WATER QUANTITY AND QUALITY OF THE SUN RIVER FROM GIBSON DAM TO VAUGHN, 1973-1974*

WILLIAM J. HILL

MONTANA DEPARTMENT OF FISH AND GAME

May 5, 1976

* Financed through Federal Aid in Fish and Wildlife Restoration Acts. Montana Projects No. F-5-R-23 and F-5-R-24.

ABSTRACT

Water quantity and quality of the Sun River from Gibson Dam to Vaughn was studied during 1973 and 1974. A total of 14 stations on the Sun River and 16 on tributary or irrigation returns to the Sun River were monitered for flow, water temperature, turbidity and total dissolved solids. In addition, flow measurements were determined for 12 irrigation diversions from the Sun River.

INTRODUCTION

Information is limited on quantity and quality of water in the Sun River. Since these attributes are important to the aquatic resource, a study of the Sun River from Gibson Dam to Vaughn was conducted from April to September, 1973 and from April to October, 1974. Objectives of the study were to measure water quantity and quality in the Sun River, in diversions and waste water tributaries to the River. Recommendations on flows needed to preserve the river fishery based on fish population data were to be made. The river, as well as the tributaries and irrigation returns were monitered for flow, temperature, turbidity and total dissolved solids. Flows into irrigation diversions were measured.

The years studied presented somewhat of a contrast; 1973 was a low water year and 1974 experienced average or above runoff from mountain snowpack. This explains why turbidities were comparatively low in 1973 and higher during runoff in 1974.

Access problem areas were encountered at several locations along the river. Consequently, these areas were not included in the study.

A total of 42 stations were monitered: 14 on the Sun River; 12 on irrigation diversions from the Sun River; and 16 on tributary or irrigation returns to the Sun River. The figures given for various measurements in this report are ranges. The field data is on file in the Choteau field office.

DESCRIPTION OF STUDY AREA

The headwaters of the Sun River lie in the Bob Marshall Wilderness Area, a mountainous region east of the Continental Divide and south of Glacier National Park. Upon emerging from the mountains, the Sun River meanders for nearly 90 miles between rolling grass-covered foothills and farmland to its confluence with the Missouri River at Great Falls.

Two impoundments formed by Gibson Dam and Diversion Dam are located on the river before it emerges from the mountains. Flows of the Sun River are controlled by Gibson Dam and are mostly related to releases for irrigation. Pishkun and Willow Creek Reservoirs, two off-stream irrigation impoundments, receive water via canals from Diversion Dam.

Sun River

The locations of 14 Sun River stations are presented in Figure 1 and the resulting data in Table 2. The following discussion pertains to stations where significant data was gathered or where changes in water conditions were noted.

Monthly mean flows of the Sun River below Diversion Dam are presented in Figure 2. Maximum and minimum flow extremes for the entire river occurred below Diversion Dam during both years of the study, and ranged from 20 to 562 cfs in 1973 and 7 to 6,990 cfs in 1974. Maximum readings are a result of spring runoff conditions while minimum readings relate to closing of Diversion Dam by the Greenfields Irrigation District to inspect the concrete structure of the dam. This occurred on April 18, 1973 and on April 25, 1974. Data for 1974 shows the river flow was progressively reduced from 33 cfs at 9:15 A.M. to seepage of 7 cfs at 3:30 P.M. (Photo 1). The reduced flow exposed stream bottom and insect life and stranded fish. Sculpins and young brown trout, rainbow trout and whitefish were observed stranded.

Continuous thermograph records at three locations on the river show that maximum water temperatures occurred during late July and early August (Figures 3-5). A gradual increase in river temperatures was noticed progressing downstream. The increase is considered normal since temperatures at mouths of most tributaries and irrigation returns are similar to the river. The exception is the Willow Creek Reservoir Drain that increased river temperatures slightly.

Turbidity of the Sun River increases gradually downstream, with maximum readings occurring during spring runoff. In 1973, turbidities increased to 38 ppm below Gibson Dam during August when irrigation drawdown created near river conditions in Gibson Reservoir (Photo 2). Mud banks sloughed into the river, and wind and wave action on exposed mud shorelines caused siltation in the river below the dam. A maximum turbidity of 69 ppm was measured in 1973 at the lowermost river station. This was caused by turbid flows from Mill Coulee and Muddy Creek which are affected by irrigation waste and seepage water throughout the irrigation season. A maximum turbidity of 750 JTU was measured in the Sun River in 1974 and again is the result of the Mill Coulee and Muddy Creek returns. Turbidity of the other returns are generally higher than the Sun River but had little effect on the river at observed flows. Turbidity of the Sun River could be affected to a greater extent if the return flows were increased or if the river flows were decreased, thus reducing the dilution factor. Gravel pits are located in this same area and may also contribute to the turbidity of the river.

Total dissolved solids in the Sun River gradually increased downstream and ranged from 90 ppm below Diversion Dam to 555 ppm at the lowermost station below Muddy Creek.

Attempts were made to estimate trout populations in the river, however, inadequate samples of fish were captured for an evaluation of flows needed to preserve the fishery.

Table 2. Flow, turbidity, total dissolved solids (TDS) and temperature of Sun River stations, 1973-1974. (Showing ranges).

Sta.	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Turbidity 1973(ppm)	1974(JTU)	TDS (ppm) 1974	Temperature °F. 1973	1974
1	8	0			6-38			56-61	
4	9	11	20-562*	7-6,990*	5-20	5-50	90-210	50-66**	46-61**
10	5	4			2- 8	8-65	110-155	60-72	48-59
13	5	8	38-409*	40-6,710*	7-10	5-73	110-220	63-69	49-63
15	0	7				5-85	110-245		48-64
17	0	3				8-75	120-175		55-56
21	6	7			3- 7	5-92	110-275	61-70	47-69
24	3	6			3- 6	5-95	120-290	51-77**	49-77**
27	0	10	39-400*	37-6,670*		5-118	120-300		46-73
32	5	5			3- 8	5-150	120-400	61-70	46-63
35	0	6				5-160	150-445	47-74**	44-77**
37	0	7				5-160	140-490		44-65
39	3	5			6-21	20-175	130-475	72-76	48-67
42	4	7			18-69	26-750	150-555	63-71	43-66

