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UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number as well as the person's name is given. All Bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

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Land Technical Services
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A newly constructed turnout structure on the Wellton Mohawk Irrigation District.

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SI METRIC

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INTRODUCTION

The article on page 1 describes a federal program, designed to decrease water salinity and improve irrigation efficiency, which has been highly successful, according to farmers in the Wellton-Mohawk Irrigation District.

The article on the Riverton Project Rehabilitation and Betterment Program, beginning on page 10, discusses and documents some of the problems encountered and the steps taken to provide practical working solutions to the problems.

The digest statement included in this issue of the Bulletin details the embankment upstream slope failure that occurred at San Luis Dam in September 1981. The digest statement begins on page 32.

IRRIGATION EFFICIENCY IMPROVED IN WELLTON-MOHAWK DISTRICT

A federal program, the first of its kind in the nation, designed to decrease water salinity and improve irrigation efficiency, has been highly successful, according to farmers in the Wellton-Mohawk Irrigation District.

Improvement projects, including redesigning irrigation systems and thus increasing water efficiency, have been installed at Bob and Robby Woodhouse's 1,600-acre wheat, alfalfa, sesame and bermuda grass farm in the Wellton-Mohawk Irrigation District, outside of Yuma. They are just two of many farmers involved in the program.

Ken King, soil conservationist project leader, discusses a proposed conservation plan with farmers Bob and Robby Woodhouse.

A big plus was redesigning the former irrigation systems and building bigger ditches, according to Bob.

"We can handle more water now, so we can irrigate in bigger blocks," the senior Woodhouse said. Where the soil permits it, "we've gone from 10-acre blocks to 20-acre blocks.

"Instead of getting 15 second feet of water, we're getting 25 to 28 second feet of water–that enables us to irrigate a 20-acre block in the same amount of time we were irrigating a 10-acre block."

The Wellton-Mohawk Irrigation Improvement Program that the Woodhouse's have been involved in is a five-year project which ended in December (1985). The goal of the program is to reduce return flows from the Wellton-Mohawk Irrigation and Drainage District through a multi-agency approach of on-farm water management and improvement assistance offered to farmers in the district.

Agencies involved and their programs include: Bureau of Reclamation — irrigation management service program and acreage reduction; Agricultural Research Service — research and demonstrations; Coopera-

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tive Extension Service — education and information; and Soil Conservation Service — on-farm irrigation improvement program.

After increasing salinity occurred in the Wellton-Mohawk water table, eventually resulting in increased salinity in Mexico's Colorado River water, an agreement was reached between the two nations for control of the problem.

In order to implement this agreement, the "Colorado River Basin Salinity Control Act" was passed by Congress in 1974.

Along with the building of a desalinization plant to treat the return flows from the district, the Irrigation Improvement Program was established. The SCS established the Wellton-Mohawk Special Project office in February 1975, to help farmers such as the Woodhouse's in establishing irrigation improvement projects.

Total acreage in the Wellton-Mohawk Irrigation and Drainage District is 75,000 acres, of which 71,000 acres have been irrigated. Between 1970 and 1972 the average efficiency of water use for the district was 56 percent.

To accomplish the goal of reducing return flows by 78,000 acre-feet of water per year, it was estimated that the average efficiency of water use would have to be raised to 72 percent.

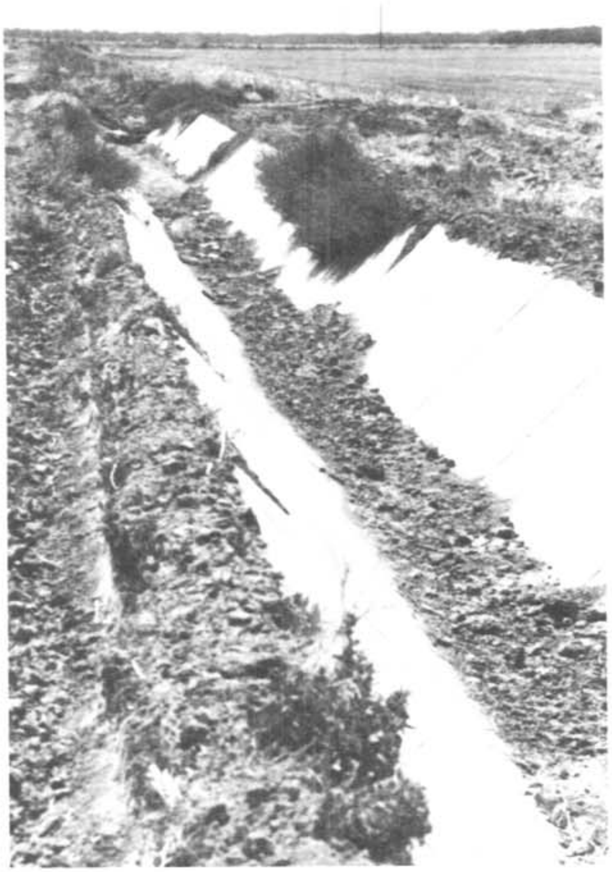
According to Ken King, Wellton-Mohawk Irrigation Project leader with the SCS, a 70- to 90-percent efficiency has been obtained through implementation of the contracts reached with individual farmers.

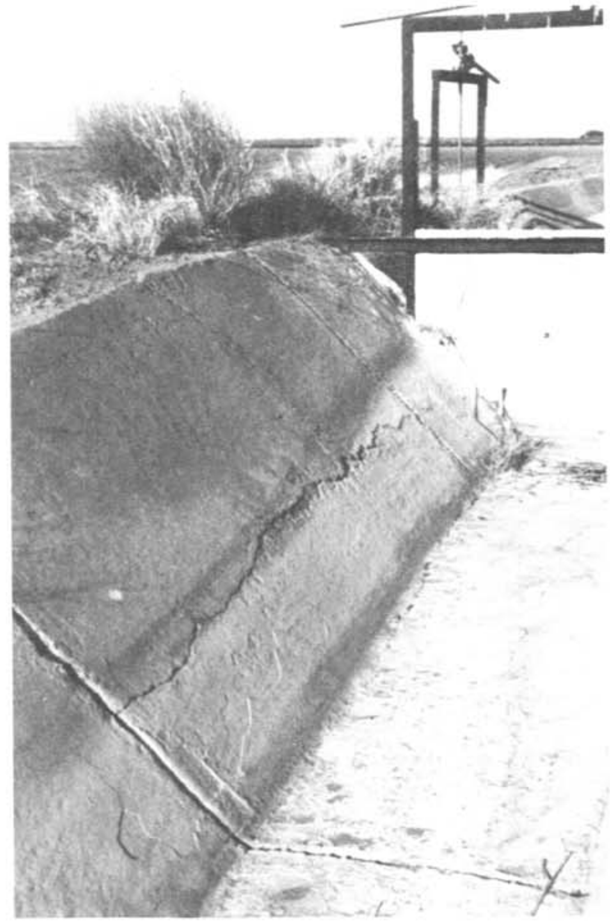
The program is voluntary, with farmers having to request assistance from the SCS. Those that do are the "conservation-minded ones," King said. "They must understand the ramifications of the cost-share program," he added.

