Water Quality Monitoring – (Old West	9,800	unknown	Montana	Fairfield Bench, 18 wells sampling
	Regional Commission)				
1980	Water Quality Monitoring Supplemental Grant	200,000	176,250	Cascade CD	On-farm land leveling, ditch lining, sprinkler water
	(Old West Regional Commission-(OWRC))				lines
1980	Muddy Creek – 223 grant (DNRC)	2,000	unknown	Cascade CD	Funds to be matched with DHES funds
1980	Title III Coal Tax (DNRC)	15,000	-0-	Teton CD	Muddy Creek planning project – bought computer software
1980	Agriculture Conservation Program (ASCS)	300,000	w/OWRC	ASCS	75% cost-share increasing irrigation efficiencies
1980	Agriculture Conservation Program (ASCS)	100,000	w/OWRC	ASCS	Cost-share increasing irrigation efficiencies in Teton County
1980-1983	MT 208 Water Quality Program (DHES)	95,000	25,200	Cascade CD	MCTF coordinator salary & miscellaneous to
					support water quality solutions for Muddy Creek
1980-1984	Agriculture Conservation Program (ASCS)	1,016,000	254,000	ASCS	75% cost-share increasing irrigation efficiencies
1981	Irrigation - CDs Earmarked Funds (DNRC)	24,228	23,052	Teton CD	Teton County Irrigation Demonstration Project
1981	Muddy Creek – 223 grant (DNRC)	2,500	unknown	Cascade CD	MCTF committee expenses
1981	Muddy Creek – 223 grant (DNRC)	2,500	unknown	Teton CD	MCTF committee expenses
1981-1982	Renewable Resources Development	300,000	unknown	Cascade CD	Producer irrigation water management projects
	Program (DNRC)				
1982	Muddy Creek – 223 grant (DNRC)	4,500	unknown	Teton CD	MCTF coordinator salary
1983	Conservation District Administration (DNRC)	2,500	unknown	unknown	MCTF coordinator salary for one month
1983-1984	Administrative Funding (BoR)	10,000	unknown	TCD & CCD	MCTF coordinator salary for four months
1983-1985	Water Development Program (DNRC)	100,000	w/ACP	TCD & CCD	50% cost-share to automate flood irrigation
1984	Montana 205J Program (DHES)	7,700	unknown	unknown	Muddy Creek assessment
1984	Agriculture Conservation Program (ASCS)	200,000	200,000	ASCS	unknown
1978-1985	Rehabilitation & Betterment Program (BoR)	-0-	8,300,000	GID	Loan, not grant. Improved delivery & reduce waste
1984-1994	Small Watershed Program (SCS)	874,000	600,000	TCD & CCD	30-50 % sprinkler or automate flood irrigation
1987	Unknown (DNRC)	100,000	unknown	unknown	Agricultural Riparian Area Rehabilitation Project
TOTAL I	KNOWN FUNDS ACQUIRED in 1980s→	3,270,728	9,578,502		

Table 1. 1980s Grants and Funding

Muddy Creek 1990s - Second Call For Action Phase Reports & Sequence of Events

1990 – Preliminary Engineering and Environmental Assessment for Muddy Creek Erosion Control Project in Cascade and Teton Counties grant, Water Development Program grant, Cascade Conservation District, May, 1990. The intent of the \$100,000 grant was the first phase of construction to improve Muddy Creek water quality by selecting projects from previous studies.

1992 Early – Muddy Creek landowner Joyce Wohlgemuth contacted Montana agencies asking for help on ways to reduce Muddy Creek erosion so he would not be losing so much land. Joyce stated if a solution could not be found soon, he would be forced to file suit against those responsible for the problem.





Great Falls City Manager John Lawton also chimed in that Great Falls would consider litigation if something did not get rolling soon. Lawton went on to say the issues of ascetics and water quality could not be ignored any longer.



1992 – <u>*"Montana Water Quality – 305 (b) Report",* Water Quality Bureau, Department of Health and Environmental Sciences, June, 1992.</u> Report highlight: Addresses many water quality issues across the entire state of Montana. Included on the lists of water quality impaired streams is Muddy Creek.

1992 July – <u>DNRC put the word out</u> through unofficial channels that anyone interested in the Muddy Creek erosion issue should attend an upcoming meeting.

1992, July 28 - 13 people participated in this <u>first meeting</u>. Those groups represented included Greenfields Irrigation District (GID); Montana Fish, Wildlife & Parks (FWP); Montana Department of Health and Environmental Sciences (DHES); Montana Department of Natural Resources and Conservation (DNRC); Bureau of Reclamation (BoR); Cascade Conservation District (CCD); Teton Conservation District (TCD); Medicine River Canoe Club (MRCC); two Muddy Creek landowners; USDA Soil Conservation Service (SCS); USDA Agricultural Stabilization and Conservation Service (ASCS); and US Fish & Wildlife Service/Benton Lake (USFWS). At this meeting the participants went through a brainstorming session on how to move forward on addressing the Muddy Creek erosion issue. DNRC committed to putting together a list of various options which included those contemplated in the 1980s. **1992, September 24** – <u>DNRC facilitated the next meeting</u> with 21 people attending. Additional groups that also participated at this meeting included Cascade County Extension Service; National Wildlife Federation, Sun River landowner and a stream restoration consultant. Participants discussed pros and cons of options presented, agreeing that many ideas looked good on paper but nearly impossible to accomplish because of high costs. Because of uncertainty of how to proceed they agreed more information was needed to develop priorities. To obtain more ideas they agreed Dr. Don Reichmuth would take aerial photos of current Muddy Creek conditions. Participants also agreed there should be consideration of resurrecting the Muddy Creek Task Force (MCTF). If there was going to be any progress of getting something done then a local coalition was needed that would pursue local support and involvement. Below drawings show some options discussed at this meeting.



1992, October 16 – <u>DNRC facilitated this next public meeting</u> with many more people attending. After much discussion of who was at fault, what should be done and how it would be paid for participants agreed it would be much more practical to have a smaller work group meet to identify best approach to tackle massive problem. So, the MCTF was revived with primary members consisting of Muddy Creek landowner representative Joyce Wohlgemuth, recreationist, environmentalist, GID manager, private consultant Don Reichmuth, CCD representative, Extension Service agent, FWP and DNRC.

1992, October 21 – Newly formed <u>Muddy Creek Task Force met</u> with a decision that since the old solutions were too costly and not practical this MCTF needed to look outside the box for a non-traditional solution. Dr. Riechmuth gave a presentation on his proposal that included pictures of his September flight of Muddy Creek. Dr. Riechmuth also produced a <u>*"Muddy Creek Grade Stabilization Project"*</u> proposal that included a series of rock drop structures and barbs in a 4-mile reach that was the most active in headcutting. Future work would be a multi-prong approach including: 1) Muddy Creek stabilization using drop structures and riparian protection; 2) use of Freezout for surge relief of excess irrigation water; and 3) improve on-farm irrigation practices. The MCTF agreed to use the below sediment and flow information to track progress of their work.



1992 - "Why Is the Sun River Dirty"; Muddy Creek Task Force; 1992. Brochure described the erosion issues.

1992 - 1993 – <u>"Proposed Bank Stabilization Project on Muddy Creek, Cascade County, Montana, Application</u> <u>No. 199290500, Corps of Engineers, 1992</u>. Montana Department of Transportation and Corps of Engineers submitted a public notice for bank stabilization on Muddy Creek along West Frontage Road north of Vaughn to protect road from damage as result of streambank erosion. Initial proposal was to move Muddy Creek channel – straightening this stream segment that would have increased erosion downstream. After MCTF obtained support from Montana permitting agencies objecting to the proposed project, Corps modified proposal to leave channel in existing location, riprap the bank to protect frontage road and install drop structure similar to ones being proposed by Dr. Riechmuth. This single project designed by Corps cost as much as full 4-miles of the Reclamation research project that would be accomplished in the following years.

1993 – <u>MCTF</u> met frequently over the next several months, identifying ideas for funding the projects and specific tasks to move forward. At a MCTF meeting the members discussed how would the proposed project get rolling. GID manager Jerry Nypen was the first to raise his hand stating GID had equipment and manpower to install the rock structures if others would supply the rock and oversee the work. Other MCTF members quickly offered their in-kind support of the tasks including: CCD for surveying, NRCS for surveying, MRCC to plant trees and FWP offered financial help for riparian improvement projects.

1993 – Dr. Donald Reichmuth put together <u>*"Conceptual Design for Muddy Creek Grade Stabilization Project"*</u> on his solution to slowing erosion.

1993- <u>*"Muddy Creek Demonstration Project";* BoR, Billings, Montana, 1993, June 4.</u> BoR submitted Research Project Proposal to BoR Denver Research and Laboratory Services Division requesting technical support for resolving Muddy Creek erosion using techniques proposed by Dr. Riechmuth. Even though project was outside GID boundaries, it was approved as a research project only. Montana BoR office brought in BoR engineer/Rod Whittler from Denver to review Dr. Riechmuth's design. BoR engineers decided Dr. Riechmuth's design needed to be modified to improve chances of success. Dr. Riechmuth bowed out since he no longer was in charge.

1993 – <u>BoR had \$100,000</u> in federal budget proposal to support Muddy Creek effort, unfortunately funding request somehow got dropped. U.S. Senator Baucus pressured BoR staff to find internal BoR funds - which they did. CCD agreed to be fiscal agent for Muddy Creek project funds brought in. Dr. Riechmuth demanded payment for his aerial flight assessment work and his name be removed from all design documents.

1993, September/October – NRCS staff with support from CCD started water surface profile survey on Muddy Creek 4-mile demo area shown on map, right. Data was used to locate rock grade control structures. After water surface profile was completed, NRCS and CCD then started detailed channel cross-section survey.

1993 – BoR staff accomplished a detailed environmental review of the demo project area prior to rock delivery and GID in-channel work.

1993 – <u>10,000 tons of rock was acquired</u> at \$15.59/ton using some of the BoR research funds. DNRC acquired easements on the private land where work would be accomplished. DNRC also acquired the necessary permits to accomplish the Phase I Muddy Creek project.

1993 – FWP acquired a <u>\$15,000 grant</u> to help with Muddy Creek riparian projects. Funds used to buy fencing, trees, and native grass seed.

1993 – Montana Power Company (MPC) <u>donated \$6,000</u> to the Muddy Creek project. There were many other groups that sent in letters of support for the Muddy Creek project and asked the Montana congressional delegation to help acquire federal funds.

1993 – <u>Marc Lee's Spring Coulee project</u>. Marc Lee acquired help from consultant Ray White to design stream restoration on ¼ mile reach of Spring Coulee, a Muddy Creek tributary, with five grade control structures to reduce headcuts and bank erosion while improving fish habitat. GID crew accomplished work as designed.





1993 – MCTF started working on an <u>EPA 319 grant application</u> to fund more on-the-ground projects, hire a coordinator and pay for USGS water quantity and quality monitoring. The MCTF also decided the work on this grant and other project oversight needed a single person to pull all the pieces together. MCTF member Alan Rollo offered to work for free for 6 months if they would hire him afterwards. The other MCTF members approved Rollo's offer after a very serious discussion.

1993 - "Muddy Creek – The Latest Story"; Muddy Creek Task Force; 1993. Brochure about projects status.

1993 - <u>"Greenfields Irrigation District – Water Efficiency Improvement Program – Three Physical Treatments"</u>; author unknown, December, 1993. REPORT SUMMARY: Identified three problem areas contributing to excessive wasteway flow and the estimated cost of remedy and water savings.

	PROBLEM 1) UNTIMELY CONTROL OF MAIN CANAL FLOWS SOLUTION: INSTALL MAIN CANAL CONTROL STRUCTURES COST: \$1,165,000 WATER SAVINGS: 3,200 ACRE-FEET ANNUALLY
	PROBLEM 2) DISTRIBUTION FACILITIES ARE OLD AND WATERWAYS SEEP
	SOLUTION: RELOCATE, REDESIGN, LINE OR PIPE LATERAL SYSTEMS
	WATER SAVINGS: 27.600 ACRE-FEET ANUALLY
	PROBLEM 3) SOME ON-FARM IRRIGATION METHODS ARE NOT EFFICIENT AND EFFICIENT METHODS ARE NOT AFFORDABLE
	SOLUTION: PROVIDE AN INCENTIVE PROGRAM TO ALLOW WATERUSERS
	COST: \$16,600,000
	WATER SAVINGS: 20,800 ACRE-FEET ANNUALLY
_	

1993-1994 winter - <u>GID started Muddy Creek instream work</u> using BoR designs as a demo project on 4.1 miles considered the worst eroding banks on Muddy Creek. BoR/Dr. Rod Wittler oversaw the work. The first round of construction included six (6) grade control structures with one-foot drop; three (3) grade control structures with two-foot drop; and 30 rock barbs on the stream banks.



1994 - <u>MCTF continued to meet</u> frequently to keep up with grants, projects status, and identifying additional ideas for funds.

1994 - <u>Marc Lee's Spring Coulee project</u>. Marc Lee fenced off the restoration reach on ¼ mile of Spring Coulee.