* USGS gage station records
** Continuous thermograph records

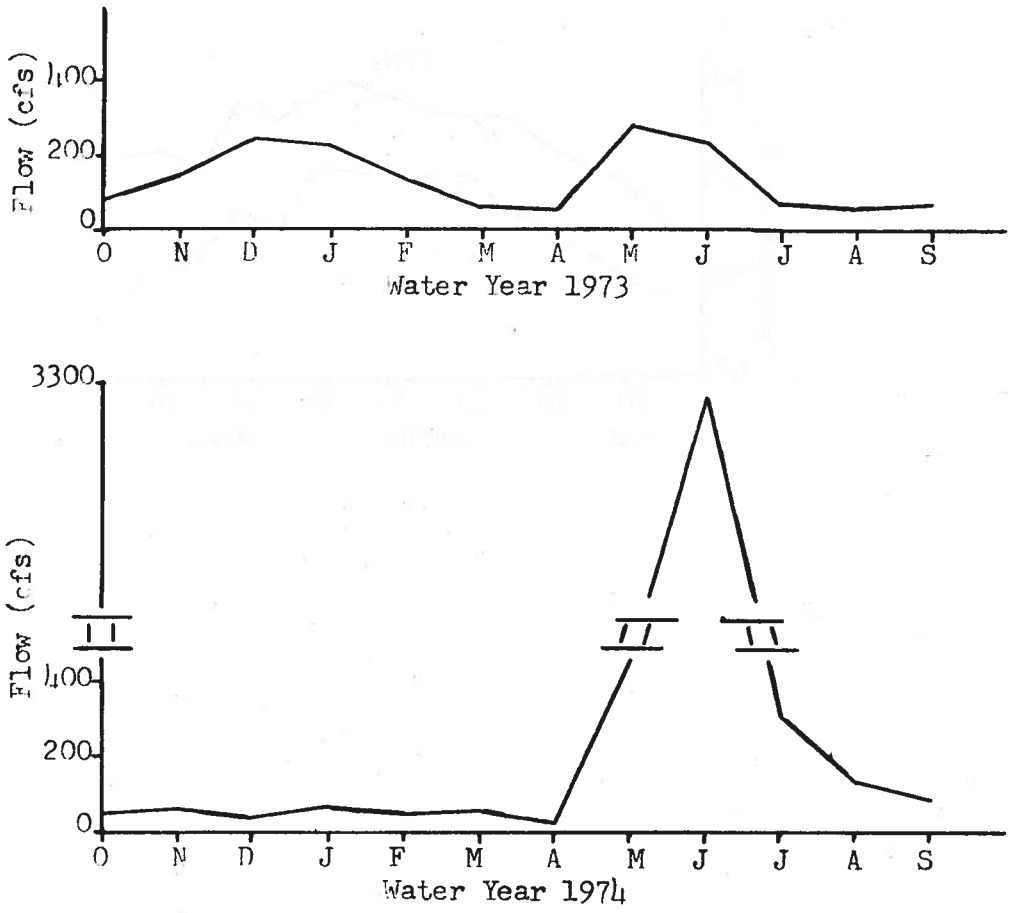
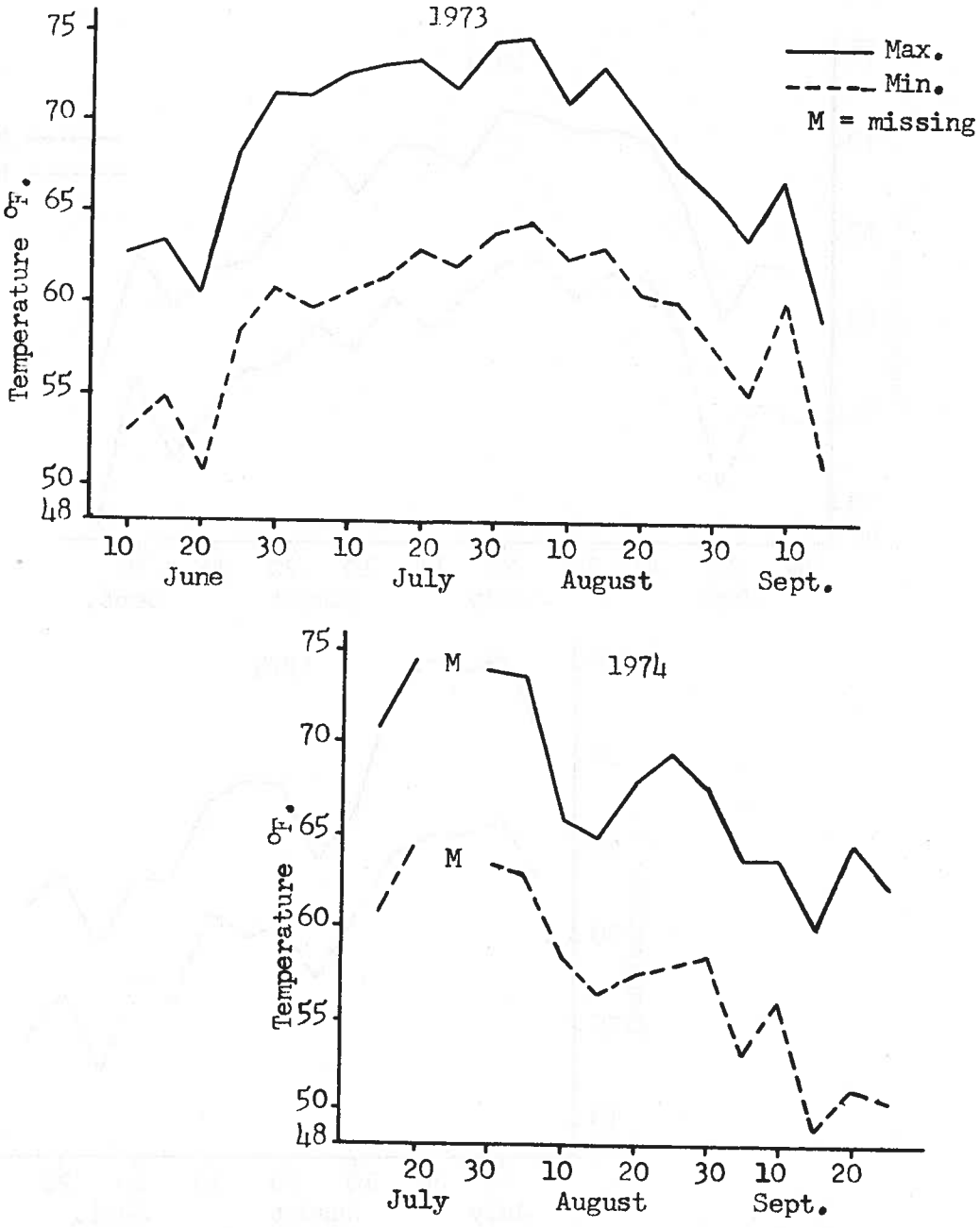


Figure 2. Monthly mean flow of Sun River below Diversion Dam for water years 1973-1974.