Farmers are required to pay 25 percent of the cost. The remainder is paid through special funds established through the 1974 act. The special funds come through the BLM and are distributed by the SCS.

A majority of the farmers in the Wellton-Mohawk Irrigation District have participated in the program. As the year drew to an end, more farmers asked to participate, King said. Reaction to the nation's only such program has been great, he said.

"Farmers are tickled pink. It has given them an opportunity to update their systems, some of which are 20- to 30-years old. In addition, we now know more about irrigation and are able to install improvements in technology we now have," King said.





Examples of cracked, weed-filled irrigation ditches and gates.

After a farmer requests participation in the program, a SCS technician develops a conservation plan and contract for cost sharing.

The first step in developing a conservation plan is to make a detailed soil survey of the farm. The staff soil scientist uses aerial photographs and either a hand auger or truck-mounted, power auger.

During his systematic mapping of the farm, he notes all soil types and any variations. The information is recorded on the photograph. At the office the map is inked to provide a permanent copy of the data.

Ripping out an old ditch.

The soil scientist then prepares a detailed description of each soil. Using these data, interpretations are made for each soil relating its potential and limitations to the planning and design of an efficient irrigation system.

The soil conservationist and engineer are now ready to complete the farm's resource survey. The condition and size of the existing irrigation system are recorded.

Lengths of run and slopes are surveyed and mapped. The farmer and conservationist discuss cropping history and decide upon the crops to be grown during the life of the contract.

Using the inventory data, the conservationist develops alternative treatments which will accomplish the goal of high level irrigation water management. The alternatives are all based on a water delivery rate of 15 cubic feet per second.

The conservationist now reviews the data with the farmer. Then, when the farmer, such as the Woodhouse's have decided on the treatment to be applied, they develop a conservation plan of operations for the farm.

The practices to be applied to achieve the desired results are recorded along with the location and date when the work will be done. A contract is then prepared and signed obligating the farmer and the Federal Government to carry out the plan.

A ditch digger makes easy work of putting in a new ditch in line with a farmer's conservation plans.

A new irrigation ditch.

Pouring cement into a float, which forms the new irrigation ditch.

Practices include concrete-lining all ditches as well as removing all ditches that are too small or deteriorated to function properly.

In addition, a critical depth flume is installed near the farm's district turnout. This flume permits easy measurement of the irrigation flow, considered an important part of the evaluation and management of the irrigation system.

In addition, most acres are leveled, according to King.

The predominant form of irrigation in the valley is border irrigation, but the SCS office has worked on irrigation efficiency with about 2,000 acres watered through drip irrigation and about 300 acres of sprinkler irrigated acreage.

"We develop a design for whatever the farmer wants. We furnish the farmer with a copy of the design, but it is up to the farmer to get it applied to the ground," King said. "The farmer does the contracting for the work–he pays the contractor and is reimbursed 75 percent of an estimated average cost."

After construction is completed, the farmer has two more years of obligation on the contract.

"The farmer has to achieve proper water irrigation management to be in compliance with the contract," he said.

Installing a measuring flume for measuring the amount of water in a ditch.

An irrigation water management team checks during irrigation on the need and actual amount of water applied. In addition, the team checks the data and the district's delivery records. The combination of the two supports whether the farmer has done a proper job or not, King said.

"We know what crop is grown, so we know what amount of water is required." he said.

If there are problems structurally, the problem is rectified by the SCS staff. In other cases, a SCS conservationist provides a farmer with irrigation guides and works with him on understanding the irrigation system that has been established.

If there are problems, the contracts are then extended for another year. Very few contracts have had to be extended, however.

"Usually, after a year the problem is ironed out," King said. "They do their darndest to work with the system."

With the end of the program, King foresees little slippage into old irrigation habits.

"I'm sure they won't revert back to poor water management," he said. "The farmer has a big stake in the program–it costs about $1,300 an acre. They are going to protect their investment."

The Woodhouses are happy with their investment. Their entire farm has undergone redesigning since the program began, with less labor, less time required, and increased irrigation efficiency as a result.

"Irrigation time is less because of the larger head of water, so labor per acre is less and water usage per acre has gone down," said Robby.

Installing a turnout for flood irrigation. The blocks are used to slow down the water.

Less water usage has also had an impact on the district, according to Bob, who is on the Wellton-Mohawk Irrigation District board of directors.

"In some years prior to this on-farm improvement we had used as much as seven acre-feet of water per acre per year on a district-wide average, and now we're down . . .The last year or two we've been under six, so we've probably reduced our overall water application through the district by at least a foot," Bob said. "But that didn't cheapen the operation of the district any, so we had to raise the price of water to compensate for selling less water."

"One other thing is where we increased field size from an average 10 acres to 20, we've actually increased our net farmable acres too, because we've eliminated about one-half the lineal footage of ditch," Robby said. "We've eliminated a lot of water-stopped borders we've had to have before, also."

Another benefit of the system has been more uniform water applications, the Woodhouses said.

"By doing it in bigger blocks and faster, the crop grows more uniformly," Bob said. "Now we'll have 160 acres of ground that we're farming in eight 20-acre blocks. We've got a lot less borders, got a lot less ground laying out."

He estimates that 3 to 4 percent more acres are available for farming because it isn't laid out in roadways, borders, and ditches.

Bob says the district's farmers aren't complaining, however, about paying more for the water, since they are using less of it. There has been a district-wide acceptance to the program, he noted.

The benefits are of a long-term nature, although money had to be borrowed to pay for the farmer's share of the program. Robby said the long-term benefits are what is important.

"We're looking at the long-term benefits, the long-term improvements that have been done to a particular parcel," Robby said.

Another plus to the program has been increased yields, caused by a more uniform cropping pattern.

"The increase in yield is when a farmer goes out and thinks he's harvested 60 acres of wheat . . .but I think his biggest increase in yield is due to his net average acreage increase," Robby said.

"There have been cases where the SCS has redesigned the farm and there's actually more net farmable acres than before. That's probably the biggest increase in yields when he thinks of that 160 acres–he can harvest more acres off of that," Robby said.

A newly completed turnout structure.

A part of the program also includes taking soil from a high part of the farm and putting it on sandy places. The soil swap exchange has worked, according to Bob, who implemented it on his farm. It also leads to a more uniform cropping pattern and, as a result, higher yields.

