INNOVATIVE STATIC SELF-CLEANING SCREEN PROTECTS FISH AND REMOVES DEBRIS AT IRRIGATION DIVERSIONS

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ABSTRACT

At the time many irrigation projects were conceived at the turn of the last century, and prior to 1930, little consideration had been given to providing screens for fish protection. The passage of the Endangered Species Act, plus recent environmental concerns for protection of fish as a natural resource having considerable economic value, however, has prompted the construction of new diversion structures to exclude both resident and migratory fish from entering irrigation canals where they would otherwise be lost. One such installation, on the Flathead Irrigation Project in Montana, included a stream diversion to accommodate a screening facility that had to be suitable for a remote location, since electricity was not available to operate a cleaning mechanism. An additional requirement for small irrigation diversions is the need to be very cost-effective and reliable with a minimum of maintenance. A screening system that meets these requirements has been developed utilizing concave screen panels arranged in a linear array. The screening system is installed along the crest of small dams or diversion structures. As the water flows over the screen, a portion passes through to the irrigation system and the remainder flows across the screen surface carrying aquatic life safely downstream. Components are fabricated from stainless steel and are designed for maintenance-free operation. The screening structure on Crow Creek, which is part of the Flathead Irrigation Project, was the outcome of negotiations between the Bureau of Indian Affairs and the Tribal Council of the Flathead Indian Tribe. Installation techniques and costs for the fish screening structure at the Flathead Irrigation Project are presented.

INTRODUCTION

The Flathead Irrigation Project is located on the Flathead Indian Reservation in western Montana within the Portland Area Jurisdiction of the Bureau of Indian

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Affairs as shown in Figure 1. The Flathead Indian Reservation was first established by the Treaty of Hellgate in 1855. At that time, the land and resources within the reservation boundary were reserved for the exclusive use of the Confederated Salish and Kootenai Tribes.

An important aspect of the reservation land ownership involved the implementation of an irrigation project in 1904, which has come to be known as the Flathead Indian Irrigation Project. In 1908, the Federal Government initiated the appropriation of funds for this project which subsequently involved the expansion of the scope of the project to include non-Indian land. Irrigated land involves the production of potatoes, grains, and hay for cattle feed.

The federal Government, through the Northwest Region of the Bureau of Indian Affairs, has the following two primary trust responsibilities as operators of the Flathead Indian Irrigation Project:

1. Efficiently and fairly delivering irrigation water to irrigators served by the project.
2. Conducting project business in a manner consistent with Federal law, regulation, and policy.