Figure 4. Maximum-minimum temperatures (5-day average) of Sun River at Fort Shaw Diversion, 1973-1974.



Diversions

The locations of 12 irrigation diversion stations are presented in Figure 6 and the resulting data in Table 3. Discussion follows on the more important diversions.

Diversions from the Sun River varied in flow from 5 to 1,537 cfs. The Pishkun Reservoir Diversion is the largest diversion from the Sun River with a maximum designed capacity of 1,400 cfs. Maximum flow diverted was 1,473 cfs in 1973 and 1,537 in 1974. Other canals carrying more water than they were designed for were Rocky Reef Diversion (initial capacity of 25 cfs with 38 cfs measured in 1973) and the Sun River Valley Diversion (initial capacity of 75 cfs with 110 cfs measured in 1973 and 84 cfs measured in 1974). The Pishkun Diversion is under the control of the Bureau of Reclamation through the Greenfields Irrigation District and supplies water to Pishkun Reservoir. From this reservoir, canals supply water to the Fairfield Bench area. Excess and irrigation waste water from this irrigation network is returned via many drainages, with the majority accumulating in Muddy Creek, Mill Coulee, Big Coulee and School Section Coulee. Besides waste of excess water into the drainages mentioned above, large amounts of water are lost through evaporation and seepage. Greenfields Irrigation District personnel (personal communication) have stated there is up to a 50 percent loss of water due to evaporation and seepage in the Supply Canal from the Sun River to Pishkun Reservoir and a 50 percent loss in the Sunny Slope Canal from Pishkun Reservoir to the Fairfield Bench. A major portion of the seepage water probably is returned to the Sun River via percolation and so may be considered beneficial. However, if this water wouldn't have been diverted in the first place, river flows could have been maintained at higher levels.

The Willow Creek Reservoir Diversion is also under the control of the Bureau of Reclamation through the Greenfields Irrigation District. Water is diverted from the Sun River through the same structure as the Pishkun Diversion and water is stored in Willow Creek Reservoir. Water is released from the reservoir during low water months to maintain a flow in the Sun River when the majority of the flow is diverted to Pishkun Reservoir. Also, the Fort Shaw Irrigation District has a storage interest of 5,400 acre feet of water in the reservoir. This diversion canal goes through the Sun River Game Range and is causing serious bank erosion where the gradient of the canal drops abruptly. Much of the eroded material is carried downstream into Willow Creek Reservoir. The Bureau of Reclamation conducted a feasibility study during 1974 on possible corrective measures.

The Fort Shaw Diversion is under the administration of the Bureau of Reclamation through the Fort Shaw Irrigation District. Excess water from this system is returned to the Sun River via a drain west of Fort Shaw and Dobie Creek east of Fort Shaw. Other instances of water diverted and not used for irrigation were monitered. These included the Greenfields Project to several tributaries already mentioned and the Sun River Valley Canal into Muddy Creek. On several occasions, unused water ran straight through the Sun River Valley Canal to Muddy Creek at Vaughn. During 1973, excess flows at this point varied from 10 to 40 cfs and in 1974 from 16 to 48 cfs.

Table 3. Flows of Diversion stations, 1973-1974. (Showing ranges).

Station	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Total Discharge (acre ft.)* 1973	1974
2	0	0	0-1,473*	136-1,537*	261,379	313,875
3	0	0	0- 160*	3- 185*	20,354	9,011
7	0	4		3- 22		
8	0	4		0- 8		
9	0	4		0- 30		
12	4	5	80(E)- 106	50(E)- 83		
18	0	4		20(E)- 58		
19	1	1	20(E)	20(E)		
23	0	3		5(E)-10(E)		
25	0	0	27- 296*	25- 296*	52,185	42,800
29	1	0	38			
33	4	5	90(E)- 110	57- 84		

(E) = Estimated flows
* From Irrigation District records

In 1973, dewatering of the Sun River was evident at three stations: below Diversion Dam (discussed under Sun River stations); below the Fort Shaw Diversion (Photo 3); and below the Rocky Reef Diversion (Photo 4). However, accretions bring up river flows a short distance downstream. Photo 5 depicts a more normal flow below the Rocky Reef Diversion.

Several diversion canals crossed irrigation return or tributary streams with little or no transfer of water. The Floweree Diversion Canal crosses over School Section Coulee near Golden Ridge with no transfer of water (Photo 6). In July of 1973, flows of 18 cfs and a turbidity of 7 ppm were measured in the Floweree Canal while measurements in School Section Coulee indicated flows of 29 cfs and turbidity of 36 ppm. Another example is the Alfalfa Diversion Canal and School Section Coulee joining together (Photo 7) downstream from the crossover of the Floweree Canal and School Section Coulee. Turbidity measurements were made twice in 1973 at the junction of the Alfalfa Canal and School Section Coulee. On June 28 and July 16, turbidity of the Alfalfa Canal was 2 and 9 ppm, respectively. Turbidity of School Section Coulee on the same dates was 95 and 30 ppm, respectively. A third example is the Sun River Valley Diversion Canal flowing beneath Mill Coulee near the town of Sun River (Photo 8). Some transfer of water is made from Mill Coulee into the Sun River Valley Canal at this point. Several turbidity samples were collected from these two waters during 1973. The Sun River Valley Canal varied from 2 to 5 ppm, while Mill Coulee ranged from 20 to 40 ppm. All three examples point to the fact that more clean water could be left in the Sun River if the taking of excess water was minimized and turbid tributary waters could be utilized for irrigation.

Bulldozer activity was evident at 7 of the 9 diversions checked. Photo 9 depicts the typical private and smaller diversions in which bulldozers are used every year to rebuild gravel and rock dikes, particularly after high water. Diversions in which bulldozer activity was evident include the Kilraven, Warden, Beecher, Floweree, Alfalfa, Simpson and Rocky Reef.

Tributary or Irrigation Returns

The locations of 16 tributary or irrigation return stations are presented in Figure 7 and the resulting data in Table 4. Items of significance are discussed below.