* * * * *

RIVERTON PROJECT REHABILITATION AND BETTERMENT

by

Jerome M. Schaack[1] and Richard E. Brohl[2]

An R&B (Rehabilitation and Betterment) Program was initiated on the Riverton Project in 1974 and the following work was accomplished:

A. Canal lining (300 to 2,000 ft^3/s)

1. Concrete lining repair	24,228 yd^2
2. PVC membrane lining	13.3 mi

B. Laterals (100.6 mi)

1. Concrete lining	11.2 mi
2. PVC membrane	13.4 mi
3. Pipelines – USBR installed	54.3 mi
4. Pipelines – Irrigation District installed	21.7 mi
5. Structure replacement	All on 100.6 miles of new ditch or pipeline

C. Drainage program

1. Buried pipe drains	300.1 mi
2. Open drains backfilled	48.5 mi

D. Other – Diversion Dam Modifications, Pilot Canal Chute (1-1/4-mile 450 ft^3/s), Ocean Drain Stabilization (3.0 miles)

Many lessons were learned from this R&B, particularly from the standpoint of what will work best *in the field*. The purpose of this document is to discuss and document some of the problems encountered and the steps taken to provide practical working solutions to the problems. Some of the problems and solutions are quite straightforward while others are complex and unique to a certain set of conditions. It should be kept in mind that field conditions may dictate the best solutions in many cases, and judgment and experience are needed in applying general rules.

Following is a description of some of the suggested solutions for each:

Membrane Lining

The use of membrane lining has proven to be an excellent means of reducing open ditch seepage. It

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particularly has advantages over concrete in this area because of severe freeze-thaw and frost heave problems with concrete. The membrane lining normally is installed on a bank side slope of 2:1. This side slope is satisfactory, but is approaching a marginal steepness. Steeper side slopes than this should not be used. A side slope of 2-1/2 or 2-1/4:1 would provide a margin of safety and allow for unfavorable field conditions and problems. In some cases, it is not possible to provide flatter (2-1/2 or 2-1/4:1) side slopes because of limited right-of-way widths. There is also a tradeoff with construction costs.

It was found that if the side slopes were left rough instead of rolled smooth, the lining and the cover material tend to stay in place better.

In this light, the lining should be laid in place loosely and not stretched. This will reduce potential for membrane damage and cover material slippage. Experience in using the lining also showed that 20-mil lining is much more desirable than 10 mil (which was used initially). Use of the 20-mil lining resulted in less lining damage during installation, and we would anticipate a longer life span. Here again there is a tradeoff in construction costs which must be considered. The cost of 20-mil lining material is about $0.14 per square foot compared to $0.09 per square foot for 10 mil (1985 prices). The contractor used a group of high school students to assist in laying the lining in place to allow placing a large area in a very short timeframe.

Another important consideration is the type of cover material used. Many times there are limitations based on economics and availability. It may be possible to use less than desirable material, but still make it work. For example, on the Riverton R&B, well-rounded, pit-run material up to 8 inches in diameter was the only economically available material and was placed over an earth cover material. During the initial filling operation, some of the cover slipped exposing the lining and/or moved into downstream structures, causing problems. After the cause and effect were analyzed, it was determined a slow filling and draw-down process and extra care in operation the first year of use would help alleviate these problems. After the cover material stabilized, the operational procedures were less critical.

Another problem encountered was the propensity for willows to grow on membrane-lined ditchbanks as shown in photographs 1 and 2. This growth could have a damaging effect on the lining. No particular reason for this happening has been determined. Control to date has been by normal methods employed for this problem.

Photograph 1–Willows growing on membrane-lined ditch bank.

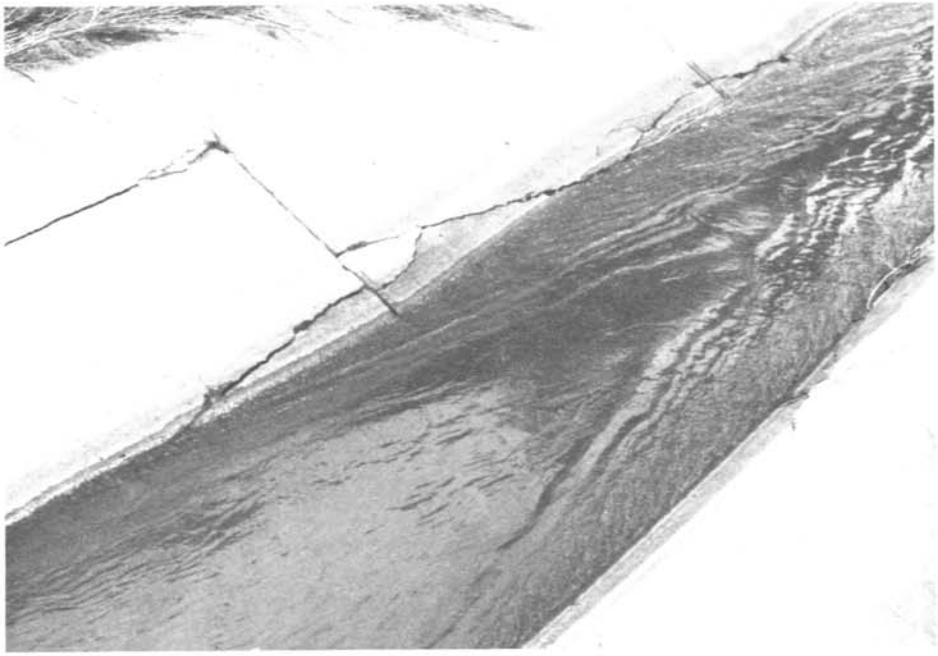
Photograph 2–Willows growing in membrane-lined ditch bank.

As mentioned earlier, the potential for severe freeze-thaw action is present in the Riverton area. Severe frost heave problems were encountered in a concrete-lined ditch within a short period after construction. A portion of the concrete lining as shown in photographs 3 and 4 was replaced. Photograph 5 shows a part of the lining which was not replaced. Due to freeze-thaw deterioration, problems with settlement and cracking, water table problems, etc., concrete lining should only be placed in ditches where membrane lining is impractical. Concrete lining may be considered if membrane lining is impractical – where the ditch can be elevated, where there is no irrigation on the uphill side, where there are free-draining soils, and no present or potential water table near the surface.

Photograph 3–Damage to concrete lining.

Restoration of Construction Areas

Care should be taken to assure that all disturbed areas are returned as near as possible to their natural state. This has been an oversight on some R&B programs in the past and measures should be taken to prevent recurrences. Provisions for seeding and other needed restoration measures should be included in contractual provisions.



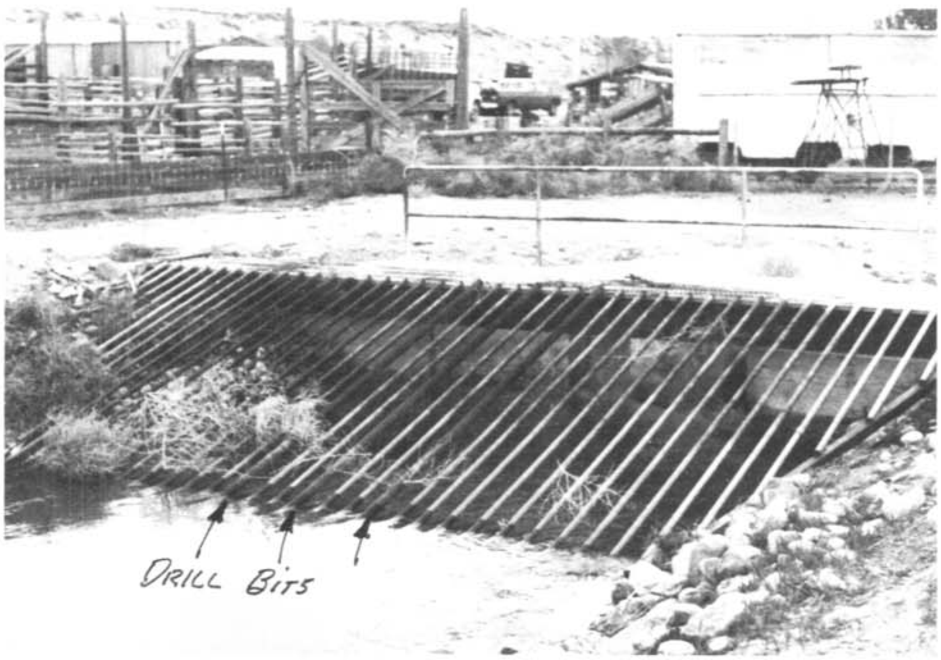
Photograph 4–Damage to concrete lining (same ditch as in photograph 3).