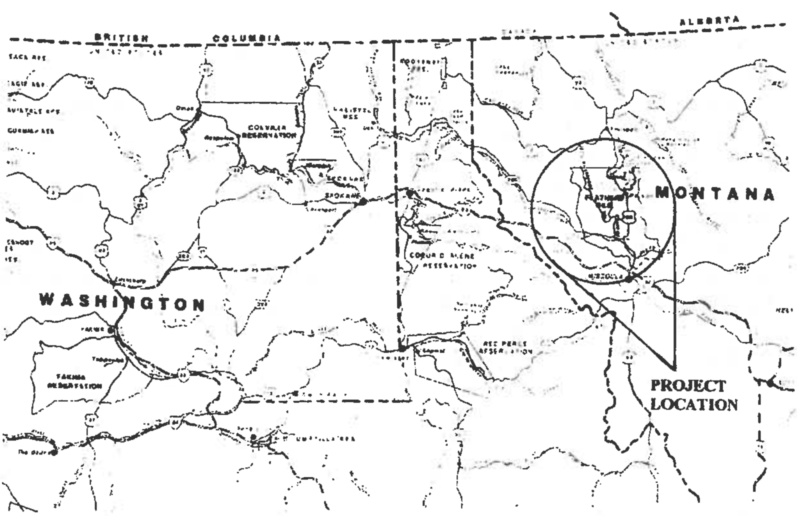


Figure 1

At the time the Flathead Indian Irrigation Project was initiated, no consideration had been given to protection of one of the most important resources of the reservation; i.e., fish, consisting primarily of bull trout (<u>Salvelinus confluentus</u>) and west slope cutthroat trout (<u>Salmo clarkie</u>) with the latter being the only native species. Seasonal demands for irrigation water from the reservation streams and reservoirs invariably led to fish losses which had adversely impacted the reservation resources. A typical fish kill when irrigation canals were shut off at the end of an irrigation season is shown in Figure 2. The fish happen to be yellow perch (Perca florescens); other species had already succumbed from the deprivation of oxygen prior to a total shut-down of the canal. In an effort to mitigate these losses the Bureau of Indian Affairs in 1987 decided to incorporate within a single structure, a fish screen, a fish ladder, and a new diversion on Crow Creek located within the reservation and southwest of Ronan, Montana. The project was done in order to protect fish and meet the trust responsibilities of the Federal Government.

Figure 2

DISCUSSION

Problems Associated With Conventional Screens

Most of the screening facilities for fish protection at diversions prior to 1983 consisted of the then state-of-the-art standard perforated plate screens. These screens are generally 14-guage punched plate with 5/32-inch holes on 7/32-inch centers. A brush mechanism, driven by cable and pulley system powered by a reversible motor, cleans the screens continuously as shown in Figure 3. In spite of the fairly inexpensive installed cost of approximately $250 per CFS (cubic foot per second) for this type of screen, there are many inherent problems. First of all, power is required to operate the brush mechanism. Since the diversion for many small irrigation sites is typically far removed from a source of power, supplying power to the diversion can be very expensive. Where icing conditions occur, the screens frequently freeze up and have to be removed during the winter to prevent damage. Pine needles and small rocks also tend to become wedged in the punched holes and clog the screen. A special clogging problem can occur with these types of screens in streams that are high in filamentous algae during summer

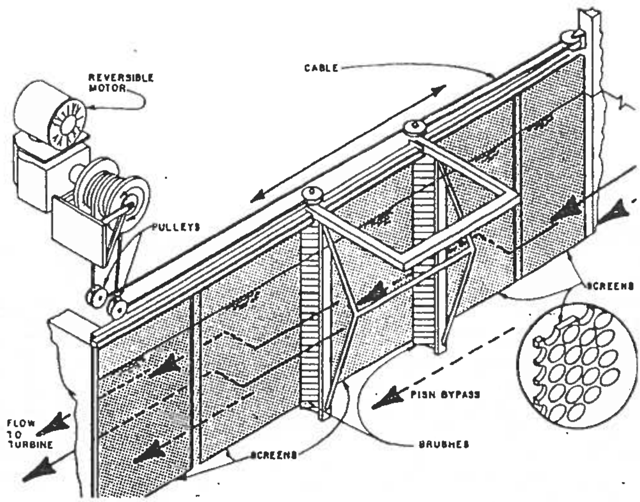


Figure 3

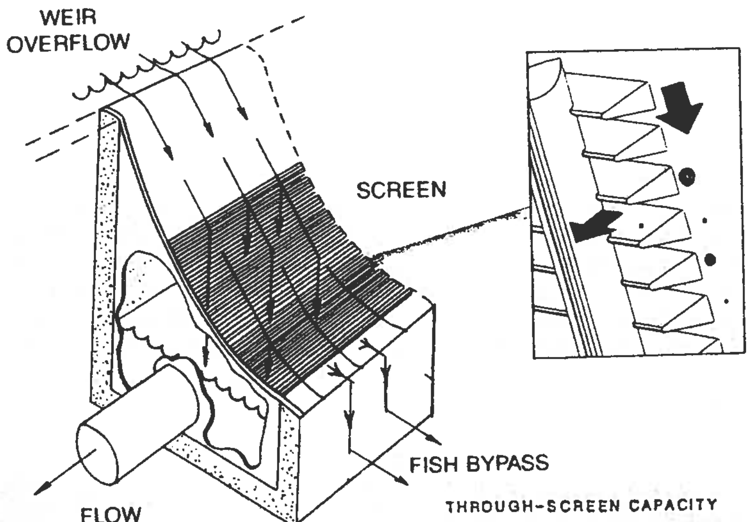
months. If a special anti-fouling coating or material is not used, repeated hand brushing may be necessary to control some types of algae growing on the screen surfaces. Finally, provision should be made to ensure that the by-pass flow parallel to the screen will remove debris carried from the screen face as well as guide fish downstream.