1994, February – <u>Montana Department of Transportation protects frontage road</u> with engineering assistance from the Corps of Engineers. A contractor was hired to install a "sill" on Muddy Creek at a cost of <u>approximately \$250,000</u>.





1994, February 18 – <u>Muddy Creek tour by Senator Baucus</u>. With reestablishment of MCTF and specific erosion control projects started, Senator Baucus toured Muddy Creek to see first-hand the new direction.

1994, April 30 – <u>35 Volunteers planted 6,000 willows</u> on Muddy Creek banks as shown below.



1994 - <u>Financial contributions supporting new Muddy Creek effort coming in.</u> Great Falls Gas Company donates \$100; Medicine River Canoe Club, \$500; Cascade County, \$500; City of Great Falls, \$750 – for <u>total = \$1,850</u>.

1994 – <u>MCTF hosts many tours and briefings</u> to get word out about the latest erosion control teamwork. These were for Bureau of Reclamation upper management, Soil Conservation Service upper management, Montana Water Resources Association, Burlington Northern Railroad management, Department of Natural Resource and Conservation, local TV stations, Soil & Water Society, Western Governors Association, GID water users, Dave Rosgen with his stream restoration class, Montana State Fair and many more.

1994-1998-<u>Sun River Basin - Muddy Creek Watershed Phase I</u>, U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by Cascade Conservation District. Work began in 1995 with the primary goals to address the severe erosion problem of Muddy Creek and start expanding teamwork into entire Sun River Basin. Under this project there were 13-grade control and over 400 barbs installed, reducing erosion in Muddy Creek by 75%. TMDL plan for Muddy Creek was submitted to Department of Environmental Quality (DEQ) for review but was added to the Sun TMDL planning process. Leveraged \$209,000 in-kind and cash support for the <u>\$101,750 of 319 funds allocated</u>. Additional project results included:

- Almost 8 miles of fencing along Muddy Creek to protect riparian area
- Installed 6 off-stream waters for livestock
- Improved overall grazing on 8 miles of Muddy Creek riparian area
- Planted more than 8,000 willows and trees along streambank
- Four major tours with numerous smaller tours of interested parties
- 12 workshops with slide show presentation at meetings of all interested groups
- Watershed coordinator was hired for this project

1994, July 11-14 – <u>NRCS and CCD surveying</u> continued on Muddy Creek in Phase I reach.

1994, fall - <u>GID continued Muddy Creek instream work in Phase I reach</u>, with BoR oversight.

1994, fall – <u>MCTF hired contractor to fence</u> areas along Muddy Creek where GID installed grade control structures. This was needed to prevent landowner's sheep from damaging new vegetation planted on banks disturbed during stream work.

1994, December 10 – An educational <u>"Know Your Watershed"</u> workshop was held in Great Falls sponsored by the Montana Watercourse and CCD. As agreed at the beginning of the Muddy Creek project when progress was being made, it would be time to expand the collaborative effort beyond Muddy Creek to the entire Sun River Watershed.



1995 – <u>"Muddy Creek Phase II Class I and Class III Cultural Resources Inventory, Northern Cascade County,</u>

Montana", Ethos Consultants, January 1995. MCTF hired Ethos Consultants Inc. in 1994 to accomplish cultural resources inventory on segment of Muddy Creek. Inventory was accomplished in October and November 1994.

1995 - <u>MCTF meetings</u> continued but less often with so much on-the-ground work going on. Each meeting always addressed grants, projects status, identifying additional ideas for project funds.

1995, Spring – <u>NRCS and CCD continued Muddy Creek survey</u> with cross section in Phase I reach.

1995 - <u>Rock barbs and grade control installation</u> continued by GID using BoR designs as a demo project on 4.1 miles considered the worst eroding banks on Muddy Creek.

1995, Spring – <u>Arial topographic survey accomplished by Morrison Maierle, Inc./Horizons, Inc.</u> Aerial survey project went from confluence of Sun River to the Muddy Creek Gordan bridge at cost of \$19,815.

1995, Fall – <u>NRCS and CCD continued Muddy Creek survey</u> with water surface profile in Phase II reach.

1995, September 26 – <u>Muddy Creek slide presentation</u> by Alan Rollo to 20 landowners around Manchester area on current projects and future direction. Presentation intent was positive word about Muddy Creek effort.

1995, October & November – <u>Alan Rollo walked/videotaped</u> the 4-mile demo section of Muddy Creek to document changes. Also took pictures that were used in a slide show to local groups of Muddy Creek work.

1995, November 14 – <u>Muddy Creek slide presentation</u> by Alan Rollo to 11 landowners at Power school on current projects and future direction.

1995 – <u>Muddy Creek slide presentation by Alan Rollo</u> to City of Great Falls commissioners, Sun Prairie Water Board, Great Falls Conservation Council and many more.

1995, December - <u>GID & BoR installed 2 grade control structures and 30 rock barbs</u> along Muddy Creek banks.

1995, fall – <u>BLM offered Joyce Wohlegmuh a land trade</u> for his Muddy Creek property as part of a BLM land consolidation project. Proposal was dropped when Joyce would ONLY accept an offer that was significantly higher than appraised value of his property.

1995 - <u>*"Cultural Resources Inventory for Phase III of the Muddy Creek Project, Cascade County, Montana",*</u> <u>MTAO Project No. SR-95-71, Bureau of Reclamation, November 1995.</u> The Bureau of Reclamation accomplished additional cultural resource inventory for next phase of construction in Muddy Creek.

1995, December – <u>GID and BoR started work in "next" section</u> of Muddy Creek as shown on maps below, installing 30 more barbs over three weeks. Also installed two additional grade control structures in original demo

area.





1995 – <u>NRCS, Bozeman Public Affairs staff completed a video</u> of the Muddy Creek effort that was used as outreach tool at public events.

1995-1996 – <u>4,000 tons of additional rock hauled</u> by Walter Savoy to next project sites. Cost was \$12.45/ton for total of \$49,800.

1995-1996 – <u>Bob Durocher Muddy Creek bridge project</u>. Bob Durocher had requested on several occasions that GID install a Muddy Creek crossing on his property. After not getting any assistance, Bob installed his own bridge as shown below.





1996 - <u>MCTF meetings</u> were held less frequently now with so much on-the-ground work going on. Each meeting continued to address grants, projects status, and identifying additional ideas for funds.

1996, January <u>*"Sun River Watershed – Water Quality and Quantity Issues";* NRCS, January 1996</u>. Plan of Work for NRCS to allocate resources.

1996, January – <u>GID worked for three weeks</u> installing barbs with BoR oversight.

1996, March – <u>NRCS and CCD surveyed proposed "J-lake project"</u> area at request of BoR and GID. The proposed project was at start of Spring Coulee, major tributary to Muddy Creek, that when built would help reduce wastewater entering Muddy Creek.



1996, April – <u>Memorandum of Understanding</u> formally entered into between NRCS and BoR to cooperate on Sun River Basin projects.

1996, April <u>GID installed 50 additional rock barbs</u> using BoR designs as a demo project on 4.1 miles considered the worst eroding banks on Muddy Creek.

1996, May – GID installed two bank revetments near Gordon to prevent possible meander cutoffs.

1996, **May-July** – Five local high school youth assisted with the project by seeding disturbed rock pile areas and placing straw bales in Muddy Creek side drainages to slow that sediment contribution.

1996, August – <u>GID installed 50 rock barbs</u> at 5 sites with BoR oversight using BoR designs.

1996, December – <u>Low water crossing installed</u> by GID per BoR/Wittler design. Crossing also served as grade control structure, 2D.







1996 – <u>"Analysis of the Effects of Stabilization on Muddy Creek, Montana", Dr. Chester C. Watson, Colorado State University, 1996</u>. At the request of BoR/Dr. Wittler, in 1995 the MCTF hired Colorado State University, Dr. Watson to accomplish an analysis of the effects of stabilization of Muddy Creek using grade control and barbs.

1996 – <u>Muddy Creek stream assessment</u> accomplished by the NRCS Riparian Team. Intent of this assessment was to acquire baseline data and identify possible solutions for controlling erosion on Muddy Creek. The team identified a few sites requiring attention in near future. <u>*"ECS—Muddy Creek revegetation"*</u>, NRCS, Larry Holzworth, May 30, 1996 was the NRCS team's recommendations to reduce Muddy Creek erosion.

1996 - <u>"Greenfields Irrigation District Canal Modernization"</u>, Bureau of Reclamation, August 6, 1996. This study and report examined different methods to improve canal operations, considering technical, economic, and social feasibility to help reduce wastewater into Muddy Creek.

1996 – <u>Spring Coulee stream assessment</u> from August 20–22 accomplished by the NRCS Riparian Team. Intent of this assessment was to acquire baseline data and identify possible solutions for controlling erosion on Spring Coulee, a major tributary of Muddy Creek. <u>See NRCS assessment notes for more details of conditions</u>. Unfortunately, NRCS was unable to follow-through with any designs.

1996, October 23-26 – <u>BoR, Rod Wittler toured Muddy Creek</u> to evaluate current conditions.

1996, October 25 – BoR, Rod Wittler toured Muddy Creek with landowners, FSID, GID, FWP and SRWG.

1996, December – <u>Muddy Creek work continued by GID staff</u> with BoR oversight. The work included 30 barbs and two new grade control structures upstream of Wohlgemuth's buildings.



1997, January – <u>BoR & GID in-depth review of "J-lake project"</u> that is at head of Spring Coulee, major tributary to Muddy Creek, as a tool to reduce tailwater from reaching Muddy Creek.

1997, January – <u>Muddy Creek work continued by GID staff</u> with BoR oversight.

1997, February – <u>Low water crossing failed</u> during ice jam and high-water event. BoR/Wittler redesigned crossing with the modification including a concrete wall on culverts outlet.

1997, May – <u>NRCS and MCTF tested new pump</u> system on Muddy Creek for off-stream livestock waters. Did not work because of too much "moss" coming down the stream.

1997, May – <u>North Middle School students adopted coulee</u> entering Muddy Creek near Wohlgemuth's lane. They installed erosion matting and straw bales in attempt to slow erosion.

1997, May – <u>Marc Lee's Spring Coulee surveyed by NRCS and MCTF</u> to document current conditions of stream restoration project.



1997 – Dan Andrews acquires Muddy Creek water right to pump up to 3,100 gpm to irrigate 440 acres near Power. Project also intended to help reduce water in Muddy Creek. After this irrigation project approved, several other landowners along Muddy Creek also acquired water rights to pump Muddy Creek water.



1997 - *Muddy Creek DNRC grants* began in 1997, helping pay for trees, fencing, rock, and stream work.

1997, fall – <u>160 barbs placed</u> by GID crew with oversight by BoR and MCTF.

1997–1999 – <u>Marc Lee's Spring Coulee project.</u> Marc was <u>awarded \$16,810</u> through FWP Future Fisheries program that helped pay for his project on Spring Coulee. Project included NRCS surveying the project reach, 6,000 feet of riparian fencing, lined 2,100 feet of bank with conifer trees acquired on Lewis & Clark National Forest, and planting native willows along the banks.



1998 - <u>Muddy Creek Demonstration Stream Restoration Research Project, CRDA-96-1</u>, Dr. Rodney J. Wittler, Spring 1998. Funding for the original partnership came from a grant by the State of Montana to the Cascade County Conservation District. Funding for the new partnership comes partially from a State of Montana grant (\$10,000) and a grant by the National Fish and Wildlife Foundation (\$41,000) to the Cascade County Conservation District. Reclamation and the MCTF partner via Cooperative Research & Development Agreement (CRDA) 96-1 and its amendments between Reclamation and the CCCD. Dr. Wittler and others wrote 12 additional research papers including the following:

- <u>Gradient and Plan Form Stabilization of an Incising Stream</u>; R.J. Wittler, S.D. Keeney, B.W. Mefford, S.R. Abt, C.C. Watson; Wittler, R.J., Keeney, S.D., Mefford, B.W., Abt, S.R., Watson, C.C., "Gradient and Plan Form Stabilization of an Incising Stream." Proceedings of the Sixth Federal Interagency Sedimentation Conference, Las Vegas, Nevada. Pp. III-78. March 1996. Abstract: This paper describes the efforts of a partnership of Federal and local government agencies and a local citizen task force to solve the water quality problems associated with the incision of Muddy Creek near Great Falls, Montana. The US Bureau of Reclamation and Greenfields Irrigation District are collaborating to reduce return flow to Muddy Creek. Reclamation, Cascade County Conservation District, and the Muddy Creek Task Force, are collaborating to stabilize the gradient and plan form of the stream.
- <u>Siting Low Profile Grade Control Structures for the Muddy Creek Demonstration Stream Restoration</u> <u>Research Project</u>; R.J. Wittler, D.R. Eby, S.D. Keeney, C.C. Watson, S.R. Abt; Abstract: In the Fall of 1993 Reclamation began a demonstration stream restoration research project on Muddy Creek, near Great Falls, Montana. Muddy Creek captures return irrigation flow from a nearby irrigation district. The return flows increase the average discharge in Muddy Creek to eight times the historical mean. The increase in discharge in Muddy Creek since the 1930's has led to severe incision of the channel. In the lower reaches of the creek incision approaches ten meters in elevation. The demonstration stream restoration project includes grade control and lateral control using chevron weir rock ramps and barbs. This paper describes the process of siting the rock ramps based upon a water surface profile of the reach and a site reconnaissance. Siting criteria include discontinuities in the low-water surface profile, identification of a stable reach of the creek for emulation, access for construction, and economics of the project.
- <u>Features of a Chevron Weir Rock Ramp</u>; R.J. Wittler; Abstract: This paper presents the features of a new type of low-profile grade control structure, the chevron weir rock ramp. As the name infers, the planform of the structure is in the shape of a chevron. The weir crest angles with the vertex of the angle pointing upstream. The constituent material is angular rock, sized according to standard riprap sizing criteria. Downstream of the rock weir crest is a ramp of rock, angling the flow towards the center of the structure at
its toe. The first implementation of this type of grade control structure is by Reclamation on the Muddy Creek Demonstration Stream Restoration Research Project. After two seasons in place, nine grade control structures are performing within expectations. In late 1995 Reclamation installed two grade control structures using an evolved design based upon observations and performance of the original design.