Flows of returns varied from no flow to a maximum of 730 cfs. Absence of flow in some returns relate to all of the water being used for irrigation (Split Rock Lake Drain, and Simms Creek) or the water shut off such as the Willow Creek Reservoir Drain. The maximum reading of 730 cfs was recorded in Muddy Creek following heavy rainfall and much of the flow is attributed to spillage of excess water from the Greenfields Irrigation Project. Maximum flows of most other returns also correspond to excess water from irrigation following rainstorms.

Table 4. Flow, turbidity, total dissolved solids (TDS) and temperature of Tributary or Irrigation Return stations, 1973-1974. (Showing ranges).

Station	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Turbidity 1973(ppm)	1974(JTU)	TDS(ppm) 1974	Temperature °F.* 1973	1974
5	0	3		1(E)		3	310		
6	0	4		0					
11	6	5	0-170**	0- 75**	7-20			64-68	
14	0	5		3(E)- 88		2- 13	225-295		52-77
16	0	7		3(E)- 38		5- 42	260-380		53-65
20	0	5		5(E)		20- 95	240-630		50-73
22	6	7	31	5(E)-30(E)	4-21	22- 75	200-330	56-67	43-69
26	0	5		0-10(E)		12- 22	250-710		53-71
28	2	7		5(E)-40(E)	13-20	15- 135	350-2500	68-70	43-86
30	0	7		5(E)-39		6- 75	240-450		49-70
31	0	5		5(E)-58		10- 90	350-1250		47-66
34	7	4		5(E)-10(E)	6-30	43- 125	300-380	64-72	51-70
36	6	7	15	5-39	20-40	12- 170	310-745	63-74	41-63
38	1	3			18	45	525	80	65
40***	7	6	10- 40	16-48	3-14	15- 130	150-460	64-75	44-65
41	7	8	14-446****	19-730****	20-250	30-1000	230-700	62-69	41-73

(E) = Estimated flows
* Spot temperature checks
** From Irrigation District records
*** Return to Muddy Creek
**** USGS gage station records

Maximum temperatures of the Sun River ranged from 66°F. on the upper thermograph station to 77°F. on the lower stations. Temperatures at mouths of returns were generally comparable to those of the Sun River where they met. The only return that increased temperatures in the Sun River was the Willow Creek Reservoir Drain.

Use of bulldozers for constructing gravel and rock dikes to divert water was evident in seven out of nine diversion stations checked. This does not include the Bureau of Reclamation Diversions to the Greenfields and Fort Shaw Irrigation Districts which are of a more permanent nature.

There is up to a 50 percent loss of water due to evaporation and seepage in each of the Pishkun and Sunny Slope Canals. Several instances were noticed where ditches carried more water than their designed capacity and this may add to seepage problems. The canal from Diversion Dam to Willow Creek Reservoir has serious bank erosion on the Sun River Game Range where the gradient of the canal drops abruptly. It was also documented that several ditches crossed irrigation return or tributary streams with some or no transfer of water. These involve the Floweree Canal and School Section Coulee, Alfalfa Canal and School Section Coulee, and Sun River Valley Canal and Mill Coulee. If the return waters could be recycled, higher quality water could be left in the Sun River. Several instances were noted where water diverted for irrigation and not used was running straight through canals and emptying into a return. Dewatering of the Sun River below diversion structures wasn't too drastic during the two-year study period but could have a greater effect if the river experienced lower flows. The dewatering noticed below the Fort Shaw and Rocky Reef diversions was of short distance as accretions brought the river flow back up again. The low flows below Diversion Dam during the annual dam inspection periods probably have a greater impact on aquatic life than do low flows from any other diversions.

DISCUSSION

In a pollution study on Muddy Creek, Johnson, (1972) stated that the source of silt from Muddy Creek is in the lower reaches where the stream cuts as much as 20 feet into the streambed in a sheer face. Approximately 204,000 tons of sediments are dumped into the Sun River each year from Muddy Creek. Some of this sediment is composed of very fine colloidal silt. Sediment ponds would have little effect in removing this material. Johnson also stated that the Bureau of Reclamation admits that water use is not measured nor are farmers charged for excess water used. Consequently, Muddy Creek is carrying nearly 25 percent of the available water away as wastage. In order to bring bank erosion under control, the flow would have to be brought below 25 cfs. An alternate suggested by Johnson is a lined flume to bypass eroding banks.

4. Rectify erosion problems of the Willow Creek Supply Canal through the Sun River Game Range.

5. Diversion structures in the Sun River should be made more permanent to eliminate bulldozer activity in the river every spring.

6. Devise methods to prevent seepage in canals. If this could be accomplished, river flows could be stabilized. Improve manipulation of headgates to minimize wasting of water. Ditches should carry only the amount of water they are designed for to help cut down on seepage loss.

7. Where canals cross canals and/or irrigation returns, turbid return waters should be recycled wherever possible, as is now being done in several places on the Fairfield Bench.

8. Cut down flows in diversions when not needed to minimize the amount of water diverted but not used. Examples would be after periods of heavy rain and during haying season. This would relieve excess flows in return drainages such as School Section Coulee, Big Coulee, Dobie Creek, Sun River Valley Drain, Mill Coulee and drains to Muddy Creek.

9. Urge the Bureau of Reclamation to further develop plans for stabilizing erosion of Muddy Creek.

APPENDIX I. Photos depicting various situations in the study area.