Practical Solution For Crow Creek

For the remote diversion site at Crow Creek, it was desirable to find a screening technique that met not only regulatory criteria, but had no moving parts or power requirements, and was simple and inexpensive to install. It was also desirable that the fish screen be self-cleaning, and require little or no maintenance. To meet all these criteria, the concept of the Coanda-type screen was selected as illustrated in Figure 4.

The Coanda-type screen originated in 1955 as a simple apparatus for wet screening slurries in the mining industry utilizing the Coanda Effect; that is, the phenomenon whereby a fluid tends to follow a solid surface. In addition, the wedge-shaped wire is tilted on the support rods during the manufacturing process.

The wire tilt produces an offset which causes a shearing action along the screen surface. A portion of water flowing over each slot is sliced or sheared off. Water flows over the weir plate and onto an acceleration plate which provides for even distribution of flow across the screen width and increase in velocity of the fluid across the horizontal slot. The screen is shaped in the form of an ogee as in a dam over-flow spillway. Flow of diverted water is through the screen slots, which are normally 1mm wide, to a water conveyance channel located beneath the screen. Because the acceleration plate increases the velocity of the water across the slots, 90% of the suspended solid particles as small as .5 mm do not pass through the



THROUGH-SCREEN CAPACITY

FLOW (CFS/FT)	DIMENSIONS A	B	C
1.0	35 3/4"	34 1/2"	4 1/2"
1.5	47"	44"	5 3/4"

Figure 4

screen. The smooth surface of the stainless steel screen provides an excellent fish conveyance to a fish by-pass. Since both the debris and fish pass over the screen surface, very little, if any, cleaning is required. The underside of the screen is reinforced with supports to handle all large debris passing over it which may include rocks and tree limbs which would otherwise incapacitate a perforated plate screen.

Generally, these Coanda-type screens are sized to handle 1 to 4 cfs per lineal foot of screen width measured at the weir crest, depending on approach conditions as well as available head loss. The cost of the screening material and supports is approximately $700 per cfs; however installation is relatively simple making them very cost-effective. The Coanda-type screen is installed by merely placing the frame assembly onto two concrete walls as shown in Figure 4. Also shown in Figure 4 are the general dimensions for flow densities of 1 and 1 ½ cfs per lineal foot of screen width measured along the weir crest.

The irrigation diversion at the Crow Creek site involved 120 cfs, and it was decided to utilize a flow rating of 1 ½ cfs per lineal foot of screen width which required a total weir length of 80 feet. Since the screen panels are normally finished in 5-foot widths, a total of 16 panels were to be placed on the structure to be erected at the site.

Crow Creek Site

The project site selected on Crow Creek for the diversion structure, fish ladder, and fish screen is shown in Figure 5. The control gates to Moiese A Canal, an irrigation diversion southwest of Ronan, Montana, are shown to the right of the center of the photograph. Particular care had to be taken so as not to disturb the tree in the center of the photograph, because markings on the tree provided indication that an encampment site was at one time nearby. During the permit process, it was decided that this tree held significant cultural importance for the Confederated Salish and Kootenai Tribes, and therefore, was not disturbed in any manner.