- <u>Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, Restoration</u>; In May 1997 the Task Force and Reclamation presented five papers at the conference "Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, Restoration," May 20-22, 1997, Oxford, Mississippi. Reclamation and the Muddy Creek Task Force hosted a session at the conference titled "Western Incised Channel Restoration: Engineering, Biology, and Cultural Resources." The titles, authors, and abstracts from the papers are listed below. Attendance at this conference was funded by Reclamation, not this project.
- <u>Case Study: Muddy Creek, Montana</u>; R.J. Wittler, S.D. Keeney, A.W. Rollo, C.C. Watson; Abstract: The Muddy Creek Task Force under the auspices of the Cascade County Conservation District began a Stream Restoration Project on Muddy Creek in 1993. The Task Force is using the latest stream restoration and watershed planning technology to enhance water quality, fisheries, and wildlife habitat in the Muddy Creek watershed. Reclamation, the Natural Resources Conservation Service, Greenfield Irrigation District, and the Muddy Creek Task Force, are collaborating on the project. This report summarizes progress to date while illustrating the successful implementation of some advanced restoration technology.
- <u>Cultural Resources Considerations for Stream Restoration Projects</u>; R.J. Wittler, M. Andrews, E.I. Friedman; Abstract; Cultural resources are remnants of previous cultures. Traditional methods of archaeology are useful for discovering and investigating cultural resources. Stream restoration projects on public lands or by state or federal officials must by law consider consequences of disturbing cultural resources during restoration activities. This paper discusses management of cultural resources applied to stream restoration projects. Two case studies illustrate cultural resources considerations for stream restoration projects.
- <u>Field Data Plan for Muddy Creek</u>; R.J. Wittler, D.R. Eby, D.L. Burgett, A.W. Rollo; Abstract: This paper describes the evolution of the field data plan for the Muddy Creek Stream Restoration project. The paper includes descriptions of the various types of data collected over the course of the three-year project. An overall view of the project at the beginning is the characteristic of a good field data plan. The overall view should include a thorough search for all previous aerial photography and topography. A search for photographs by local citizens, newspapers, and agencies is very valuable for establishing the condition of the stream and watershed before, during, and after disturbance. Of great use is a high-resolution aerial survey of the project reach at the smallest affordable contour interval. Cross-sectional data, both current and historical, is very valuable from an analysis standpoint. Hydraulic analysis requires cross-sectional data along the reach.
- <u>Building Banks on Muddy Creek With Barbs</u>; R.J. Wittler, S.D. Keeney, D.R. Eby, D.L. LaGrone; Abstract: Barbs are jetties that extend from the bank and angle down into the channel, and upstream into the thalweg. Barbs vary in size depending upon channel size, shape and flow levels. Typical barb construction uses rock whose size primarily depends on stream velocity. Barbs are effective alternative for bank stabilization problems. Barbs build stream banks and create riparian areas by trapping bedload and suspended sediments. Other names of barbs include jetties, toe dikes, habitat sills, and bendway weirs.
- <u>The Muddy Creek Partnership: How to Restore a Stream</u>, A.W. Rollo, D.L. Burgett, R.J. Wittler, S.D. Keeney; Abstract: The Muddy Creek Demonstration Stream Restoration Research Project near Great Falls, Montana

began in 1993. The Project is the result of a cooperative effort and partnership between Federal, State, and County agencies, and a local citizen task force. Together this interagency, interdisciplinary group is working to find solutions to the water quality problems originating in Muddy Creek. The sediment transported by Muddy Creek decreases water quality in the Sun and Missouri Rivers. In 1993, the state of Montana stepped in at the request of concerned citizens to look at ways to resolve the massive erosion problem of Muddy Creek. They were able to bring together a significant number of interested parties that were willing to work together to resolve the water quality problem. At the outset, the partners knew that they could not restore Muddy Creek overnight. They also knew that large amounts of federal dollars would not be available. Thus, they would need new innovative ideas and cost-effective approaches. The partners established a task force as part of a consensus building process. The process allowed for open discussion, and contributes to a feeling of ownership for the outcome of the project. The Muddy Creek Task Force now gives progress reports to a larger group of interested individuals, communities and agencies, concerned with the Muddy Creek sediment issue.

- Muddy Creek restoration and Sun River Watershed Plan Coordination, Alan W. Rollo, Rodney J. Wittler, Sean D. Keeney; Abstract: Muddy Creek is a tributary to the Sun and Missouri Rivers near Great Falls, Montana, USA. This paper discusses the coordination issues between the Muddy Creek Stream Restoration Task Force and the Sun River Watershed Planning group. In the past, the erosion contributed more than 200,000 tons of sediment annually to the Sun River. Recent conservation and restoration efforts have reduced that amount to 40,000 tons per year. Watershed groups and stream restoration projects like Muddy Creek owe their success to dedication of volunteers and the effectiveness of the project or group coordinator. The Muddy Creek project and Sun River Watershed group are true success stories due to the selfless works of people willing to take chances and coordinate efforts. The major objective of the Muddy Creek Task Force and Sun River Watershed group is to implement solutions. The focus remains on small victories, as each becomes important asset for accomplishing long term goals. Dedication to the cause by the representatives of the various interests is necessary. Building public and congressional interest is essential for receiving government support. The Muddy Creek Task Force was first step towards watershed planning and soon became a subset of the Sun River Watershed Planning Group. The larger effort built upon the local success of the Muddy Creek Task Force.
- <u>Restoration and Historic Preservation: Protecting Cultural Resources along a Meandering Stream</u>, R.J. Wittler & M. Andrews; Abstract; Reclamation proposes to preserve archaeological site 24BE529 from erosion by the Red Rock River in southwestern Montana. The Red Rock river is naturally meandering towards site 24BE529, slowly eroding the bank containing the resource. Federal historic preservation laws require Reclamation to address the impact. The preservation plan calls for the installation of three or four Bendway Weirs, also called Thalweg Displacing Barbs. The order of construction excludes all equipment activity in the stream. The barb materials will be large stones, up to 24 inches (61 cm) in diameter, quarried nearby. The bank buttressing material will be smaller stones, less than 12 inches (30 cm) in diameter. A top soil will be placed on both the finished barbs and the bank buttressing material. The soil will be seeded with native grasses and willows, forming a natural looking bank.
- <u>Initial Analysis of Water Quality Changes on Muddy Creek</u>, R.J. Wittler, S.D. Keeney, & A.W. Rollo; Abstract: The Muddy Creek Task Force and the US Bureau of Reclamation constructed eleven grade control structures and more than three-hundred bank stabilization structures between 1994 and 1996 as part of the Muddy Creek Demonstration Stream Restoration project. Under Reclamation sponsorship, the US Geological Survey operates a water quality sampling station at Vaughn, Montana, below the restoration reach of Muddy Creek, and since 1995 at Gordon, Montana, above the restoration reach. Initial water quality data indicates a decline in sediment transport in Muddy Creek over the past 25 years. This paper is an analysis of the initial sediment transportation data from these two gaging stations.

1998 – <u>GID worked for two weeks on Muddy Creek</u> erosion control projects. The work included one week near Vaughn and one week stopping at meander cutoff near Power.

1998, March – <u>Six MAFB volunteers built fences</u> along Muddy Creek.

1998, April – <u>Six MAFB volunteers built fences</u> along Muddy Creek.

1998, May – <u>MAFB volunteers planted trees</u> and laid erosion matting along Muddy Creek.

1998, June 25 – <u>Special Muddy Creek tour</u> with local Montana legislators and landowners to demonstrate progress of erosion control work accomplished to-date and a request to help fund additional work.

1998 - <u>"Muddy Creek – Stream Stabilization Project"</u>; Muddy Creek Task Force, 1998. Latest brochure to describe and show through pictures results of teamwork.

1999 – <u>BoR/Rod Wittler and MCTF, Alan Rollo walked Muddy Creek</u> from approximately Vaughn to just north of Gordan identifying priority sites for GID to install rock structures to control erosion. Property owners of these priority sites were Ingold, Durocher, Wolgemuth, Somerfeld, Neuman, Sherrod, and just north of Vaughn. Several of the sites were maintenance of previous work accomplished.

1999, Winter – <u>1,000 tons of rock hauled to project near Power</u> by Sierra Rock & Dirt. DNRC grant # RRG-00-1091 paid for the rock at a cost of \$13.95/ton for total of \$13,950.





End of reports and data for 1990s.

1990s GRANTS and IN-KIND PROJECTS FUNDING

WHEN (FY)	GRANT PROGRAM and SPONSOR	GRANT	IN-KIND MATCH	FISCAL	PROJECT PURPOSE
1993	Highway Funds (MDT)	-0-	100.000	MDT	Protection of Frontage Road (MDT/Corps)
1993	Special projects (BoR)	100,000	-0-	CCD	Rock, for Muddy Creek erosion control
1993	Contribution (MPC)	6,000	-0-	CCD	Contribution to Muddy Creek erosion control
1994	Riparian Enhancement (FWP)	15,000	15,000	CCD	Fencing, trees, off-stream waters
1995	Muddy Creek Project (DNRC)	300,000	233,237	CCD	#RIT-96-8594 - Rock for erosion control projects
1995	Sun River & Muddy Creek Monitoring (EPA)	49,000	unknown	CCD	Water quality monitoring
1995	Research project; #5-FG-60-06020 (BoR)	10,000	-0-	BoR	#5-FG-60-06020 - Aerial survey of Muddy Creek
1995	GID Water Improvement, RRGL (DNRC)	-0-	-0-	GID	GID canal checks - \$100,000 gave back, change of manager
1994-1996	Muddy Creek Restoration (DEQ/EPA)	101,750	208,928	CCD	#250013 - Muddy Creek stream project and coordinator pay
1996	Muddy Creek Restoration	41,000	91,774	CCD	#96-156 - Muddy Creek Demonstration Restoration
	(Fish & Wildlife Foundation)				
1997	GID Water Improvement, RRGL (DNRC)	-0-	-0-	GID	J-lake project - \$100,000 gave back due to sink hole
1998	J-lake study, special funds (BoR)	-0-	-0-	BoR	J-lake project - \$1 million gave back due to sink hole
1998	Spring Coulee, Lee; Future Fisheries (FWP)	16,000	30,000	Lee	Erosion control on tributary Spring Coulee
1999	Research project (BoR)	50,000	-0-	BoR	BoR engineer help with designs
1999	Research project (BoR)	2,360	5,200	BoR	Muddy Creek crossing
1999	GID Water Conservation (BoR)	20,000	20,000	GID	Special Muddy Creek project assistance
тот	711,110	704,139			

Table 2. 1990s Grants and Funding

Muddy Creek 2000s – CONTINUED PROJECTS PHASE

NOTE: The following summarizes reports and special projects that took place from 2000 to today.

1999-2004 – <u>Kings vs. Ratliff lawsuit</u>. In September 1999 the Kings filed suit against Ratliffs for excess irrigation runoff causing erosion AND contamination of ground water. The contamination of ground water litigation was dropped due to lack of evidence. In 2002, the District Court ruled in favor of the Kings. In 2004, the Montana Supreme Court upheld the District Court's ruling.

2000 - <u>Marc Lee's Spring Coulee project</u>. <u>"Spring Coulee Bank Stabilization - Fisheries Evaluation 1998 – 1999",</u> <u>Montana Department of Fish, Wildlife & Parks, November 2000</u>. This report documents fish numbers on a stream restoration project that FWP helped pay for through a Future Fisheries grant.

2000 – Marc Lee's Spring Coulee project included a crew of 8 college youth from April 24 – 27 planting 1,350 trees.

2000 – <u>"Assessment of Water Quality for the Sun River and Muddy Creek, Sun River Watershed, West-Central</u> <u>Montana"</u>, MBMG Open-file Report 412, Montana Bureau of Mines and Geology, July 2000. The data in this report helped in determining if the listed impairments are supported by sufficient and credible data. Also, it was used to help develop a TMDL for the Sun River Watershed.