Photograph 5–Concrete lining which is in good condition.

Trashracks

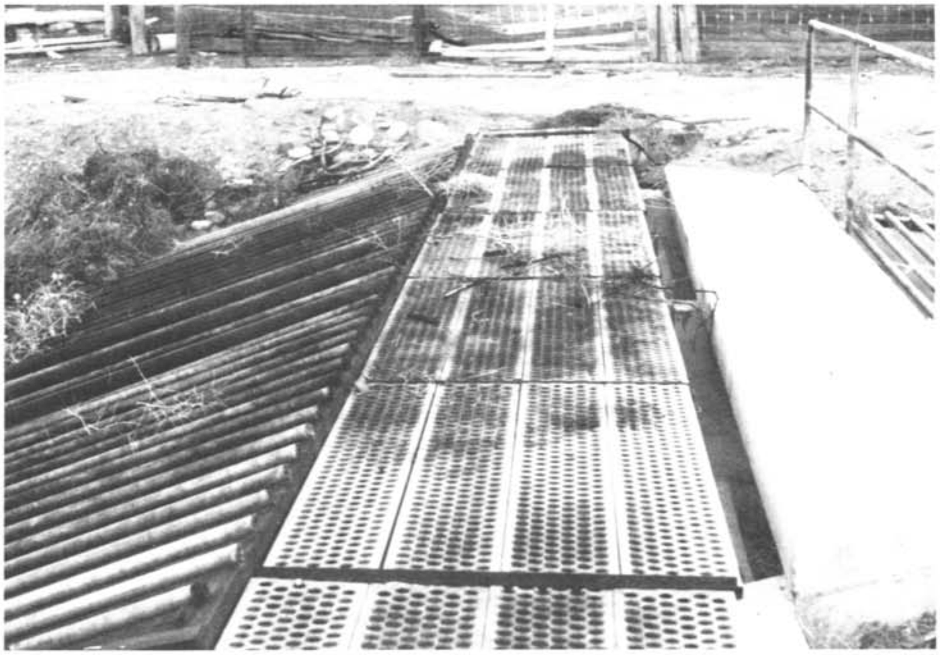
Trashracks were not initially an area of concern relative to this R&B work; however, problems developed which prompted that their design, operation, and maintenance be given more attention. A search of O&M Bulletins (see No. 97, pages 206-238) was helpful in establishing design procedures. Some of the considerations and characteristics of a "good" trashrack are discussed below.

1. *Number, spacing, and strength of members.*–The rack should have no more members than necessary to provide the needed collection capability and strength for the anticipated load. The longitudinal members should always be parallel with no cross braces. Photographs 6 and 7 illustrate a well-designed rack. Drill stems were used to provide the needed strength in some of the longer spans (photograph 6).



Photograph 6–A well designed and installed trashrack.

2. *Slope.*–The minimum slope should be 3:1, and 4:1 is more desireable in most cases. A flatter slope is more likely to provide self-cleaning capability and there is less chance of plugging. Vertical trashracks or trashracks steeper than 3:1 should not be used unless conditions eliminate all other options and plugging of the trashrack can be tolerated (fail safe).



Photograph 7–Same trashrack as seen in photograph 6, taken from the side.

3. *Self-cleaning capability.*–Although stationary trashracks are not totally self-cleaning, they can be designed to prevent plugging under normal operating conditions. The slope of the rack, conformity to the transition structure, and configuration are the most important aspects relative to self-cleaning (nonplugging). The rack in photographs 6 and 7 meets most requirements for an efficient trashrack.

4. *Safety.*–Trashrack areas can be particularly hazardous. Common sense should be used in designing in safety precautions; i.e., safety belts, guard rails, nonskid surfaces, etc., and should be considered and used when appropriate.

5. *Storage and disposal of trash.*–A suitable area should be set aside for containing trash and a method devised for disposing of it. A chain link fence or netting may be one way to contain the trash until it can be burned or otherwise disposed of. It should not be burned on the structure as this will be detrimental to it.

6. *Conformity to transition structure and configuration.* The trashrack should conform as near as possible to the transition shape to prevent trash from moving past and/or hanging up on the structure. The configuration of the rack should be such that trash moves upslope easily. The members should be parallel, there should be no intermediate cross members, and the cross member on the bottom should conform smoothly to lateral members. Photograph 8 illustrates a trashrack which has several undesirable characteristics; i.e., poor conformity, nonparallel members, steep, etc. It should be kept in mind, however, that despite some undesirable characteristics, a trashrack must suit specific conditions.

Photograph 8–A trashrack which has undesirable features (poor conformity, nonparallel members, steep, etc.).

7. *Ease and convenience of cleaning.*–Many of the items discussed in 1-6 above contribute toward ease of cleaning the racks. Since this is a very tedious job at best, it is important that it be made as easy and safe as possible. Experience in this area practically adapted to the conditions at hand will usually result in the most effective setup.

Pilot Canal Chute

The Pilot Canal Chute is shown in photograph 9. This is a concrete-lined chute which experienced capacity problems as a result of larvae (caddis fly) activity. The chute was covered as shown in foreground of photograph 9 to minimize or eliminate this activity. Covering the chute to exclude sunlight proved to be an effective method of control after sandblasting the concrete surfaces clean.

Photograph 9–The Pilot Canal Chute was covered with wooden members to control larvae activity. Uncovered portion is in background.