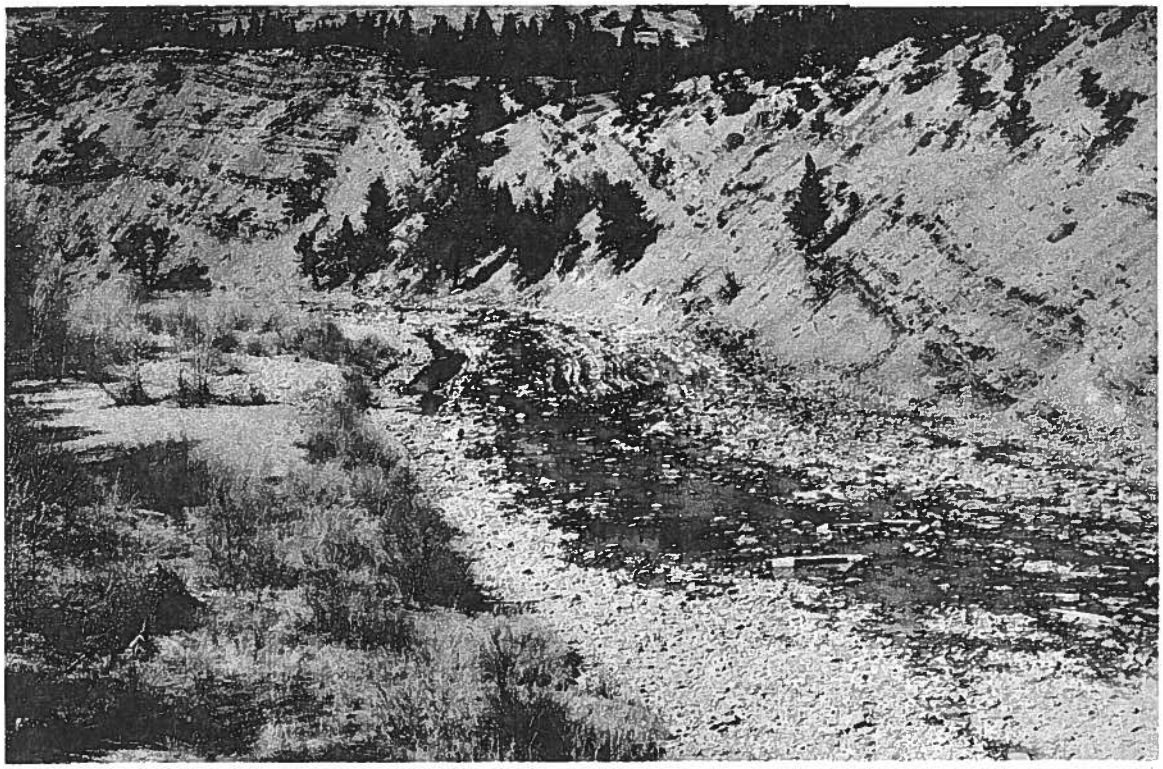


Photo 1. Sun River downstream from Diversion Dam. Dewatered conditions relating to annual inspection of structure of Diversion Dam.

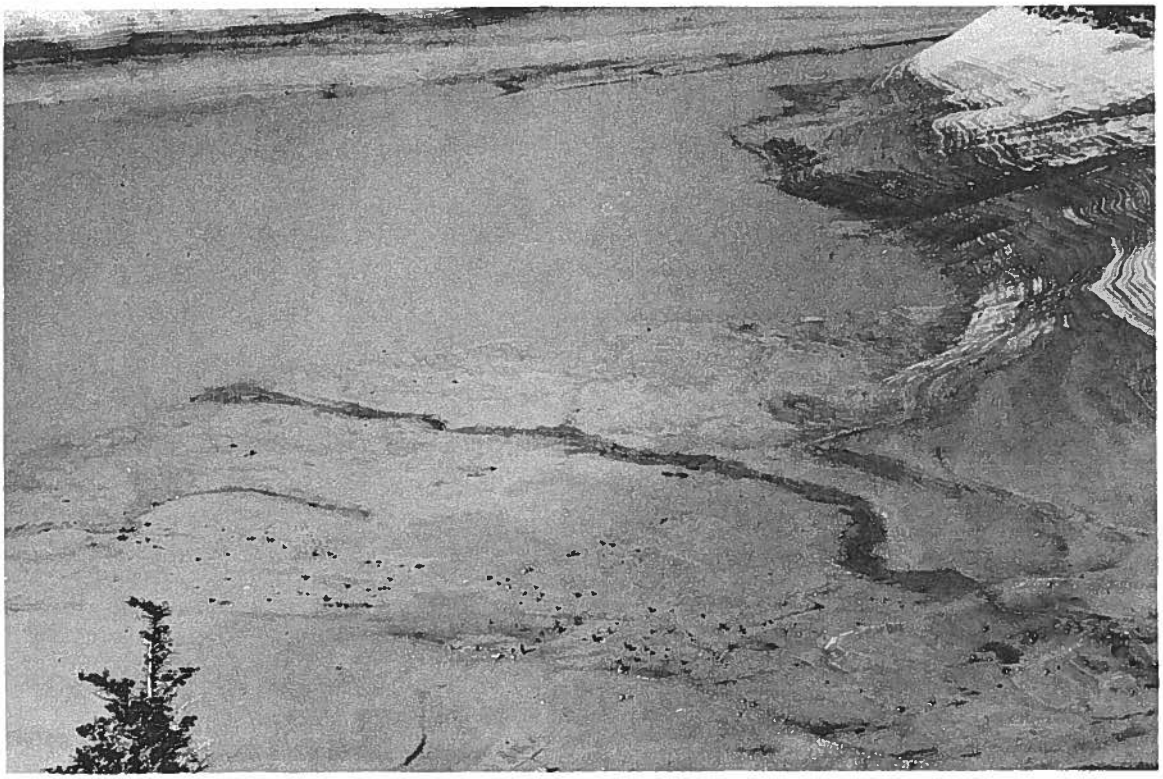


Photo 2. Drawdown of Gibson Reservoir. Mud shorelines responsible for siltation in Sun River below dam.

Photo 3. Low flow in Sun River below Fort Shaw Diversion.