2000-2002 – <u>Muddy Creek project; # RRG-00-1091 (DNRC);</u> Cascade Conservation District <u>awarded \$77,000</u> for continuation of Muddy Creek erosion control work.

1) over 165 rock barbs over the 10-mile river reach were placed by in-kind services

2) installed over 7 miles fencing to help riparian corridor. planted over 1,000 trees and seeded all disturbed banks.

3) Monitoring continued over 40 miles of Muddy Creek. Key tools were: 1) USGS continued to monitor flows and water quality at two key sites on Muddy Creek 2) Bureau of Reclamation helped monitor flows at six additional sites on Muddy Creek tributaries and on Muddy Creek, and 3) an aerial survey was completed and photopoints continue to be used for long-term progress documentation.

2000-2002 - <u>EQIP Priority Area Proposal; Spring Coulee South</u>; Teton County; Prepared by: Stacy Denny Eneboe, John Streich, Cari Ostberg, and Alan Rollo. A steering committee of 5 local landowners helped give direction on this proposal. This project was supposed to be a multi-year effort so all the contracts with local landowners would not be at one time but after only <u>one year of funding (\$300,000</u>), NRCS was unable to acquire any more money. Local Working Group met on March 5, 2002 and finalized the follow goals for this proposal:

- 1) Improve irrigation efficiencies by 20%
- 2) Reduce irrigation return flows by 20%
- 3) Maintain base flows in Spring and Tank Coulees to 10 cfs
- 4) Increase fish populations to 50 trout/mile in 10 yrs.
- 5) Reduce streambank erosion by 40%
- 6) Reduce sediment loading by 30%
- 7) Reduce Assert levels to within label expectations
- 8) Improve range trend from a negative to a positive
- 9) Improve native plant health and vigor on 50% of the area
- 10) Control noxious weeds on 50% of the infested acres

2001 – <u>Larry Beerman's Spring Coulee project</u> included GID crew sloping banks and installing rock barbs. NRCS designed a livestock stream crossing for Larry Beerman's Spring Coulee project. MCTF supplied the rock for the project.



2001 – <u>Arial topographic survey accomplished by Morrison Maierle, Inc./Horizons, Inc.</u> NRCS accomplished overlay of the two flights to show changes between 1995 and 2001. Aerial survey project went from confluence of Sun River to the Muddy Creek Gordan bridge at cost of \$10,000.

2002 – <u>"Estimated suspended-sediment discharge (loads) for Muddy Creek near Vaughn and Muddy Creek at Vaughn</u> for water years 1997 through 2001", U.S. Geological Survey, June 2002. The USGS computed load estimates between sediment load and streamflow to generate daily sediment loads.

2002 - "Ground-Water and Surface-Water Quality. Herbicide Transport, and Irrigation Practices: Greenfields Bench Aquifer, Teton County, Montana", MBMG Open-file Report 463, Montana Bureau of Mines and Geology, 2002. The study evaluated water quality issues related to chemical use on the Fairfield Bench.

2002 - <u>"A TMDL Approach to Muddy Creek;</u> J. W. Bauder, Professor, and Holly Sessoms, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2002. REPORT HIGHLIGHT: Evaluation of Muddy Creek data and best solutions to control erosion. Suggested looking more closely at Muddy Creek tributaries to control flows.

2002 - <u>"Section 319 Success Stories Vol III</u>"; EPA, February 2002. REPORT HIGHLIGHT: The EPA gave compliments to the Muddy Creek effort and how their 319-grant program was a key reason for the success.

2002-2004 - <u>Sun River Basin/Sun River Watershed - Phase III Grant #202082</u>; U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by Cascade County Conservation District<u>; \$99,800 grant funds</u>; \$1,409,278 match. Project results included: reduced sediment load by approximately 7,500 yards per year with 50 rock barbs; 15,600 feet of fencing installed; 1,000 trees planted and one grazing workshop to 20 producers; Reregulating reservoir has been partially installed and is controlling excess return flows. Monitoring of water quality and quantity took place over two-year period at 3 USGS sites and 12 MSU sites.

2003 – <u>Briefing Paper on Benton Lake Siphon Project</u>, MCTF, February 2003. This point paper was developed by the MCTF for the Montana Congressional delegation and other partners requesting support to obtain necessary resources/funds to install a siphon using GID tailwater before it enters Muddy Creek to deliver water to the Benton Lake NWR. Estimated project cost for preferred option was \$2.8 million. Benefits was the Refuge would have a reliable source of clean water without any pumping cost and Muddy Creek would see an inflow reduction of approximately 20 cfs during the irrigation season.

2004 – <u>Muddy Creek projects assessment</u> by BoR, Sean Keeney and MCTF, Alan Rollo. They walked almost the entire reach of Muddy Creek from Vaughn north to Spring Coulee to identify what sites need additional work and where no work is needed.

2004 – <u>"Muddy Creek Flow and Sediment Study",</u> J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2004. MSU produced Muddy Creek Flow and Sediment study for BoR, MOU No. 99-FC-60-1144, to determine sources and amounts of flow and sediment entering Muddy Creek. See attached charts for summary of data acquired.



2004 – <u>US Fish & Wildlife Service streambank work</u> accomplished at their Muddy Creek pump site. At USFWS request, MCTF tried to find some large trees to be used as revetments but what was found did not work for them. USFWS contracted out the restoration project.



2004 – SRWG requested; GID approved request to fence part of GID pasture #43 to allow riparian area along Tank Coulee to recover from being overgrazed. SRWG hired MCC crew to fence the pasture.





2004 - "Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River Planning Area". Montana

<u>Department of Environmental Quality, December 2004.</u> This document describes water quality conditions and restoration strategy for the Sun River and tributary, Muddy Creek.



2004-2006 – <u>Muddy Creek Water Quality Implementation Project</u> - <u>Grant #204076</u>; U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by Cascade County Conservation District; <u>\$80,000 grant funds</u>; \$383,250 non-fed match; \$34,550 fed match.

2004-2006 – <u>Richard Allen Muddy Creek project.</u> GID placed rock barbs on Richard Allen's property that is just north of Vaughn. MCTF supplied the rock. Richard Allen also placed a large culvert for a crossing in a coulee entering Muddy Creek. This coulee is where SRVDC dumps their irrigation tail water.

2005 – <u>Benton Lake survey and design</u>. NRCS and CCD accomplished a detailed survey for the proposed Benton Lake NWR siphon project. BoR used the survey data to put together a draft siphon design.



2005 – <u>"Mill Coulee and Muddy Creek Water Quality Assessment Project"</u>, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2005. The intent of this project was to determine whether projects, programs and practices implemented within the Mill Coulee and Muddy Creek watersheds resulted in definitive or quantifiable changes to Mill Coulee and Muddy Creek water quality and quantity. Data evaluation on next page.

The following table provides a summary of differences in identified water quality
and quantity characterizations between Post-EQIP vs. Pre-EQIP conditions. Decrease or
increase is reported only for those comparisons where the level of difference between pre
and post-EQIP means was determined to be significant at the 0.05 probability level.

Parameter or flow characterization x flow regime	Low Flow	Moderate Flow	High 1 Flow	High 2 Flow	Composite Flow
Conductivity in MC @ Vaughn; (uS/cm)	decrease	no difference	decrease	decrease	<u>decrease</u>
Conductivity in MC @ Gordon; (uS/cm)	decrease	decrease	no difference	<u>decrease</u>	<u>decrease</u>
Nitrate + Nitrite - N in MC @ Vaughn; (mg/L)	no difference	no difference	no difference	no difference	no difference
Nitrite + nitrate - N in MC @ Gordon; (mg/L)	<u>decrease</u>	<u>decrease</u>	no difference	<u>decrease</u>	<u>decrease</u>
Phosphorus in MC @ Vaughn; (mg/L)	<u>increase</u>	<u>increase</u>	<u>increase</u>	increase	increase
Suspended Sediment Concentration in MC @ Vaughn; (mg/L)	no difference	no difference	decrease	<u>decrease</u>	<u>decrease</u>
Suspended Sediment Concentration in MC @ Gordon; (mg/L)	<u>decrease</u>	<u>decrease</u>	<u>decrease</u>		<u>decrease</u>
pH in MC @ Vaughn	no difference	no difference	<u>increase</u>	increase	increase
Selenium in MC @ Vaughn; (ug/L)	decrease	no difference	decrease	decrease	<u>decrease</u>
Flow characterization x hydrologic period of annual hydrograph	January- March	April - May	June - August	September - December	
Cumulative flow in MC @ Vaughn (acre-feet)	no difference	no difference	no difference	no difference	
Difference between monthly max and min flows @ Vaughn (cfs)	no difference	decrease	no difference	no difference	
Daily mean flow @ Vaughn (cfs)	no difference	no difference	no difference	no difference	

2005 – <u>"Muddy Creek Follow-up Project"</u>, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; <u>Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2005</u>. This study helped pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.



2005 – "Sun River Watershed Water Quality Monitoring Project", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, July 2005. Study helped understand water quality conditions in the Sun River and tributaries which included Muddy Creek.





2006 – <u>Skip Neuman Muddy Creek above Gordan project</u>. GID installed rock barbs on Muddy Creek banks above Gordan. Rock furnished by MCTF.

2006 – <u>Roland Durocher Muddy Creek near Vaughn/Frontage Road project</u>. GID installed 10 rock barbs on Muddy Creek banks near Vaughn/Frontage Road. Rock furnished by MCTF.

2006 – *"Muddy Creek Project - 2006"*, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2006. This study helped pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.













2007 – <u>"Muddy Creek Flow & Sediment Study - 2007"</u>, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2007. This study helped pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.





Figure 9. Flow and sediment calculations for the 2007 monitoring stations.

Figure 7. Average daily flows for stations in Tank Coulee from Middle Tank Coulee to Lower Tank Coulee, and tributaries from Middle Tank Coulee to Lower Tank Coulee, 2007. 2008 – <u>"Muddy Creek Flow & Sediment Study - 2008"</u>, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2008. This study helped pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.





Figure 7. Spring Coulee – Daily flow changes between Upper and Lower monitoring sites and daily flows in Upper Spring Coulee and Lower Spring Coulee, 2008.

2009 – <u>Skip Neuman Muddy Creek above Gordan project</u>. GID installed rock barbs on Muddy Creek banks above Gordan. Rock furnished by MCTF. MCTF also tried installing straw bales along bank where GID equipment could not reach. Straw bales did not hold.

2010 – "Upper Muddy Creek Water Quality Investigation", Adam Sigler, Department of Land Resources and Environmental Sciences Montana State University – Bozeman, January 2011. This study was preliminary data collection to provide baseline data for future projects.



2010 - <u>Sun River Watershed WQRP Implementation; EPA Grant # Sg-97868801</u>; Sponsored by SRWG; <u>\$68,674 grant funds;</u> \$83,950 match. Project Summary: Four miles riparian fencing installed on tributary to Muddy Creek; 75 rock barbs on four miles of highly erosive banks; Banks sloped and erosion matting installed on 200 feet of eroding bank; Pump back unit that will capture 5 cfs of irrigation tail water before it reaches Muddy Creek; Two USGS and three MSU and DNRC monitoring gauges; SRWG keeping partners informed of project status at monthly board meetings.

2011-2015 - Muddy Creek Restoration Project; Grant # 211079; SECTION 319 NONPOINT SOURCE POLLUTION CONTROL

PROGRAM. The following tasks for grant <u>award of \$59,694</u> completed in support of this goal:

- 48 monthly SRWG board updates on project status, budget and work plan
- A Quality Assurance Project Plan (QAPP) to guide long-term water quality trend monitoring in the Sun River watershed
- Salinity project area map developed
- Salinity project area Sampling Analysis Plan (SAP) developed
- Salinity water Quality monitoring accomplished with a stand-alone report of results
- Salinity study report
- 15 Saline Seep reclamation plans
- Watershed tour on September 26, 2014 reaching a total of 3 people
- 2 educational workshops reaching a total of 26 people

2012 – <u>Skip Neuman Muddy Creek meander cutoff project</u>. GID installed 8 rock barbs on a Muddy Creek meander that is almost ready to cut through</u>. Shale rock furnished by landowner.

2012 – <u>Muddy Creek Bank Erosion Adjacent to BNSF Railroad Embankment meeting</u> between CCD, SRWG, BNSF and Shannon & Wilson, Inc. on January 24, 2012. This special meeting was at the request of BNSF engineers to discuss best options for BNSF to protect their railroad along Muddy Creek while be compatible with past stream projects. Despite BNSF engineer's advice, BNSF decided not to pursue or cooperate with the MCTF on Muddy Creek erosion projects. Their perspective is to wait until there is a real emergency, then accomplish an emergency fix.

2012-2015 - Improving GID Water Management to Improve Sun River Flows; Reclamation Grant # R12AC60055;

sponsored by Greenfields Irrigation District; grant \$262,565; total project \$540,395. The grant paid for a new pump back and pipeline to reuse wastewater that currently enters Muddy Creek which causes huge erosion and water quality problems in the Sun River basin.



2013 - <u>Muddy Creek Tributaries Riparian Improvements; DEQ 319 grant #213028</u>; sponsored by: Sun River Watershed Group; <u>grant \$87,000</u>. Contract was started in 2013 SRWG made some progress towards the intent of the project to reduce animal waste into Muddy Creek tributaries but not enough to actually put projects on-the-ground in a timely manner. Gave all money back to DEQ.