Operations

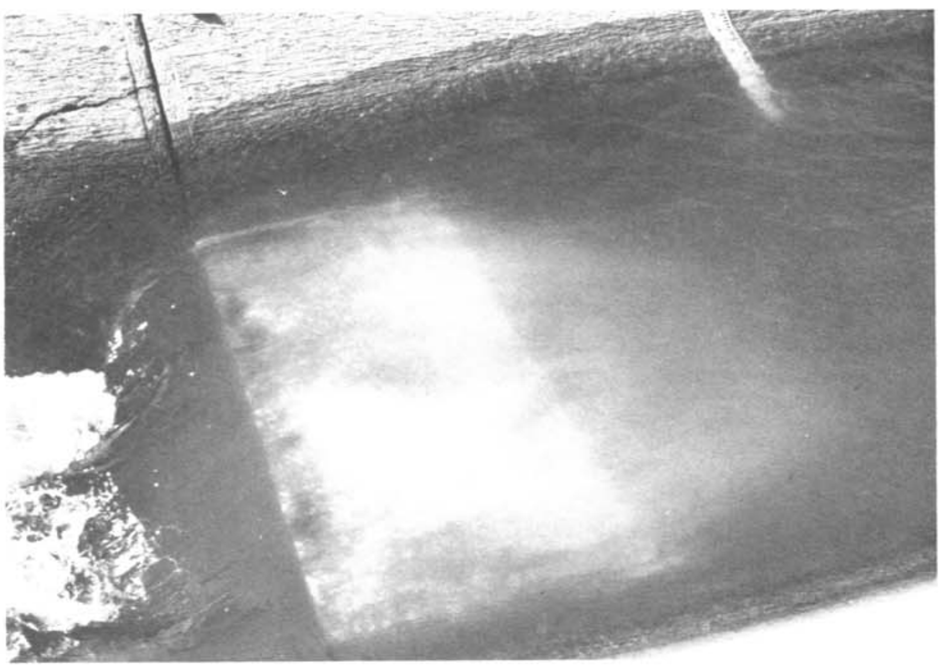
Water measurement is obviously very important in managing and controlling the water through a system. It is particularly important to have a very good measuring device going into a pipe system and also to have a wasteway at the same point. This provides required control and flexibility in operation of the system.

Photograph 10–Ramp flume and propeller meter (background).

Photograph 10 illustrates two methods of water measurement in an open channel. A propeller meter (background) and a ramp flume are being utilized in tandem to demonstrate the operation of the two methods. The propeller meter (photograph 11) is portable and can easily be transferred to other sites for use and can be stored inside when not in use. This is an accurate and economical way to measure water. The ramp flume (photograph 12) is a relatively recent device which is quite accurate, very economical, easy to install and operate, and is easily adaptable to field conditions. Special anchoring of the ramp flume should be accomplished to ensure it does not heave and reduce its accuracy.

Photograph 13 shows a weir used to measure water on the project. This particular device has an excessive accumulation of silt in the weir pool area which will result in erroneous readings. These devices require frequent surveillance and maintenance (cleaning) to provide consistently accurate records.

Photograph 11–Closeup of propeller meter.



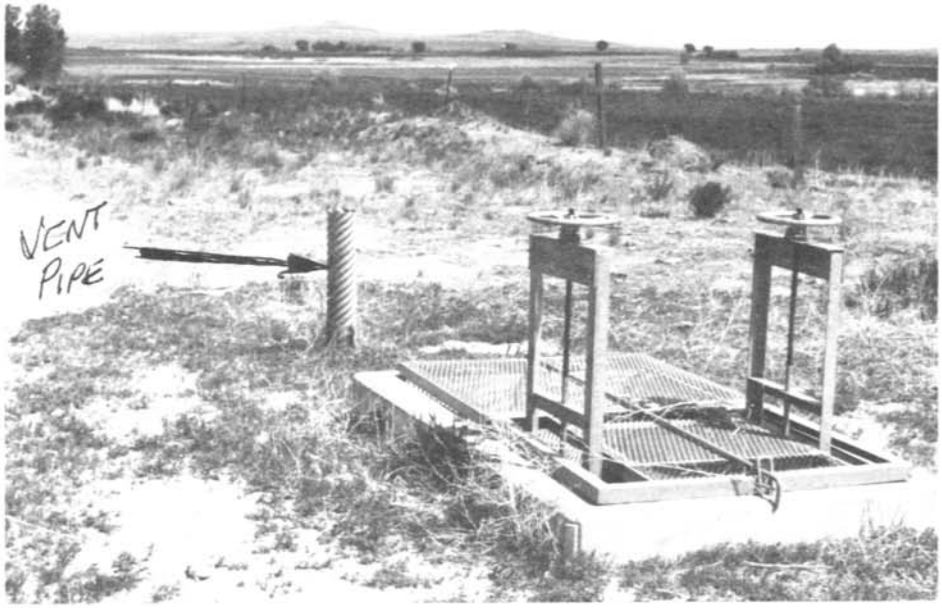
Photograph 12–Closeup of ramp flume.

Photograph 13–Weir for making water flow measurements. Note silt accumulation in weir pool.

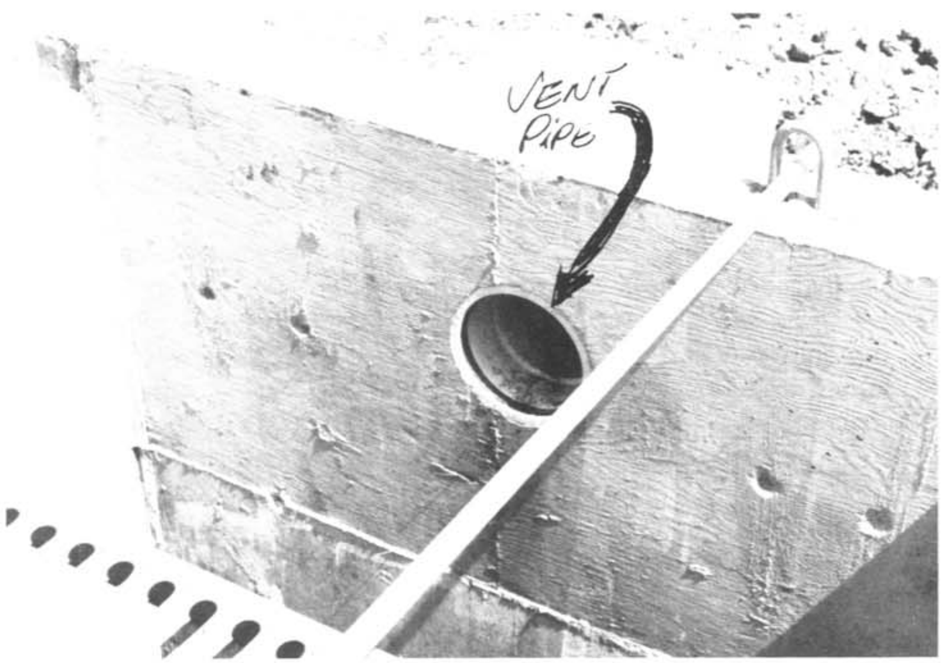
Turnouts

1. *Air vents.*–Photographs 14 and 15 illustrate the changes made in the air vents for the pipe system. Photograph 14 shows the original location of a vent pipe which was subject to damage by animals, vehicles, etc., and resulted in frequent wetting of the area. Photograph 15 shows the change in design which eliminated these problems. This vent pipe discharges water back into the structure.