Figure 5

Construction Phase

The employees of the Flathead Indian Irrigation Project constituted the work force of this project, many of whom had never worked on a project of this size before so that this project served as on-the-job training for many of the crew. On December 31, 1987, the construction phase of this project was completed as shown in Figure 6 and the site was ready for landscaping in the spring of the following year.

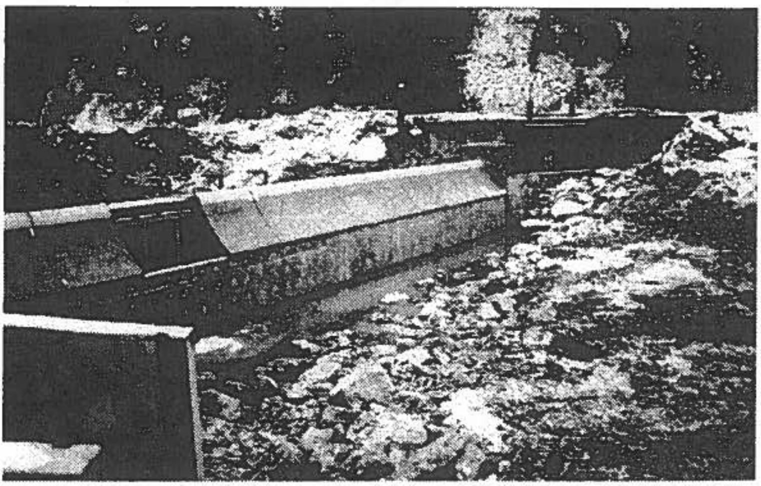


Figure 6

Cost Analysis

In accordance with the accounting records of the Bureau of Indian Affairs, the total cost of the project in 1999 dollars is broken down as follows:

Material	$44,199
Labor	$64,911
Static fish screen	$72,765
Total Project Cost	$181,375

It should be noted that this total cost reflects the irrigation diversion structure as well as for a five-step-and-pool fish ladder in addition to the static fish screen

Therefore, rather than operating at the original design of 1 ½ cfs per ft. of weir length, the screens were operating in excess of 2 cfs per ft. of weir length.

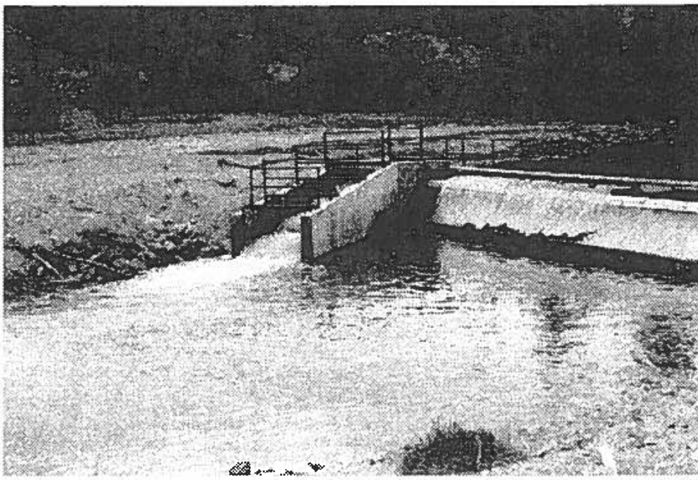


Figure 7

Soon after the static screen installation was placed in service, an algae growth was observed on the wetted surface of the screens. It was found that brushing the screens once a week removed any build-up of material on the screens.

<u>Second Site – K Canal</u>

As a result of the reliable operation of the Crow Creek installation, the Bureau ofl Indian Affairs decided that a second site at the Flathead Irrigation Project at K Canal should also be considered for a Coanda-type static screen. After careful hydraulic studies, it was decided that this second site on K Canal had the available head loss of 54 inches to make a static screen suitable at this location.