2014– present - <u>Greenfields Irrigation District Water Conservation; Reclamation Grant # R14AS60055</u>; sponsored by Greenfields Irrigation District; <u>grant \$100,000</u>. Project is to modify GID's J-wasteway structures to reduce wastewater into Muddy Creek. DNRC delayed this project because of their interpretation of water rights. PROJECT IS NOT COMPLETED YET.



2014 - <u>"Sun River Valley History II"</u>; Sun River Valley Historical Society, 2014. The book documents the history of the Sun River Valley.

2016 – <u>Skip Neuman Muddy Creek meander cutoff redo project</u>. GID had to repair 6 existing rock barbs on a Muddy Creek meander that is almost ready to cut through again. Rock furnished by MCTF. Appears the barbs spacing was too wide allowing current to erode bank between barbs.

Unknown date – GID installed rock barbs on Muddy Creek with landowner furnishing rock.

WHAT NEXT: On October 18, 2017 representatives from GID and area landowners toured the Muddy Creek to discuss the need to accomplish more erosion control projects and canal flows. The tour participants agreed on a plan of action including: 1) lowering canal flows; 2) compile all past data into a report summary for all interested parties to ensure everyone stays on the same page; 3) find funds and then hire qualified firm to accomplish an assessment of the Muddy Creek to identify what past erosion control projects are or are not working and what future erosion control projects are needed; 4) participants meet to prioritize projects identified in the assessment; and 5) project participants start work as soon as possible on erosion control projects, such as the one shown below, prioritized by the group.

End of reports and data for 2000s.

2000s GRANTS and IN-KIND PROJECTS FUNDING

WHEN (FY)	GRANT PROJECT and SPONSOR	GRANT	IN-KIND	FISCAL	PROJECT PURPOSE
		AMOUNT	MATCH	AGENT	
1999-2002	Muddy Creek project; # RRG-00-1091 (DNRC)	77,000	281,932	CCD	Muddy Creek erosion control projects continuation
2001	EQIP - Spring Coulee South; (NRCS)	Unknown	Unknown	NRCS	On-Farm irrigation improvements -
2001	Muddy Creek project, Schaefer; Future Fisheries (FWP)	13,750	12,189	Schaefer	Upper Muddy Creek stream project
2000-2002	Fairfield Bench – Ground water; # 270068 (EPA/DEQ)	135,929	71,845	TCD	MBMG Fairfield Bench study of ground water quality
2000-2002	Fairfield Bench – Surface water; # 280099 (EPA/DEQ)	117,224	43,228	TCD	MBMG Fairfield Bench study of surface water quality
1999-2004	Sun River Basin Project Phase III; #290079 (EPA/DEQ)	135,480	1,959,690	SRWG	Muddy Creek stream projects and coordinator. Grant also included some funds for other Sun River tributaries projects.
2002-2004	Sun River Basin TMDL; #202082 (EPA/DEQ)	99,800	1,409,278	CCD	Muddy Creek stream projects and coordinator. Grant also included some funds for other Sun River tributaries projects.
2004-2006	Muddy Creek Water Quality Implementation Project; # 204076 (EPA/DEQ)	80,000	417,800	CCD	Muddy Creek stream projects and coordinator pay
2008-2012	Muddy Creek Wastewater & Erosion Reduction Project; # RRG-08-1332	100,000	135,155	GID	Pump was installed reuse tailwater and reduce wastewater entering Muddy Creek
2007-2010	SRW WQRP Implementation; # SG-97868801 (EPA)	68,674	83,950	SRWG	Muddy Creek stream projects, USGS gages and coordinator pay
2011-2015	Muddy Creek Restoration Project; # 211079 (EPA/DEQ)	59,694	49,405	SRWG	Muddy Creek saline seep assessment and coordinator pay. There was another \$41,000 available to address animal waste but was returned due to non-project complications.
2013-2015	Muddy Creek Tributaries Riparian Improvements; #213028 (EPA/DEQ)	0	0	SRWG	Muddy Creek stream projects and coordinator pay. There was \$87,000 available to address animal waste but was all returned due to non-project complications.
2012-1015	Improving GID Water Management; # R14AC60055 (BoR)	262,565	277,830	GID	McAlpine pump change, reduce wastewater into Muddy Creek
2014- IW	Improving GID Infrastructure; # R14AP00092 (BoR)	97,000	IW	GID	J-Wasteway project to reduce wastewater into Muddy Creek
1	TOTAL FUNDS ACQUIRED in 2000s	1,247,116	4,742,302		

Table 3. 2000s Grants and Funding

Sun River/Muddy Creek Watershed Maps

Sun River Watershed with Muddy Creek Location



Figure 1. Map Depicting Sun River Watershed with Location of Muddy Creek drainage







Figure 3. Aerial Map of Muddy Creek Watershed

Muddy Creek Watershed

Aerial Map with GID Boundary



Figure 4. Aerial Map of Muddy Creek Watershed (red) with GID Boundary (pirk) overlapping

Aerial of <u>Worst</u> Eroding Reach



Figure 5. Aerial of Worst Eroding Reach of Muddy Creek

Muddy Creek Watershed

Projects Location Map



Figure 6. Projects Locations on Muddy Creek

Muddy Creek Watershed

"Grade Control" Structures in Demo Reach #1



Figure 7. Grade Control Structures Locations in Demo Reach #1 on Muddy Creek

NOTE: See next page for grade control structure basic facts

Muddy Creek Grade Control Structures Facts

NAME	STATION	POINT	ELEVATION CHANGE	CHANNEL WIDTH/FT	ROCK VOLUME/YDS	COMPLETION	COMMENTS
CORPS	54+40	10-12				1994	Elevation @ 3,354.2
1A	60+55	16	1-foot drop	80	200.0	1994	Had repair on right groin
1B	72+15	26	1-foot drop	81	202.5	1994	
1C	84.70	43	1-foot drop	51.5	128.8	1994	Had repair on left groin
1D	121+60	82	1-foot drop	90.5	226.3	1994	
1E	145+60	95	1-foot drop	93	232.5	1994	
1F	?	?	1-foot drop	?	?	1994	
2A	178+00	131	2-foot drop	87	304.5	1994	Scour hole below & repair on right side
2B	199+15	162	2-foot drop	99	346.5	1994	Widened groin to reduce scour
2C	211+60	173	2-foot drop	100.5	351.8	1994	
2D	225+00	197	2-foot drop	113	395.5	1994	
3A	?	?	3-foot drop	?	300.0	1995	Was suppose to only be 2-ft drop
3B	?	?	3-foot drop	?	?	1995	Was suppose to only be 2-ft drop
Cut 1	?	73-77	?	?	?	1994	

Muddy Creek

USGS Monitoring Data – Location & Periods of Record

--- Stream Gage Number and Location ---



----- Stream Flow Gage Data -----

- Muddy Creek near Power 1935, April to 1983, October
- Muddy Creek near Vaughn 1968, June to 2007, October
- Muddy Creek at Vaughn:
 - 1925, May to 1926, February
 - 1934, April to 1968, September
 - 1971, July to present

---- Suspended Sediment Data ----

- Muddy Creek near Vaughn 1968, June to 1982, September
- Muddy Creek at Vaughn 1971, July to 1982, September

----- Chemical Analysis Data -----

- Muddy Creek near Power 1982, July to 1992, April
- Muddy Creek near Vaughn 1968, July to 2007, August
- > Muddy Creek at Vaughn:
 - 1967, October to 1968, September
 - 1972, July to 1982, September



Muddy Creek Flow Charts



Muddy Creek Sediment Charts



Chart 2. Muddy Creek Sediment Data Charts

Muddy Creek at Vaughn

Annual Peak Streamflow by Water Year



#2 - June 9, 1964 – 3,750 cfs #3 – May 7, 1975 – 3,830 cfs #4 – May 22, 1981 – 3,910 cfs

Chart 3. USGS Muddy Creek at Vaughn Peak Flow Chart

Fairfield Bench Geology



Figures 14. Fairfield Bench Geology

Ground-Water Flow Direction

December 1998 - ground water is discharging to Muddy Creek





Muddy Creek

Barb Design



Figure 6. Plan of barbs in series.

Figure : shows the process of barbs displacing the thalweg and main current away from the toe of a nearly vertical bank. The deposition between the barbs has two sources, sediment and caved bank material. Seeding and willow post planting in combination with fencing and grazing management accelerates bank stabilization. The barbs in Figure 7 are defensive in nature. The bank in the right of the picture is less than 4 meters thick. The upstream loop of the meander is on the other side of the bank. The meander loop was physically moved to prevent a cutoff from the upstream direction.

Figures 16. Rock Barb Design

Muddy Creek Ramp Design

Second Generation Structure Design

Figure is a profile and plan view of the redesigned rock ramp. In the second generation design, an arch replaces the chevron at both the upstream weir and downstream toe.



Figures 17. Ramp Design

Muddy Creek

GRANTS and IN-KIND PROJECTS FUNDING

--- Totals Summary ---

WHAT DECADE	DECADE ACTIVITIES	TOTAL GRANT AMOUNT	TOTAL IN-KIND MATCH
1960s	Beginning	unknown	unknown
1970s	Studies Phase	unknown	unknown
1980s	1 st MCTF Actions and Studies Phase	3,270,728	9,578,502
1990s	2 nd MCTF Actions Phase	711,110	704,139
2000s	Continued Actions Phase	1,247,116	4,742,302
	TOTALS ->	5,228,954	15,024,943

Table 4. Grants and Funding Summary

Muddy Creek - Pictorial History

1936 - Olden Days before Major Erosion





Olden Days – Start of Erosion





1960s - Erosion Problems – Real Bad Now















1960s – Sediment View in Sun and Missouri Rivers



Muddy Creek entering Sun River



Sun River entering Missouri River



Sun River entering Missouri River



Missouri River above Black Eagle dam

Early 1980s – Irrigation Improvements





Newly poured concrete lined ditch



Automated ditch turnout unit



Newly installed pivot under program

Early 1990s – No noticeable improvement

Eroding Banks









1990s – Muddy Creek – Preparing for Change

Surveying for Projects













1990s – Muddy Creek Changing - GID Work


















1990s – Muddy Creek Crossing - GID Work







1990s - Muddy Creek Change - Volunteers Work



















Stray bales - attempt to control erosion on very tall banks

1990s – Muddy Creek Looking Better



Muddy Creek – Continuing to Change





Riparian Fencing Project



Muddy Creek Tributaries – Changing Also



Muddy Creek - Other Projects







Muddy Creek

Referenced Documents

Key Studies and Reports about Muddy Creek

"The Journals of Lewis and Clark – 1804-1806"; Meriwether Lewis and William Clark, 1804-1806. JOURNAL HIGHLIGHT: Describes the expedition's first encounter and reaction on condition of the Sun River.

<u>"Eleventh Annual Report of the USGS – 1889-1890 – Part II – Irrigation</u>"; USGS, 1891. REPORT HIGHLIGHT: USGS surveys potential irrigation sites which included Sun River area.

1935-1983 - <u>Muddy Creek Discharge, Water Quality Data and Suspended Sediment</u>. U.S. Geological Survey.

<u>"Reconnaissance Report on Sun River Basin – Sub-Basin Report No. 13";</u> Bureau of Reclamation, June <u>1942.</u> REPORT HIGHLIGHT: This report was a thorough evaluation of where/if additional storage and irrigated lands was possible in the Sun River Basin.

1946 - <u>Missouri River water quality survey</u>. (NOT FOUND) referenced in the <u>*"Pollution Studies of the Missouri River in the Great Falls Area"*, Montana State Board of Health Report, November 26, 1957.</u>

<u>*"Reconnaissance Report – Sun-Teton Division";* Bureau of Reclamation, March 1956.</u> REPORT HIGHLIGHT: Report was a follow-up evaluation of where/if additional storage and irrigated lands was possible in the Sun and Teton River Basins.

<u>"Pollution Studies of the Missouri River in the Great Falls Area"</u>, Montana State Board of Health Report, <u>November 26, 1957</u>. REPORT HIGHLIGHT: Investigation primarily focused on obtaining data on the water quality in the Missouri River downstream of Great Falls.

"Memorandum of Understanding between the Bureau of Sport Fisheries & Wildlife and the Bureau of Reclamation"; April 28, 1958. REPORT HIGHLIGHT: Use of Muddy Creek water for Benton Lake.

<u>"Geology of the Vaughn Quadrangle, Montana"; USGS, 1961.</u> REPORT HIGHLIGHT: Geology for this region.

<u>"Water Resources Survey – Cascade County, Montana"; State Engineers Office, June 1961.</u> REPORT HIGHLIGHT: Summary of irrigated lands in Cascade County, Montana.

<u>"Water Resources Survey – Teton County, Montana"</u>; State Engineers Office, June 1962. REPORT HIGHLIGHT: Summary of irrigated lands in Teton County, Montana.