2. *Design.*–The main problems encountered in turnout structures are turbulence, fluctuating flows, leakage, and high velocity. Each of these inhibit equitable control and distribution of water. Adjustable rectangular gates with no sealing surfaces were initially used as check gates in the boxes, but this resulted in unacceptable leakage around the gate. A belting material was installed to prevent the leakage, but it created excessive friction and a very difficult operating gate. Ease of gate operation is important to encourage needed regulation. Handwheels of sufficient diameter, quality workmanship, bearings, etc., should be specified to ensure obtaining the needed operating ease.



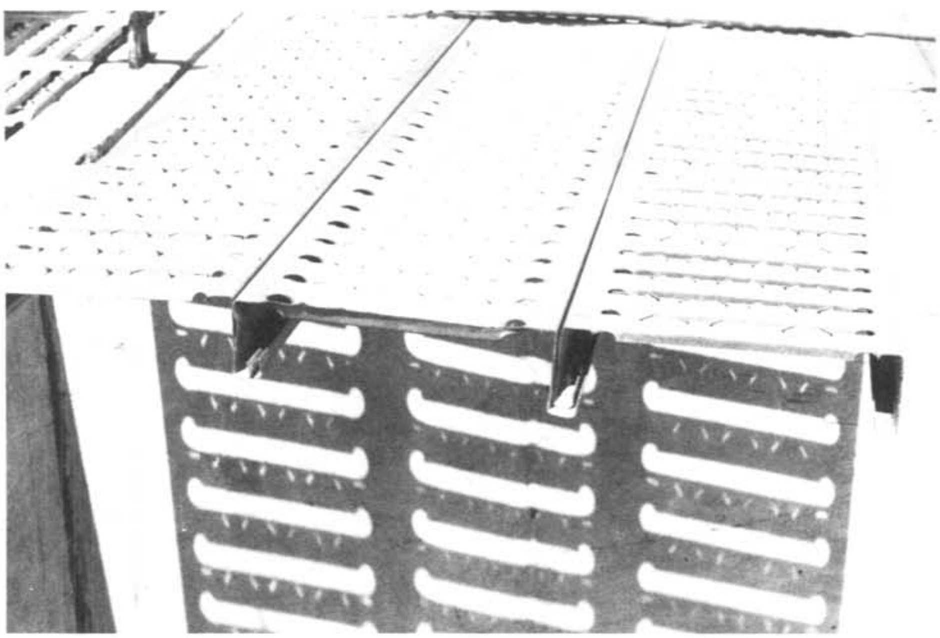
Photograph 14–Turnout with air vent pipe subject to damage and wetting of surrounding area.



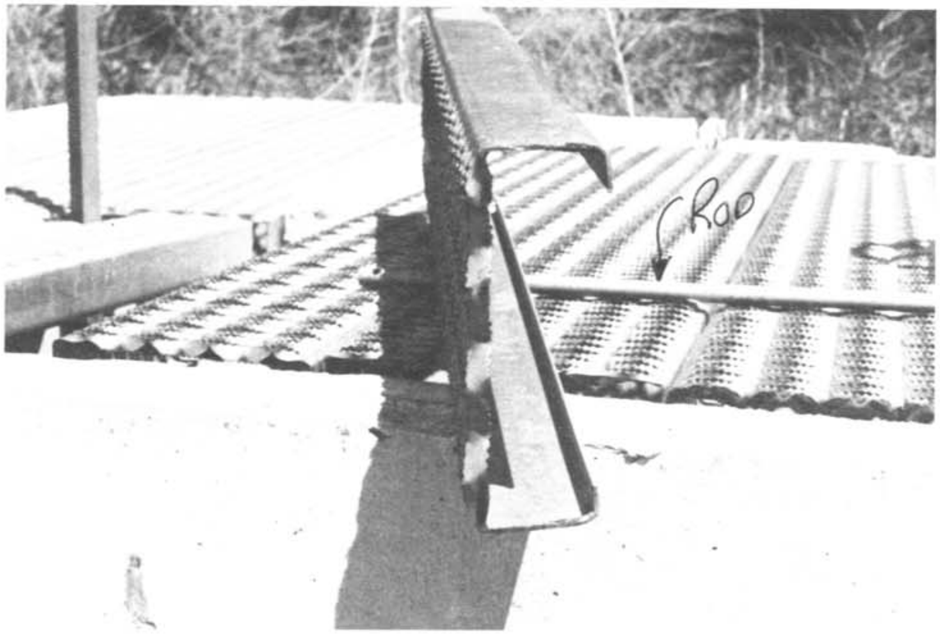
Photograph 15–Modified air vent pipe rectifying problems cited in photograph 14.

There may not be one turnout structure that satisfies all conditions; however, utilization of below-surface regulating devices will usually minimize turbulence and high velocities. The ideal turnout structure for a pipeline which will satisfy all Riverton Project R&B conditions has not yet been found; however, the design shown in figure 1 comes closest to meeting these conditions. Fluctuations in deliveries and turbulence, which reduce measuring accuracy, are the two major problems encountered at Riverton which must be dealt with in design. Also, careful thought must be put into what will happen at maximum flows as well as minimum flows.

Photographs 16 and 17 show two different covers for the turnout structures. Interlocking cover pieces are shown in photograph 16, which are difficult to remove and replace. Consequently, the cover shown in photograph 17 was used instead and is much more convenient and desirable. Other types should also be considered which may be more economical. The rod going over the top of the cover (photograph 17) is for the purpose of locking the cover into place; however, it is used infrequently.



Photograph 16–Turnout structure cover. Note interlocking cover pieces.



Photograph 17–Turnout structure cover with noninterlocking cover pieces. Note rod for locking covers into place.

Stilling Basins

Considerable problems have been experienced with stilling basin damage on the R&B work. Stilling basins are quite susceptible to damage and all measures should be taken to minimize problems such as performing a design analysis, taking precautions to keep rocks out of basins, and evaluation of O&M factors.

Overflow Protection

Provisions should be made at all structures to provide an overflow (spillway) capability to protect against canal washouts in case of high flows. Photographs 18 and 19 illustrate two overflow spillways constructed on the Riverton Project.

Photograph 18–Overflow spillway.

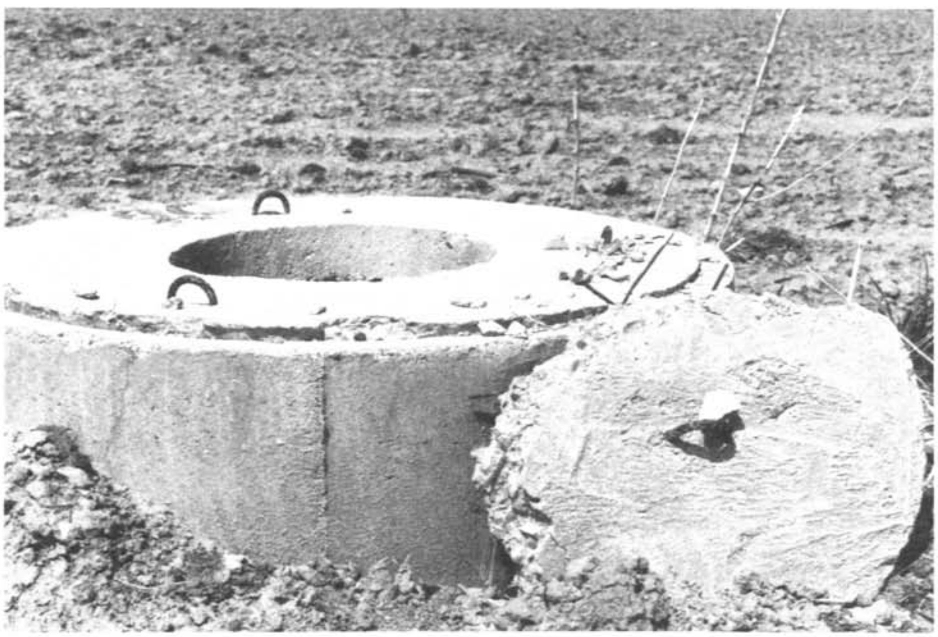
Photograph 19–Overflow spillway on check structure.