K Canal is a 240-cfs off-channel structure, located on the Jocko River, east of Arlee, Montana on the Flathead Indian Reservation. This second Coanda-type static screen structure was completed in 1992 and the operation is identical to Crow Creek only it is twice as long. For the 240 cfs flow, sixteen 5 ft. wide panels were utilized to handle the total flow; that is 3 cfs per lineal foot of screen width measured along the weir crest. This is virtually double the original guaranteed flow of 1 ½ cfs per lineal foot of screen width measured along the weir crest.

In light of this, the Bureau of Indian Affairs declared one-half the original total of sixteen panels at Crow Creek surplus and relocated them to K Canal site and purchased an additional quantity of eight more panels in 19192. The completed installation at K Canal is shown in Figure 8.

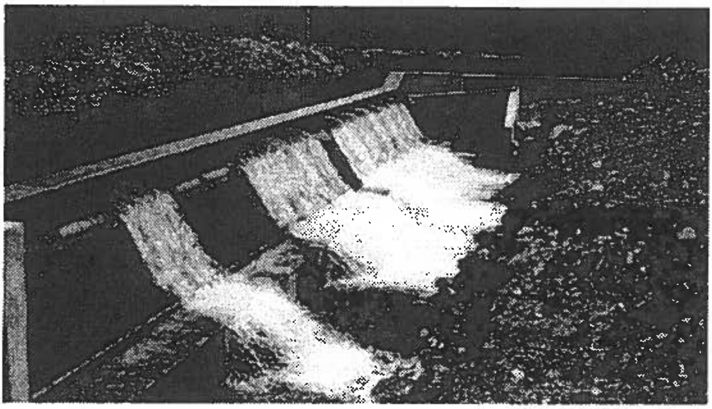


Figure 8

No decreased capacity resulted from wear on the leading edges of the tilted wires has been observed at either Crow Creek or K Canal. As the years have passed, however, increased maintenance has been required at both sites. Aquatic vegetation build-up on the screens has required high-pressure washing to clean them. Undoubtedly, the use of copper/nickel alloy for the screen material would virtually eliminate this biofouling; however, copper/nickel alloy is approximately three times the cost of Type 304 Stainless Steel and does not have comparable strength.

Summary and Conclusion

In conclusion, the irrigation diversions of Crow Creek and K Canal, incorporating the fish ladder and static screen installation, are operating as originally intended by meeting the in-stream flows as well as providing positive protection by excluding fish from entering the irrigation canals. Previous installations of the Coanda-type static screen concept had been applied to hydroelectric diversions for fish protection. The installations of Crow Creek and K Canal were the first such Coanda-type screen applications involving fish protection on irrigation diversions and show a promising concept that may be considered as an alternative to conventional fish-screening techniques. The Coanda-type screen concept, therefore, appears equally adaptable to irrigation diversions as well as to hydro diversions.

In the case of hydro diversions, the hydraulic turbine determines the flow through the screens, and reduced load means rejection of water by overflowing the screens. In the case of irrigation diversions, the irrigation demand determines the flow through the screens and should the screens not meet the irrigation demand, water overflowing the screens may be considered wasted. Therefore, it is important that the screens be sized correctly to meet the irrigation demand. There are many factors influencing the sizing of the Coanda-type screens, and in the case of the Crow Creek installation, the original design obviously was more conservative than required.

Subsequent experience with Coanda-type static screens at the irrigation diversion of East Fork Irrigation District near Hood River, Oregon has proven the capability of this type of screen to be cost effective at much lower head losses than originally conceived. For example, under the ideal approach conditions at the East Fork Irrigation District site, the differential head between the upstream level in the compartmental sand trap and the tailwater of the screen is only approximately 18 inches. Even so, the screens are still capable of handling the capacity of 90 cfs or 1 ½ cfs per foot of horizontal weir length of screen. For more information of this installation, please refer to the Proceedings of the 1999 USCID Workshop, Modernization of Irrigation Water Delivery Systems under "Protecting Fish at Irrigation Diversions", pages 637 through 644.

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