<u>*"Water Quality Control Study – Sun-Teton Unit, Montana*; Federal Water Pollution Control Administration, July, 1966</u>. REPORT HIGHLIGHT: Bureau of Reclamation requested the Federal Water Pollution Control Administration participate with planning for possible construction of three more dams on the Sun River.

<u>*"Muddy Creek Study"*</u>, Bureau of Reclamation, 1967. REPORT HIGHLIGHT: Investigation primarily focused on obtaining estimates of salt pick-up from the irrigated bench lands. Also provided some flow data and field observations of sediment problems.

<u>"Sun River Sediment Problem</u>", Bureau of Reclamation, 1970. REPORT HIGHLIGHT: Study describes problems of erosion in the Muddy Creek channel and identifies lower reach from Gordan to Vaughn as in serious condition. Also, states the need of a preliminary investigation to determine possible corrective measures.

"Water Pollution Control in Cascade County", Montana Department of Health and Environmental Sciences, December 1972. REPORT HIGHLIGHT: Majority of report focused on classification of streams and sewage discharges but also references effects of farming practices on water quality have only been determined in one area which was Greenfields Bench irrigation project which returns water to Muddy Creek.

<u>"Muddy Creek, Montana--Streambank Erosion Control Alternatives";</u> U.S. Army Corps of Engineers, <u>September 1979</u>. (NOT FOUND)

"Muddy Creek: A Pollution Study", Proceedings of the Montana Academy of Sciences 32: 58-65, Eugene Johnson, 1972. REPORT HIGHLIGHT: Purpose of study was to investigate the extremely silt laden stream, Muddy Creek, at Vaughn, Montana, along with the detrimental effect it produces in the Sun River and the Missouri River.

1972–1980 - <u>Muddy Creek Water Quality Data</u>. MT Department of Health and Environmental Sciences, 1972-1980.

1973, September 27 – <u>Aerial photos of Muddy Creek</u> documenting erosion. (NOT FOUND) Where at & who took?

<u>"Information on Muddy Creek Erosion Problem"</u> Sun-Teton Division; Pick-Sloan Missouri River Program; Montana; April 1974. REPORT INTRODUCTION: Purpose of this information summary is to present information pertaining to and resulting from an appraisal study of possible solutions to the silt-deposition problem from Muddy Creek into the Sun River.

<u>"Water Quality Inventory and Management Plan – Missouri-Sun-Smith River Basin, Montana"</u>; Water Quality Bureau, Environmental Sciences Division, Montana Department of Health and Environmental Sciences; August 1974. REPORT INTRODUCTION: Report presents information relative to the water quality and water quality inventory and management in the Missouri-Sun-Smith basin with identification of Muddy Creek as the cause of water quality issues in the Sun and Missouri Rivers "because of high sediment loads due principally to poor irrigation practices in the Muddy Creek drainage".

<u>"Montana Water Resources Development"</u>; Corps of Engineers, 1975. REPORT HIGHLIGHT: Describes results and damages of the 1964 flood as a reason to relocate the Muddy Creek channel near Vaughn and construction of a levee.

<u>"Water Quantity and Quality of the Sun River from Gibson Dam to Vaughn, 1973-1974"; Montana</u> <u>Department of Fish and Game; May 5, 1976</u>. REPORT INTRODUCTION: Study of the Sun River from Gibson Dam to Vaughn conducted from April to September 1973 and from April to October, 1974. <u>"Proposed rehabilitation and Betterment Program for Greenfields Irrigation District"</u>, <u>Bureau of</u> <u>Reclamation, June 1976</u>. REPORT HIGHLIGHT: Result of past studies conducted by the Bureau of Reclamation; R&B program is proposed for Greenfields Irrigation District.

"Montana Water Quality Bibliography 1974 – Summer 1977"; Statewide 208 Planning; Montana Department of Health and Environmental Sciences; 1977. REPORT INTRODUCTION: This work updates information about water quality in Montana to mid-1977. The management plan relating to Muddy Creek were as follows: clearly, major problem of concern is high sediment load in the lower Sun River.

<u>"Boots and Shovels – A History of the Greenfields Irrigation District, Division of the Sun River Project,</u> <u>Fairfield, Montana"; The Fairfield Sun Time, 1978</u>. BOOK HIGHLIGHT: Gives a very thorough compilation of this area's history through the eyes of local people who lived in those times.

"Corps Supplemental Environmental Statement"; Sun River Flood Protection Project, Great Falls, Montana; U.S. Army Engineer District; January 1978. REPORT HIGHLIGHT: Primary purpose of environmental review was to consider a levee in the Great Falls area to address public concern of the 1975 flood impacts. Also discusses fisheries impacts because of the heavy silt load entering the Sun River from Muddy Creek.

"Statewide Water Quality Management Plan"; Statewide 208 Water Quality Management Planning Project; Montana Department of Health and Environmental Sciences; 1978. REPORT BACKGROUND: Plan identifies significant sources of water pollutants with Muddy Creek as one of the major nonpoint source problems in the entire statewide area.

<u>"Enterprise Costs for Irrigated Crops – Fairfield Bench in Teton County";</u> Cooperative Extension Service, <u>February 1978.</u> REPORT HIGHLIGHT: Was a summary of production inputs to produce irrigated crops.

<u>"Biological Conditions of the Sun River and Muddy Creek"</u>, Montana Department of Health and <u>Environmental Sciences; 1979</u>. REPORT HIGHLIGHT: Revealed large concentrations of algal nutrients (nitrogen and phosphorus) in the Sun and Muddy waters.

<u>"Biological Water Quality Monitoring – Northcentral Montana, 1977-1978"</u>; Montana Department of <u>Health and Environmental Sciences, March 1979.</u> REPORT HIGHLIGHT: Water quality indicators were used to develop a composite rating on biological conditions.

<u>"Muddy Creek Special Water Quality Project"</u>; Systems Technology, Inc; November 1979. REPORT HIGHLIGHT: Teton and Cascade Conservation Districts hired Systems Technology to complete a report of relevant Muddy Creek data and provide recommended solutions to the erosion problem.

1979, November 7 – <u>Montana Association of Conservation Districts (MACD) passes resolution</u> as their annual meeting supporting the pursuit of collaboration and federal funding for the Muddy Creek project.

<u>"Muddy Creek Property Owner Affects from Sediment Waters</u>"; unknown author, December 6, 1979. REPORT HIGHLIGHT: Summarizes financial impacts to landowners that live along Muddy Creek.

<u>"Evaluation of Channel Erosion Structures for Muddy Creek"</u>; Corps of Engineers, 1979. REPORT HIGHLIGHT: Corps review using stone revetments, stone-filled interceptor trenches and reopening old meanders to reduce channel slope.

<u>"Costs and Benefits of Muddy Creek Project"</u>; Systems Technology, Incorporated, December 1979. REPORT HIGHLIGHT: Using segments of their earlier report on specific costs for project implementation.

<u>"Muddy Creek Story – 1980s Workgroup Information"</u>; many authors; 1979-1987. Notebook of Muddy Creek meeting minutes and financial information.

<u>"Statewide 208 Newsletter to Achieve and Preserve Clean Waters – Issue #20"; Montana Department of Health and Environmental Sciences, January-February 1980.</u> Newsletter highlighted a tour of Muddy Creek and project funding.

<u>"Report and Evaluation of the Muddy Creek Problem Area near Great Falls, Montana"; David Carter,</u> <u>March 1980.</u> REPORT HIGHLIGHT: Summarizes current status of Muddy Creek Task Force work and recommendations of how to move forward.

<u>"Statewide 208 Newsletter to Achieve and Preserve Clean Waters – Issue #21"; Montana Department of</u> <u>Health and Environmental Sciences, March-April 1980.</u> Newsletter highlighted under special projects how the Muddy Creek effort just keeps rollin' along.

<u>"Technical Assistance Report – Muddy Creek Task Force";</u> Dr. Arthur Hornsby, EPA, April 9, 1980. REPORT HIGHLIGHT: Reviews preliminary studies and recommend future direction.

<u>"Upper Missouri River Basin Level B Study</u>", Missouri River Basin Commission, April 1980. REPORT HIGHLIGHT: Major objective to develop 15-20-year plan coordinating water and related land use management; identifying major water quality problems in state including Muddy Creek where excessive erosion and sedimentation degrade water quality.

"Program for the Conservation of Teton County's Natural Resources"; Teton County Conservation District, April 1980. REPORT HIGHLIGHT: Identifies natural resource issues within Teton County.

"Appraisal of the Problem and Strategy for Federal Agency Action on Muddy Creek", SCS Technical Field Committee, 1980. REPORT HIGHLIGHT: Describes alternative solutions of the Muddy Creek erosion problem, proposes further analysis of recommended solutions, describes the scope of work that is required to define at feasibility grade level of solving problem.

<u>"Water Quality Sampling of Domestic Wells"</u>; John Andrews, August 1980. REPORT HIGHLIGHT: Summarized wells data sampled in August 1980.

"Simulation of Water-Quality Data at Selected Stream Sites in the Missouri River Basin, Montana"; USGS <u>Report 80-76, September 1980</u>. REPORT HIGHLIGHT: Describes statistical water quality data evaluation.

<u>"Water Quality in Montana"</u>; Montana Department of Health and Environmental Sciences, 1980. REPORT HIGHLIGHT: Describes statewide water quality data.

<u>"Statewide 208 Newsletter to Achieve and Preserve Clean Waters – Issue #23"; Montana Department of</u> <u>Health and Environmental Sciences, October 1980.</u> Newsletter highlighted that Muddy Creek will not meet 1983 goals and project funding.

1980, October 22 – <u>Formal bylaws signed by Muddy Creek Executive Board members</u> that included Cascade Conservation District, Teton Conservation District, Muddy Creek Landowners Association, Cascade ASCS County Committee and Teton ASCS County Committee.

1980, October 22 – <u>Formal cooperative agreement signed by</u> Cascade Conservation District, Teton Conservation District, Muddy Creek Landowners Association, Cascade ASCS County Committee and Teton ASCS County Committee.

<u>"Trip Report – Special Water Quality Study on Muddy Creek, Montana, October 20-24, 1980"; John</u> <u>Hedlund, SCS, November 7, 1980</u>. REPORT HIGHLIGHT: Assess needs for an "Interim USDA On-Farm Progress Report.

"Summary, USDA Department of Agriculture Portion of Upper Missouri River Basin Level B Study"; SCS, <u>1981.</u> REPORT HIGHLIGHT: Identifies recommended plan to resolve Muddy Creek erosion.

<u>"Muddy Creek Project Benefits and Costs"</u>; John Andrews, January, 22, 1981. REPORT HIGHLIGHT: Summarizes financial impacts to local producers and financial benefits if projects implemented.

<u>*"Muddy Creek Demonstration Projects";* John Andrews, January 30, 1981.</u> REPORT HIGHLIGHT: Interview of SCS staff on irrigation improvement projects.

<u>"Nitrates in Wells of the Greenfields Irrigation District Fairfield, Montana"</u>; Kit C. Walther, Environmental Specialist, Water Quality Bureau, Department of Health and Environmental Sciences, April 20, 1981. REPORT HIGHLIGHT: Nitrate concentrations in groundwater of the Greenfield Bench east of Fairfield where levels too high for infants to drink.

<u>"Muddy Creek Erosion Problem – A Coordinated Strategy for Federal Action";</u> SCS, BoR, Corps, EPA, April <u>1981.</u> REPORT HIGHLIGHT: Provides a strategy for coordinated federal agency action to solve the Muddy Creek erosion problem.

"Annual Report Irrigation Demonstration Project, Fairfield, Montana"; Montana Extension Service, Bauder and Cullen, 1981. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Agreement on the Management and Administration of Montana's Environmental Programs FY 1982", Water Quality Bureau, Department of Health and Environmental Sciences, September 1981.

<u>*"Muddy Creek Special Project Annual Report"*</u>; John Andrews, March 20, 1981. REPORT HIGHLIGHT: 1980 and 1981 updates on Muddy Creek project accomplishments.

<u>*"Muddy Creek Progress Report – October 28-December 29, 1981"*; John Andrews, unknow date. REPORT HIGHLIGHT: Irrigation practices update.</u>

1982 – <u>Application for Watershed Protection Program Funding</u>; Muddy Creek Task Force, January 1982.

<u>"Muddy Creek Project Progress Report";</u> Clarence Tarum, SCS, February 1982. REPORT HIGHLIGHT: Irrigation projects update.

<u>"Managing Fertilizer and Irrigation Water on the Fairfield Bench to Minimize Nitrate Leaching Below the</u> <u>Root Zone</u>", Montana Extension Service, Bauder, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Irrigation Scheduling in the Greenfields Irrigation District", Montana Extension Service, Bauder and Jones, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Irrigation Nitrogen Demonstration Plots", Montana Extension Service, Bauder, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

<u>"CONSUMPT, A New Approach to Irrigation Scheduling"</u>, Montana Extension Service, Bauder, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Scheduling Irrigation with Evaporation Pans", Montana Extension Service, Bauder and Jones, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

<u>*"Technical Irrigation Scheduling – Does It Pay?";* Montana Extension Service, Bauder, 1982</u>. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

<u>"Geological and Materials Report; Three Damsites and Two Surge Relief Canal Alignments"; Greenfields</u> <u>Division; Muddy Creek Study; by Lovell M. Parish; February, 1982.</u> REPORT HIGHLIGHT: Presents geological data pertinent to three damsites and two surge relief canal alignments visited during the field reconnaissance.