Drains

The problems encountered with drains on the Riverton R&B are apportioned generally as follows: manholes (mostly covers) – 50 percent; willows – 45 percent; and outlets – 5 percent.

Photographs 20 and 21 show manhole covers in an advanced state of deterioration. These manholes are about 8 years old. The cause of the rapid deterioration is suspected to be poor quality control in the manufacturing process which has been difficult to correct. The attached drawing (fig. 2) shows a manhole cover fabricated from a 30-inch steel pipe and steelplate as proposed by Columbia Basin Project drainage personnel. This cover replaces the concrete inspection covers previously used and the first of this type is scheduled for installation in the fall of 1985. The weight of this cover is about the same as a concrete cover (40 pounds).

At present, it is recommended that willows, or other similar plants, not be allowed to grow within 100 feet of any drain. If allowed to grow near the drain, their roots have been known to completely plug drainpipes in 1 to 2 years' time. Solid nonperforated drainpipe with taped joints may be a solution to the problem for outlet lines, but plant growth control is required for interceptor drains.



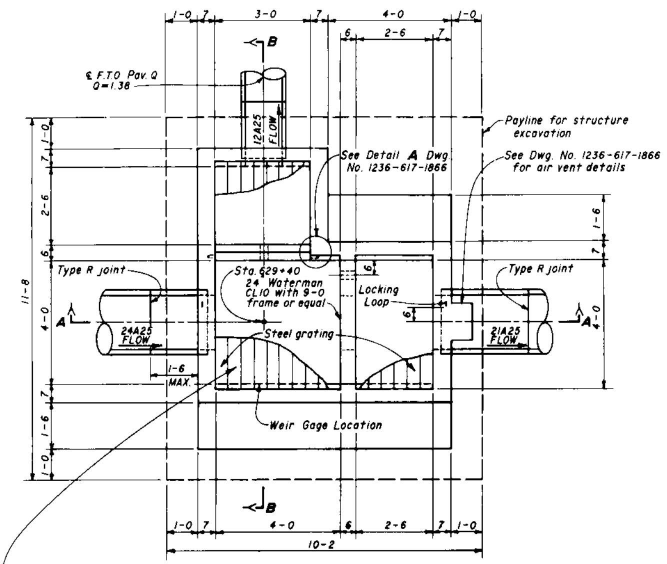
Photograph 20–Manhole cover in an advanced state of deterioration. Approximate age is 8 years old.

Photograph 21–Manhole cover deteriorating fast. Approximate age is 8 years old.

Outlets should be protected with a screen to prevent small animals from entering and plugging. The design of the screen should assure that it is nonplugging.

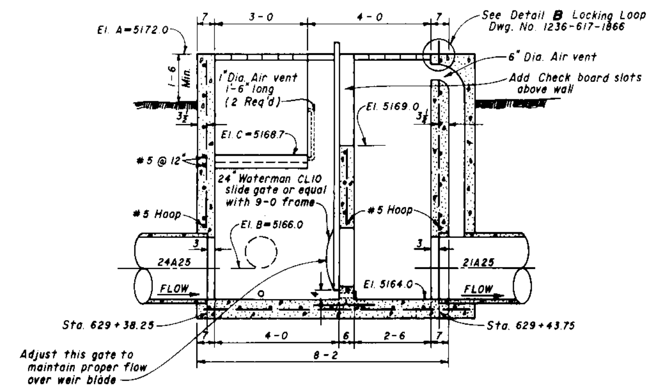
Policies and Procedures

A rehabilitation project provides a good opportunity not only to make structural and physical improvements to the system but to also evaluate policies and procedures used by the operating entity. Many times a rehabilitation project will dictate that operational procedures change. In this light, previously established policies may not "fit" the rebuilt system, i.e., a pipe system may require different policies than an open system. It is a good idea for operating personnel to evaluate system and district operation with other experienced O&M people to gain a wider perspective of these aspects.



Note to designers:
Area of this compartment must be large enough to reduce upward velocity to 1 ft./sec. Also velocity of water exiting pipe must be minimized to prevent excessive turbulence and resultant loss of measurement accuracy.

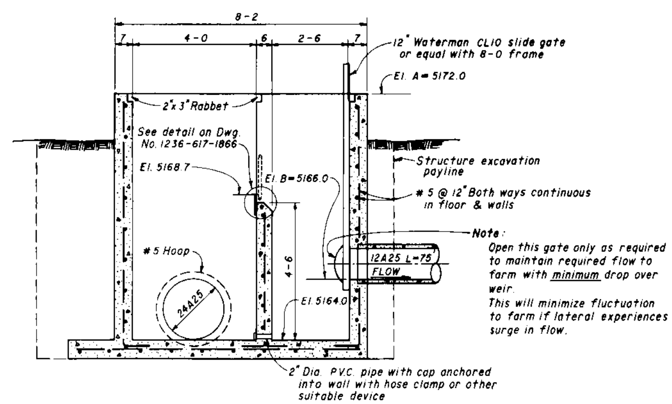
PLAN



SECTION A-A

NOTES

Reinforced concrete design based upon concrete compressive strength of 3,000 psi & a steel reinforcement tensile strength of 40,000 psi.
For concrete & reinforcement details, see Dwgs. No. 40-0-6263 & 40-D-7006.
Clean & roughen all pipe surfaces encased in concrete.
Anchor bolts to have square heads & hex. nuts.
Weir blade shall be galvanized by the hot dip process after fabrication.
Provide enameled weir gauge 1'-0" long in accordance with Dwg. No. 40-C-71 located as directed.
All air vents to have water tight joints. For detail of air vents see Dwg. No. 1236-617-1866.
See specification for painting requirements for locking bars & loops for covers.
Steel grating shall be interlocking with male & female legs or attached to each other as specified by the manufacturer. Grating shall be designed for a uniform live load of 100 psf. The first plank for each section shall have double male legs.