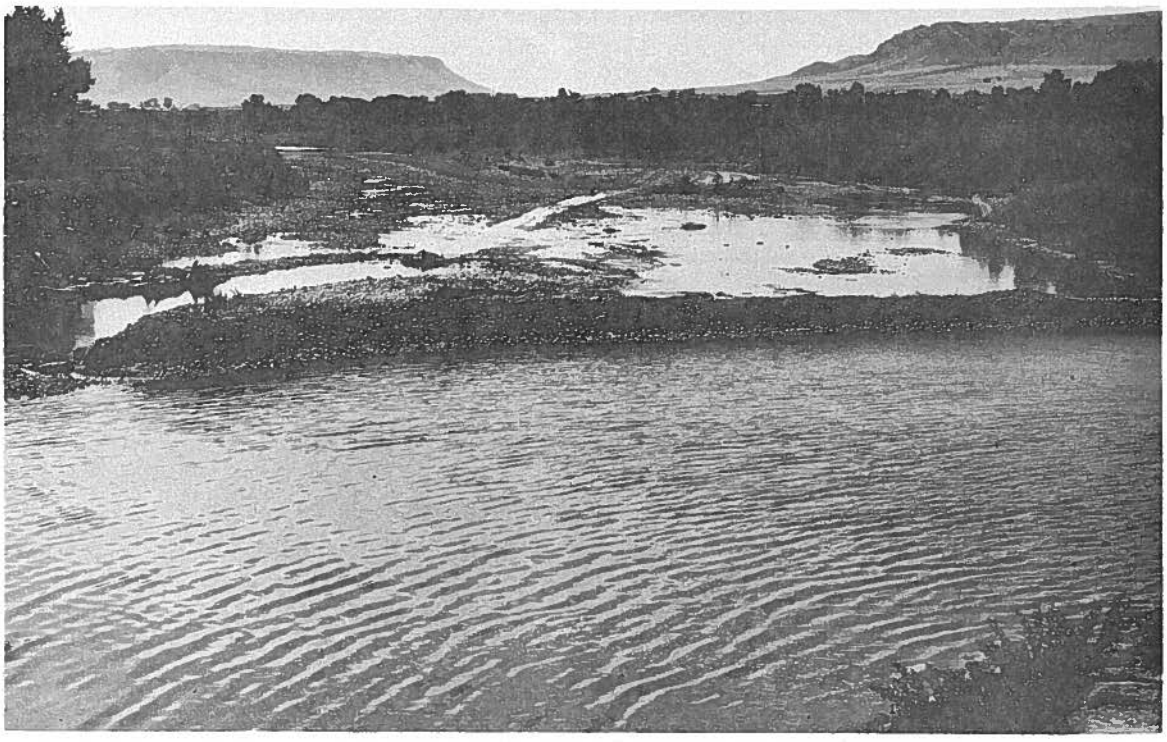


Photo 4. Low flow in Sun River below Rocky Reef Diversion.

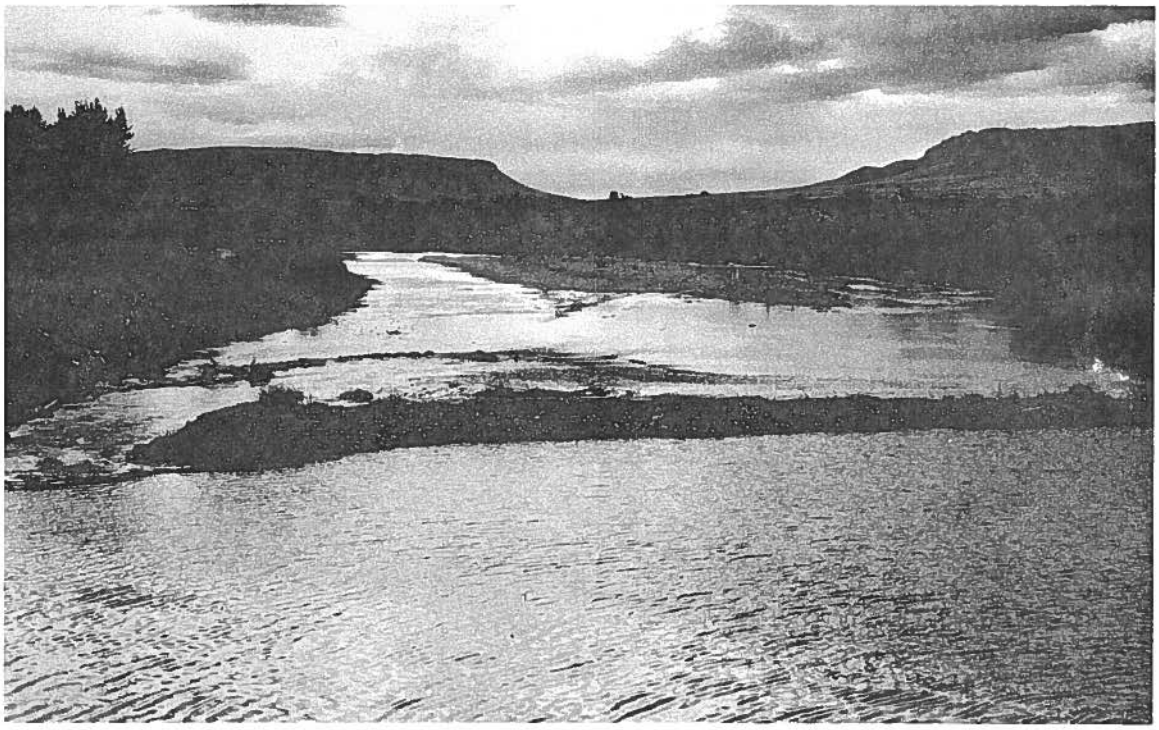


Photo 5. Normal flow in Sun River below Rocky Reef Diversion.

Photo 6. Floweree Canal over School Section Coulee at Golden Ridge.

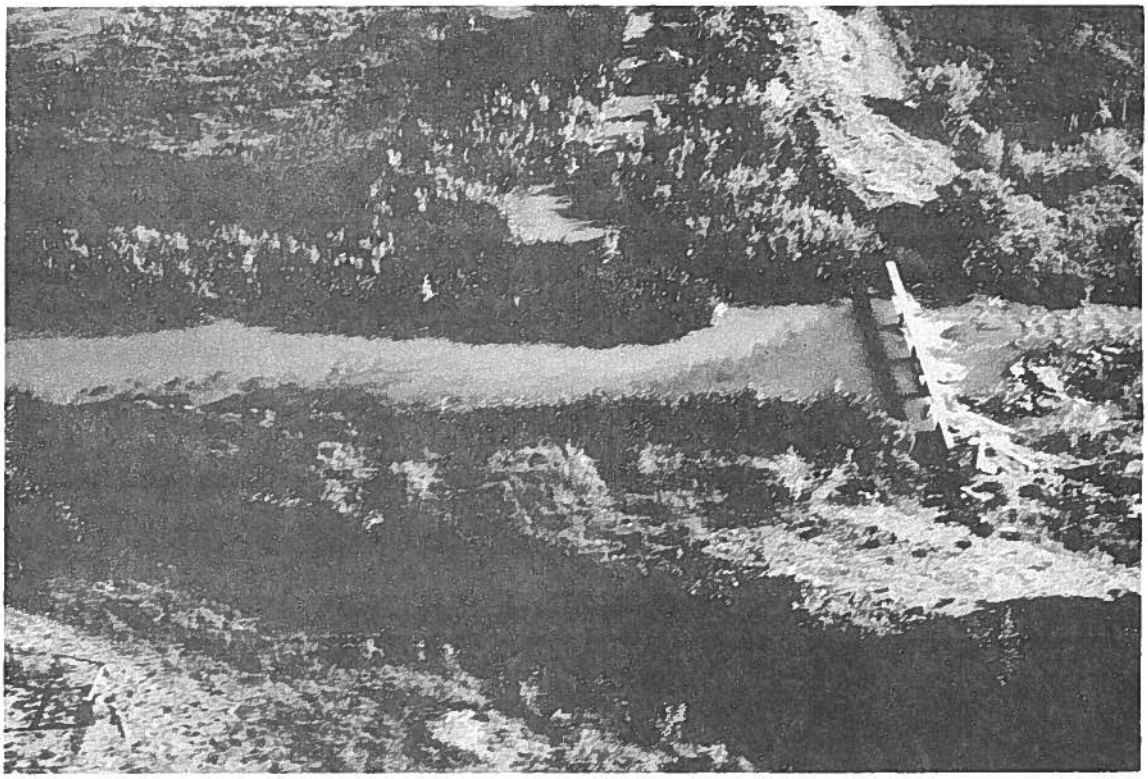


Photo 7. Mixing of water of Alfalfa Canal (clear) with School Section Coulee (turbid).