<u>"Nutrients in Muddy Creek and Wastewater Drains of the Greenfields Irrigation District", Kit C. Walther,</u> <u>Environmental Specialist, Water Quality Bureau, Department of Health and Environmental Sciences, March,</u> <u>1982.</u> REPORT HIGHLIGHT: April to October 1980 study of nutrient sources into major irrigation drains and dryland tributaries to Muddy Creek

<u>"Muddy Creek Study – Plan Formulation Review Document", BoR, July 1982</u>. (NOT FOUND)
- ??

<u>"Montana Water Quality – 1982"</u>, Water Quality Bureau, Department of Health and Environmental Sciences, July 1982. REPORT HIGHLIGHT: Water quality issues across the entire state of Montana addressing water quality impaired streams including Muddy Creek as one them.

<u>"Water Quality Inventory and Management Plan – Missouri-Sun-Smith River Basin, Montana"; Water</u> Quality Bureau, Environmental Sciences Division, Montana Department of Health and Environmental Sciences; 1982. INTRODUCTION: Presents information relative to the water quality and water quality inventory and management in the Missouri-Sun-Smith basin. It identifies soils erosion as a major problem in the Muddy Creek drainage.

"Fairfield Bench Water Control Reports", Montana State University, Civil Engineering Class, Hertzog, 1982. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Appraisal of Water in Bedrock Aquifers, Northern Cascade County, Montana"; USGS Report 82-1025, January 1983. REPORT HIGHLIGHT: Describes Lake Great Falls sediment issues.

<u>"Muddy Creek Watershed, Review Material";</u> Gene Thornburg, January 17, 1983. REPORT HIGHLIGHT: Consists of land treatment measures for individual landowners.

<u>*"Muddy Creek Status Report, December 1982 – March 1983"*; John Andrews, March 23, 1983</u>. REPORT HIGHLIGHT: Irrigation projects update.

<u>"Groundwater Re-Use Study, Greenfields Irrigation District</u>" – MBMG 113, Montana Bureau of Mines and <u>Geology, 1983</u>. REPORT HIGHLIGHT: MBMG investigated characteristics of the ground-water system to see if excess irrigation runoff could be controlled.

<u>"The Influence of Screen Size on Washtub Evaporation"</u>, Montana Extension Service, Westesen and Ismail, <u>1983</u>. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

1983 – <u>Muddy Creek Watershed Protection and Irrigation Improvement</u> project through Montana's Water Development Grant Program submitted by Cascade and Teton CDs. The state legislature awarded them \$100,000 to reduce wastewater into Muddy Creek by improving irrigation practices.

1983, May – <u>Muddy Creek Watershed Protection (Northeast Unit)</u> federal financial assistance proposal submitted to Soil Conservation Service (SCS) by Cascade CD, Teton CD and GID, April 26, 1982. Project objective was to promote better irrigation water management by providing a cost-share program focused on water saving practices on approximately 10,000 acres on lands located in northeast area of the Muddy Creek drainage.

<u>"Evaluation of the Ground-water Contribution to Muddy Creek from the Greenfields Irrigation District -</u> <u>Report #113</u>", Montana Bureau of Mines and Geology, December 31, 1983. REPORT HIGHLIGHT: Hydrologic investigation of the Greenfields Irrigation District was undertaken to determine the sources and quantities of runoff to the Muddy Creek drainage.

<u>"Special Report on Muddy Creek Study, Montana"</u>, U.S. Bureau of Reclamation, Billings, Montana, <u>December 1983.</u> REPORT HIGHLIGHT: Presented results of past studies, short review of all alternatives considered and a more detailed analysis of a dam near Power.

"Irrigation Scheduling in the Greenfields Irrigation District – 1980-1983", Montana Extension Service, Bauder and Hertzog, 1983. REPORT HIGHLIGHT: Improve on-farm irrigation practices.

<u>"Muddy Creek Special Water Project", Renewable Resources Development Grant Summaries, Cascade</u> <u>Conservation District, January 1984.</u> REPORT HIGHLIGHT: Reflect all of the studies from agencies involved in the RRD grant program.

<u>"The Effects of Muddy Creek on the Biology of the Lower Sun River"</u>, Water Quality Bureau, Department of Health and Environmental Sciences, January 1984. REPORT HIGHLIGHT: Identifies Muddy Creek as Montana's worst water quality problem.

<u>*"Muddy Creek Special Project Report, January - April 1984"*; John Andrews, May 24, 1984. REPORT HIGHLIGHT: Irrigation projects update.</u>

<u>*"Muddy Creek Special Project Report, July - October 1984"*; John Andrews, September 24, 1984. REPORT HIGHLIGHT: Irrigation projects update.</u>

<u>"The Use of a Dosing Siphon for Surge Flow Irrigation"; G.L. Westesen, MSU, September 1984.</u> REPORT HIGHLIGHT: Improve on-farm irrigation practices.

"Muddy Creek II Data"; Bob Remer, SCS, November 8, 1984. REPORT HIGHLIGHT: Land use survey.

<u>"Muddy Creek Study"</u>, U.S. Bureau of Reclamation, Billings, Montana, when?. (NO DATE ON REPORT) REPORT HIGHLIGHT: Intent was to address concerns of storm related water discharges into Muddy Creek. <u>*"Muddy Creek Special Water Project Final Report"*, John Andrews, January 1985</u>. REPORT HIGHLIGHT: Accomplishments to-date and proposed projects in the future.

<u>"Stream Inventory: Muddy Creek Drainage, Cascade and Teton Counties</u>", John Andrews, January 1985. REPORT HIGHLIGHT: Summarized baseline conditions through a physical inventory of streambanks and channel survey of Muddy Creek in November and December 1984.

<u>"Surge Flow Border Irrigation Trials"</u>; G.L. Westesen, MSU, July 1986. REPORT HIGHLIGHT: Improve onfarm irrigation practices.

"Muddy Creek Diversion" Soil Conservation Service, November 18, 1986. REPORT HIGHLIGHT: One-page report references a request to study diverting water from Muddy Creek to lands north of Manchester.

"Muddy Creek Special Water Project Report", Water Development Program grant, Cascade Conservation District, November 20, 1986. REPORT HIGHLIGHT: Accomplishments to-date with the \$100,000 grant.

1987 – <u>Agricultural Riparian Area Rehabilitation Project grant</u>, Montana Department of Natural Resources and Conservation, July 1987. Grant provided funding to conservation districts to complete planning for rehabilitation projects on the Sun River and three other streams in Montana. Grant was for \$100,000 with match of \$20,000 from DNRC, \$5,300 DNRC 223 grant, \$6,428 from DHES, and \$25,000 in-kind from SCS, DHES, and DNRC.

<u>"Sun River Corridor Inventory Report", SCS, April 1987</u>. REPORT HIGHLIGHT: Cascade, Teton and Lewis & Clark CDs requested MT DHES to inventory Sun River physical features; describes impacts Muddy Creek erosion has on the lower Sun River.

1988 – <u>Greenfields Irrigation District Rehabilitation and Betterment (R&B) project.</u> REPORT HIGHLIGHT: \$8.3 million to improve GID infrastructure.

<u>*"Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sun River Area, West-Central Montana, 1986-87"; USGS Report #87-4244, U.S. Geological Survey, 1988.</u> REPORT HIGHLIGHT: Describes concentrations of selected inorganic and organic constituents in water, bottom sediment and biota. Mentions return flows into Muddy Creek have caused substantial sediment problems but these flows have decreased in recent years because of the GID Rehabilitation and Betterment Program.</u>*

"Estimates of Monthly Streamflow Characteristics at Selected Sites in the Upper Missouri River Basin, Montana, Base Period Water Years 1937-1986"; USGS report #89-4082, U.S. Geological Survey, 1989. REPORT HIGHLIGHT: Describes flow data for multiple years including those in Muddy Creek.

<u>"A Pictorial History of the Sun River Valley"</u>; Sun River Valley Historical Society, February 1989. REPORT HIGHLIGHT: Documents the history of the Sun River Valley.

"Preliminary Engineering and Environmental Assessment for Muddy Creek Erosion Control Project in Cascade and Teton Counties grant", Water Development Program grant, Cascade Conservation District, May, 1990. The intent of the \$100,000 grant was the first phase of construction to improve Muddy Creek water quality by selecting projects from previous studies. <u>"Water Resources Activities of the USGS in Montana, October 1989 THROUGH September 1991"; USGS</u> <u>Report 91-191, June 1991.</u> REPORT HIGHLIGHT: Compilation of data USGS acquired during that timeframe. <u>"Muddy Creek Story – 1990s Workgroup Information"</u>; many authors; 1992-1998. Notebook of Muddy Creek meeting minutes and financial information.

<u>"Montana Water Quality – 305 (b) Report"</u>, Water Quality Bureau, Department of Health and Environmental Sciences, June, 1992. REPORT HIGHLIGHT: Water quality issues across the entire state of Montana including water quality impaired streams with Muddy Creek as one them.

<u>"Why Is the Sun River Dirty"</u>; Muddy Creek Task Force; 1992. Brochure described the issues and how people can help.

"Public Notice of Pending Authorization – Muddy Creek"; US Army Corps of Engineers. November 10, 1992. Muddy Creek stream project permitting.

<u>*"Muddy Creek Grade Stabilization Project",* Dr. Riechmuth, November 16, 1992</u>. REPORT HIGHLIGHT: Ideas to reduce Muddy Creek erosion.

"Sun River Irrigation Drainage Detailed Study (MT132)"; J.R. Knapton, 1993. REPORT HIGHLIGHT: Determine sources, distribution and movement of selenium.

<u>*"Muddy Creek Grade Stabilization Project",* Dr. Riechmuth, June 1, 1993</u>. REPORT HIGHLIGHT: Ideas to reduce Muddy Creek erosion.

<u>"Muddy Creek Demonstration Project"</u>; BoR, Billings, Montana, June 4, 1993. REPORT HIGHLIGHT: Research Project Proposal to BoR Denver Research and Laboratory Services Division requesting technical support for resolving the Muddy Creek erosion.

<u>"Water Analysis of the Sun River from Gibson Dam to Sun Prairie Housing District"</u>; Chad Gilliland, CMR
 <u>High School, July 15, 1993</u>. REPORT HIGHLIGHT: Water quality monitoring data.
 <u>"Greenfields Irrigation District – Water Efficiency Improvement Program – Three Physical Treatments"</u>; author unknown, December, 1993. REPORT SUMMARY: Identifies three problem areas contributing to excessive wasteway flow and the estimated cost of remedy and water savings.

<u>"Multiple Check Structure Scheme"</u>; Lee, Bates and Bates, 1993. REPORT HIGHLIGHT: Addresses potential improvements to GID's main canal.

<u>"Muddy Creek – The Latest Story"</u>; Muddy Creek Task Force; 1993. This brochure had information about projects status.

"USGS Report 94-120, Physical, Chemical, and Biological Data for Detailed Study of the Sun River Irrigation Project, Freezeout Lake Wildlife Management Area, and Benton Lake National Wildlife Refuge, West-Central MT, 1990-92" with selected data for 1987-89, BY: USGS, USF&W, BoR, & Bur of Indian Affairs, 1994.

1994 - <u>Sun River Basin</u> - <u>Muddy Creek Watershed Phase I</u>, U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by Cascade County Conservation District, the work began in 1995 with the primary goals to address the severe erosion problem of Muddy Creek and to start expanding the teamwork into the entire Sun River Basin. Under this project, there were 13-drop structures (slides) and over 400 barbs installed which helped reduce the erosion in Muddy Creek by 75%. Stream corridor fencing, off-stream waters, tree planting, and improved land management practices were implemented on Muddy Creek. A TMDL plan for Muddy Creek was submitted to Department of Environmental Quality (DEQ) for review but has since been added to the Sun TMDL planning process. Leveraged \$209,000 in-kind and cash support for the \$101,750 of 319 funds allocated.

<u>"Sun River Project"</u>; Bureau of Reclamation, Robert Autobee, 1995. REPORT HIGHLIGHT: History of Reclamation's role in developing the Sun River Project.

<u>"Muddy Creek Phase II Class I and Class III Cultural Resources Inventory, Northern Cascade County,</u> <u>Montana", Ethos Consultants, January 1995</u>. The MCTF hired Ethos Consultants Inc. in 1994 to accomplish a cultural resources inventory on a segment of Muddy Creek. This inventory was accomplished in October and November 1994.

<u>"Muddy Creek Mess"</u>; Bryan Foster, Yale School of Forestry, January 31, 1995. REPORT HIGHLIGHT: School paper about Muddy Creek.

"Muddy Creek Demonstration Stream Restoration"; BoR, Rod Wittler, September 22, 1995. Travel report by BoR, Rod Wittler on status of Muddy Creek erosion control demonstration project.

<u>"Cultural Resource Inventory for Phase III of the Muddy Creek Project, Cascade County, Montana";</u> <u>Michael Andrews, BoR, November 1995.</u> REPORT HIGHLIGHT: Mapped archeological findings for Muddy Creek stream project.

<u>"Sun River Watershed Issues – Plan of Work"; NRCS, January 1996.</u> REPORT HIGHLIGHT: Work schedule guide for NRCS to allocate resources.

<u>"Greenfields Irrigation District Canal Modernization"</u>, Bureau of Reclamation, August 6, 1996. REPORT HIGHLIGHT: Examination of different methods to improve canal operations, considering technical, economic, and social feasibility to help reduce wastewater into Muddy Creek.

<u>"Cultural Resources Inventory for Phase III of the Muddy Creek Project, Cascade County, Montana", MTAO</u> <u>Project No. SR-95-71, Bureau of Reclamation, November 1995.</u> REPORT HIGHLIGHT: Bureau of Reclamation accomplished additional cultural resource inventory for next phase of construction in Muddy Creek.

<u>"Analysis of the Effects of Stabilization on Muddy Creek, Montana"</u>, Dr. Chester C. Watson, Colorado State <u>University, 1996</u>. REPORT HIGHLIGHT: In 1995, MCTF hired Colorado State University, Dr. Watson to accomplish an analysis of the effects of stabilization of Muddy Creek using grade control and barbs.

1996 – <u>Muddy Creek stream assessment</u> from May 20-22 accomplished by the NRCS Riparian Team. Intent of this assessment was to acquire baseline data and identify possible solutions for controlling erosion on Muddy Creek. The team did identify a few sites requiring attention in the near future. <u>See NRCS</u> <u>assessment notes for more details of conditions</u>. Unfortunately, NRCS never did follow through with any designs.

1996 – <u>Spring Coulee stream assessment</u> from August 20 – 22 accomplished by the NRCS Riparian Team. Intent of this assessment was to acquire baseline data and identify possible solutions for controlling erosion on Spring Coulee, a major tributary of Muddy Creek. <u>See NRCS assessment notes for more details of conditions</u>. Unfortunately, NRCS never did follow through with any designs. **1996** – <u>Sun River project</u>. A NRCS EQIP funding project to improve Sun River water quality.

<u>"Muddy Creek Low Water Crossing Design"</u>; Dr. Rodney J. Wittler, November 1996. REPORT HIGHLIGHT: Design for Muddy Creek crossing so GID can get equipment on other side for stream projects.

"USGS Annual Peak Streamflow for Station 06088500"; USGS, June 30, 1997. REPORT HIGHLIGHT: USGS report on maximum annual flows at stream gage at Muddy Creek at Vaughn from 1925 – 1996.

1997 - *Muddy Creek DNRC grants* began in 1997, helping pay for trees, fencing, rock, and stream work.

<u>"Muddy Creek Demonstration Stream Restoration Research Project", CRDA-96-1, Dr. Rodney J. Wittler,</u> Spring 1998. Funding for the original partnership came from a grant by the State of Montana to the Cascade County Conservation District. Funding for the new partnership comes partially from a State of Montana grant (\$10,000) and a grant by the National Fish and Wildlife Foundation (\$41,000) to the Cascade County Conservation District. Reclamation and the MCTF partner via Cooperative Research & Development Agreement (CRDA) 96-1 and its amendments between Reclamation and the CCCD.

- <u>Gradient and Plan Form Stabilization of an Incising Stream</u>; R.J. Wittler, S.D. Keeney, B.W. Mefford, S.R. Abt, C.C. Watson; Wittler, R.J., Keeney, S.D., Mefford, B.W., Abt, S.R., Watson, C.C.
- Siting Low Profile Grade Control Structures for the Muddy Creek Demonstration Stream Restoration <u>Research Project</u>; R.J. Wittler, D.R. Eby, S.D. Keeney, C.C. Watson, S.R. Abt.
- *Features of a Chevron Weir Rock Ramp*; R.J. Wittler.
- *Case Study: Muddy Creek, Montana*; R.J. Wittler, S.D. Keeney, A.W. Rollo, C.C. Watson.
- <u>Cultural Resources Considerations for Stream Restoration Projects</u>; R.J. Wittler, M. Andrews, E.I. Friedman.
- *Field Data Plan for Muddy Creek*; R.J. Wittler, D.R. Eby, D.L. Burgett, A.W. Rollo.
- Building Banks on Muddy Creek With Barbs; R.J. Wittler, S.D. Keeney, D.R. Eby, D.L. LaGrone.
- <u>The Muddy Creek Partnership: How to Restore a Stream</u>, A.W. Rollo, D.L. Burgett, R.J. Wittler, S.D. Keeney.
- <u>Muddy Creek restoration and Sun River Watershed Plan Coordination</u>, Alan W. Rollo, Rodney J. Wittler, Sean D. Keeney.
- <u>Restoration and Historic Preservation: Protecting Cultural Resources along a Meandering Stream</u>, R.J. Wittler & M. Andrews.
- Initial Analysis of Water Quality Changes on Muddy Creek, R.J. Wittler, S.D. Keeney, & A.W. Rollo.

"ECS—Muddy Creek revegetation", NRCS, Larry Holzworth, May 30, 1996. REPORT HIGHLIGHT: Identifies NRCS's recommendations to reduce Muddy Creek erosion.

<u>"Muddy Creek – Stream Stabilization Project"</u>; Muddy Creek Task Force, 1998. Latest brochure to describe and show through pictures results of teamwork.

<u>"Kings vs. Ratliff lawsuit"</u>. REPORT HIGHLIGHT: September 1999 the Kings filed suit against Ratliffs for excess irrigation runoff causing erosion AND contamination of ground water.

"Assessment of Water Quality for the Sun River and Muddy Creek, Sun River Watershed, West-Central

Montana", MBMG Open-file Report 412, Montana Bureau of Mines and Geology, July 2000. REPORT HIGHLIGHT: Helped in determining if the listed impairments are supported by sufficient and credible data. Also, it was used to help develop a TMDL for the Sun River Watershed. <u>"Spring Coulee Bank Stabilization - Fisheries Evaluation 1998 – 1999"</u>, Montana Department of Fish, <u>Wildlife & Parks, November 2000</u>. REPORT HIGHLIGHT: Documents fish numbers on a stream restoration project that FWP helped pay for through a Future Fisheries grant.

2001 - <u>EQIP Priority Area Proposal; Spring Coulee South</u>; Teton County; Prepared by: Stacy Denny Eneboe, John Streich, Cari Ostberg, and Alan Rollo. Project was supposed to be multi-year but NRCS unable to acquire more money.

<u>"Estimated suspended-sediment discharge (loads) for Muddy Creek near Vaughn and Muddy Creek at</u> <u>Vaughn for water years 1997 through 2001</u>", U.S. Geological Survey, June 2002. REPORT HIGHLIGHT: USGS computed load estimates between sediment load and streamflow to generate daily sediment loads.

"A TMDL Approach to Muddy Creek; J. W. Bauder, Professor, and Holly Sessoms, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2002. REPORT HIGHLIGHT: Evaluation of Muddy Creek data and best solutions to control erosion.

<u>"Section 319 Success Stories Vol III</u>"; EPA, February 2002. REPORT HIGHLIGHT: The EPA gave compliments to the Muddy Creek effort and how their 319-grant program was a key reason for the success.

"Ground-Water and Surface-Water Quality. Herbicide Transport, and Irrigation Practices: Greenfields Bench Aquifer, Teton County, Montana", MBMG Open-file Report 463, Montana Bureau of Mines and Geology, 2002. REPORT HIGHLIGHT: Evaluated water quality issues related to chemical use on the Fairfield Bench.

<u>"Briefing Paper on Benton Lake Siphon Project", MCTF, February 2003.</u> REPORT HIGHLIGHT: Developed by the MCTF for the Montana Congressional delegation and other partners requesting support to obtain necessary resources/funds to install a siphon using GID tailwater before it enters Muddy Creek to deliver water to the Benton Lake NWR.

<u>"Muddy Creek Flow and Sediment Study", J. W. Bauder, Professor, and Kim Hershberger, Water Quality</u> Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2004. REPORT HIGHLIGHT: MSU produced a Muddy Creek Flow and Sediment study for the BoR, MOU No. 99-FC-60-1144, with the primary goal to determine the sources and amounts of flow and sediment entering Muddy Creek. See attached charts for summary of the data acquired.

<u>"Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River Planning Area".</u> <u>Montana Department of Environmental Quality, December 2004.</u> REPORT HIGHLIGHT: Water quality conditions and restoration strategy for the Sun River and tributary, Muddy Creek.

2004-2006 – <u>Muddy Creek Water Quality Implementation Project</u> - <u>Grant #204076</u>; U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by CCD; \$80,000 grant funds; \$383,250 non-fed match; \$34,550 fed match for total of \$497,800.

2004-2006 - <u>Sun River Basin/Sun River Watershed - Phase III Grant #202082</u>; U.S. Environmental Protection Agency 319 Nonpoint Source Pollution Program and Montana Department of Environmental Quality; Sponsored by Cascade County Conservation District; Project results included: reduced sediment load by approximately 7,500 yards per year with 50 rock barbs; 15,600 feet of fencing installed; 1,000 trees planted and one grazing workshop to 20 producers;

2005 – <u>Benton Lake survey and design.</u> NRCS and CCD accomplished a detailed survey for the proposed Benton Lake NWR siphon project. BoR used the survey data to put together a draft siphon design.

"Mill Coulee and Muddy Creek Water Quality Assessment Project", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2005. REPORT HIGHLIGHT: Determine whether projects, programs and practices implemented within the Mill Coulee and Muddy Creek watersheds resulted in definitive or quantifiable changes to Mill Coulee and Muddy Creek water quality and quantity.

"Muddy Creek Follow-up Project", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2005. REPORT HIGHLIGHT: Pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.

"Sun River Watershed Water Quality Monitoring Project", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State <u>University – Bozeman, July 2005</u>. REPORT HIGHLIGHT: Understand water quality conditions in the Sun River and tributaries which included Muddy Creek.

"Nutrient and Suspended-Sediment Trends in the Missouri River Basin, 1993-2002"; USGS 2006-5231, 2006. REPORT HIGHLIGHT: Data on USGS sampling of Missouri River and tributaries.

"Muddy Creek Project - 2006", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2006. REPORT HIGHLIGHT: Pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.

<u>"Muddy Creek Flow & Sediment Study - 2007"</u>, J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, <u>2007</u>. REPORT HIGHLIGHT: Pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.

"Muddy Creek Flow & Sediment Study - 2008", J. W. Bauder, Professor, and Kim Hershberger, Water Quality Associate; Department of Land Resources and Environmental Sciences Montana State University – Bozeman, 2008. REPORT HIGHLIGHT: Pinpoint areas where follow-up was needed to completely understand the sediment and flow patterns in Muddy Creek and tributaries.

"<u>Upper Muddy Creek Water Quality Investigation</u>", Adam Sigler, Department of Land Resources and Environmental Sciences Montana State University – Bozeman, January 2011. REPORT HIGHLIGHT: Preliminary data collection to provide baseline data for future projects.

2010 - *SUN RIVER WATERSHED WQRP IMPLEMENTATION; EPA GRANT # SG-97868801;* Sponsored by SRWG; \$68,674 grant funds; \$83,950 match. Project Summary: Four miles riparian fencing installed on tributary to Muddy Creek; 75 rock barbs on four miles of highly erosive banks; Banks sloped and erosion matting installed on 200 feet of eroding bank; Pump back unit that will capture 5 cfs of irrigation tail water before it reaches Muddy Creek; Two USGS and three MSU and DNRC monitoring gauges; SRWG keeping partners informed of project status at monthly board meetings.

2011-2015 - <u>Muddy Creek Restoration Project; Grant # 211079</u>; SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM. Project Summary: Continuation of stream work.

2012-2015 - *Improving GID Water Management to Improve Sun River Flows; Reclamation Grant # R12AC60055;* sponsored by Greenfields Irrigation District; grant \$262,565; total project \$540,395. The grant paid for a new pump back and pipeline to reuse wastewater that currently enters Muddy Creek which causes huge erosion and water quality problems in the Sun River basin.

2013 - <u>Muddy Creek Tributaries Riparian Improvements; DEQ 319 grant #213028</u>; sponsored by: Sun River Watershed Group; grant \$87,000. Contract was started in 2013 SRWG made some progress towards the intent of the project to reduce animal waste into Muddy Creek tributaries but not enough to actually put projects on-the-ground in a timely manner. Gave all money back.

2014– present - <u>Greenfields Irrigation District Water Conservation; Reclamation Grant # R14AS60055;</u> sponsored by Greenfields Irrigation District; grant \$100,000. Project is to modify GID's J-wasteway structures to reduce wastewater into Muddy Creek. DNRC delayed this project because of their interpretation of water rights. PROJECT IS NOT COMPLETED YET.

"Sun River Valley History II"; Sun River Valley Historical Society, 2014. REPORT HIGHLIGHT: Documents the history of the Sun River Valley.

<u>"Montana Museum of Railroad History"; web site http://mmrh.org/</u> The museum's web site is an excellent location to find information about Montana's railroad history.