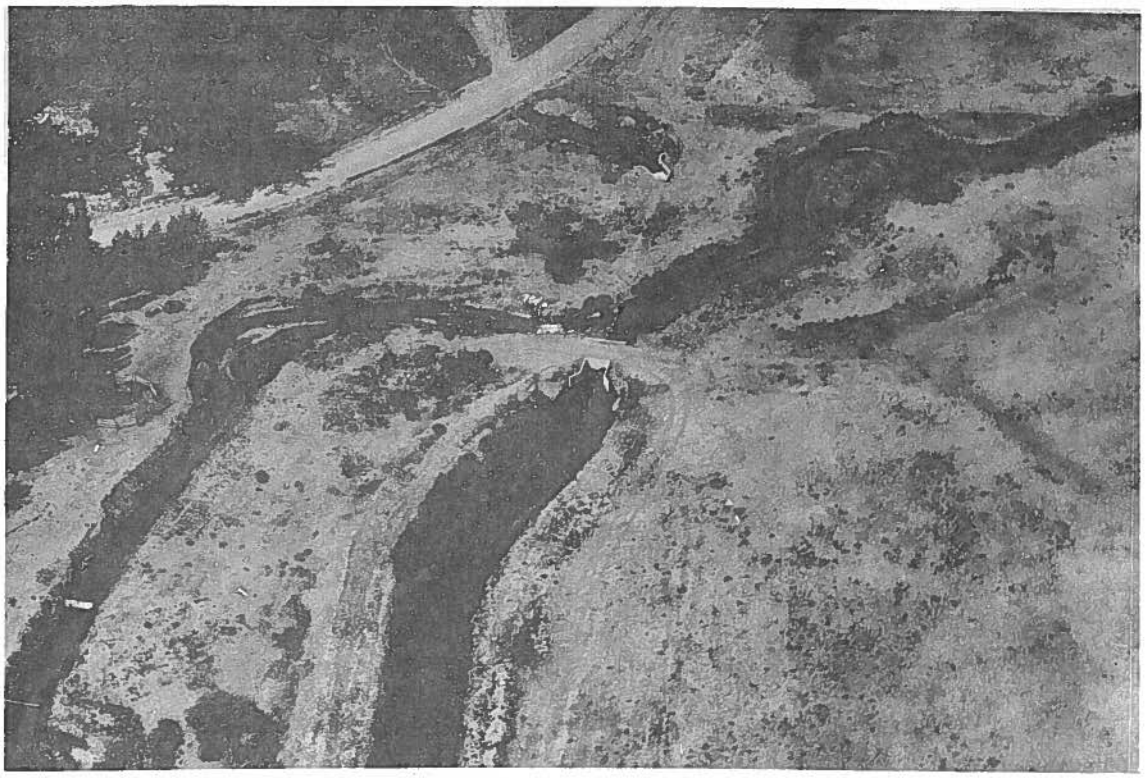


Photo 8. Sun River Valley Canal under Mill Coulee near town of Sun River.

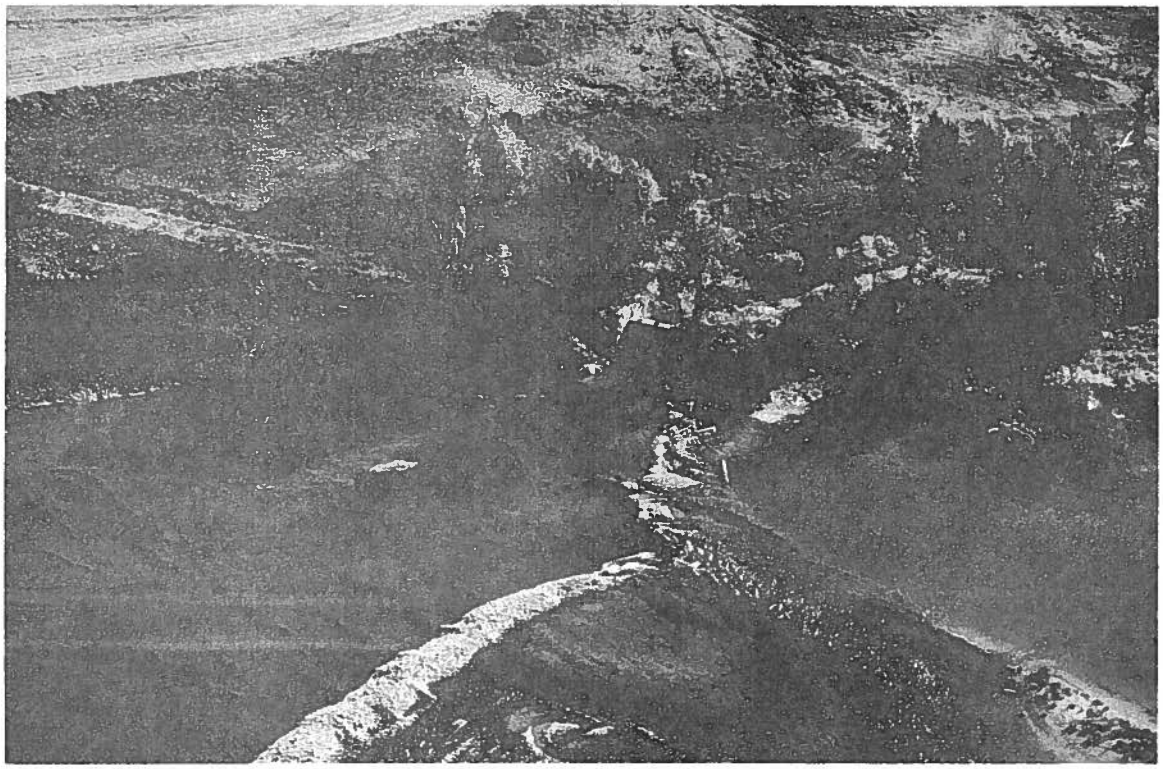


Photo 9. Typical private diversion showing gravel dike created by annual bulldozer activity.

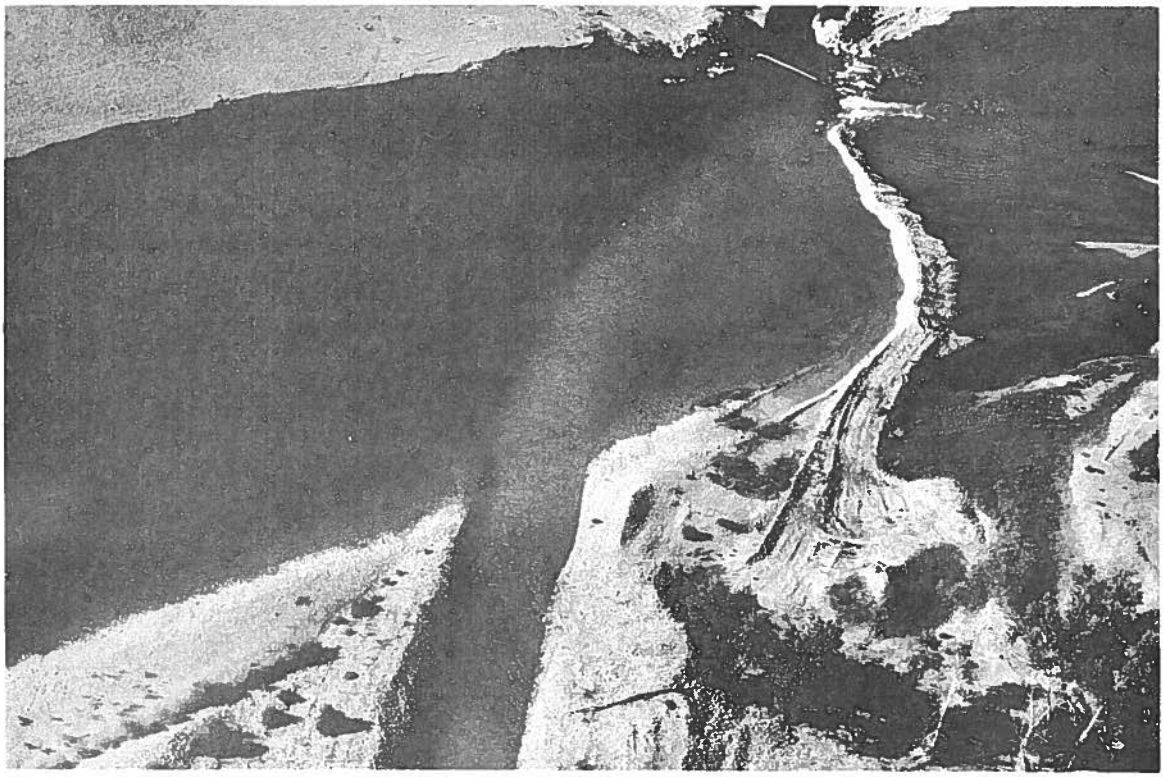


Photo 10. Turbid water entering Sun River from Willow Creek Reservoir Drain. Photo also shows gravel dike for Floweree Diversion.

Photo 11. Barsotti Drain showing red-colored water entering Sun River.

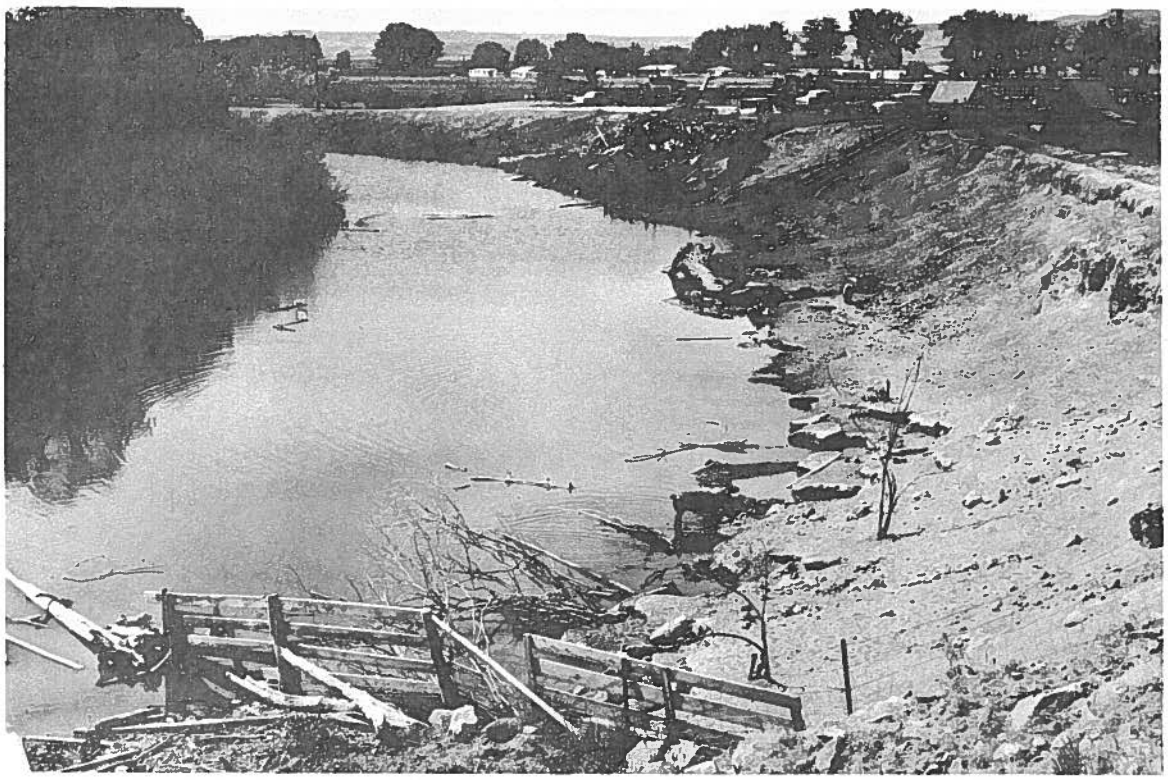


Photo 12. Domestic pollution from hogs in Barsotti Drain.

Photo 13. Muddy Creek flowing into Sun River, showing silt delta.