SECTION B-B

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PICK-SLOAN MISSOURI PROGRAM
WIND DIVISION-RIVERTON UNIT-WYOMING

PAVILLION MAIN LATERAL
DIVISION BOX STA. 629+40

PLAN & SECTIONS

DESIGNED T.R.S.		FIELD APPROVAL	R.W. Williams
DRAWN R.C.B.		TECHNICAL APPROVAL	R.E. Brohl
CHECKED C.G.P.		APPROVED	J.M. Verzuh
			REGIONAL ENGINEER
RIVERTON, WYOMING	MAY, 1981		

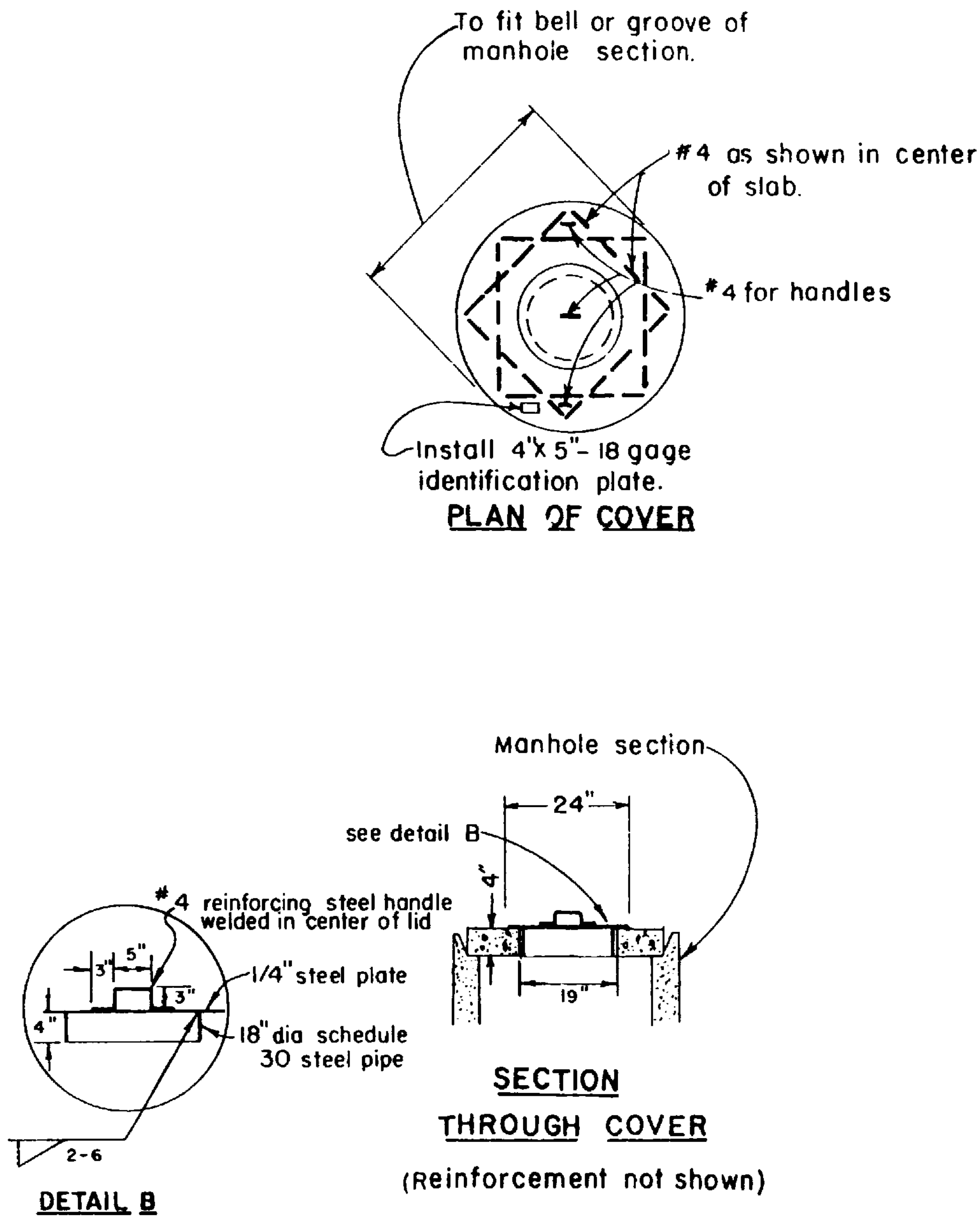

To fit bell or groove of manhole section.
#4 as shown in center of slab.
#4 for handles
Install 4"x 5"- 18 gage identification plate.
PLAN OF COVER
Manhole section
24"
see detail B
4"
19"
#4 reinforcing steel handle welded in center of lid
5"
3"
3"
4"
1/4" steel plate
18" dia schedule 30 steel pipe
2-6
DETAIL B
SECTION THROUGH COVER
(Reinforcement not shown)

Figure 2

DIGEST STATEMENT

Dams: San Luis
State: California
Type: Zoned earthfill
Completed: 1967
Hydraulic height: 319 feet
Active capacity: 2,016,000 acre-feet

Project: West San Joaquin Division, Central Valley Project
Function(s): Flood control, irrigation, and power
Crest length: 18,600 feet
Surface area: 13,000 acres

EMBANKMENT UPSTREAM SLOPE FAILURE

Design Characteristics: The principal features involved in the construction of San Luis Dam are a zoned earthfill embankment, spillway, outlet works, dike, and roadway.

A cutoff trench was constructed at the abutments under the dam to reach formation. A grout cap was placed in the formation in the bottom of the cutoff trench and a grout curtain was constructed in the foundation. Because of the depth to formation in the valley floor, the cutoff trench was discontinued in the vicinity of San Luis Creek, and upstream and downstream stability trenches were constructed which penetrate a thick, soft impervious layer of fat clay that acts as a blanket under the reservoir floor. This construction provides for a connection between the core of the dam and the natural blanket as well as support for the dam. The embankment was constructed directly on top of the fat clay layer which was to act as a seepage blanket.

Zone 1 of the dam embankment was selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers. Zone 2 consists of selected sand, gravel, and cobbles compacted by a crawler-type tractor to 12-inch layers. Zone 3 is miscellaneous material compacted by tamping rollers to 12-inch layers. Zone 4 is minus 8-inch rock fragments compacted by a crawler-type tractor to 12-inch layers.

Upstream and downstream slope protection is provided.

Evidence: Upstream slope failure.

Incident: On September 14, 1981, a slope failure involving approximately 40,000 cubic yards of riprap and drainage material occurred on the upstream face of the dam. The slide was approximately 1,000 feet long, along the axis of the dam (elevation 543 feet) to the water surface (elevation 363 feet), and was considered critical to the stability of the dam.

Causes: Static analysis indicated that a combination of weakening of the natural slope wash (the fat clay which was not excavated during construction), layers of weakness in the random fill zone 3 material, and pore pressures associated with rapid drawdown of the reservoir contributed to the failure. The failure was diagnosed as a classic slip-surface failure.

Remedy: The following plan for investigation and remedial action was prepared and implemented immediately following the incident:

1. Surveys determined the extent of the slide and provided an indicator for additional movement.

2. An exploration and materials testing program was established to provide information on the mechanism for the slide and to provide reliable data for stability analysis.

3. Inclinometers were installed in several drill holes to locate the depth of the slide.

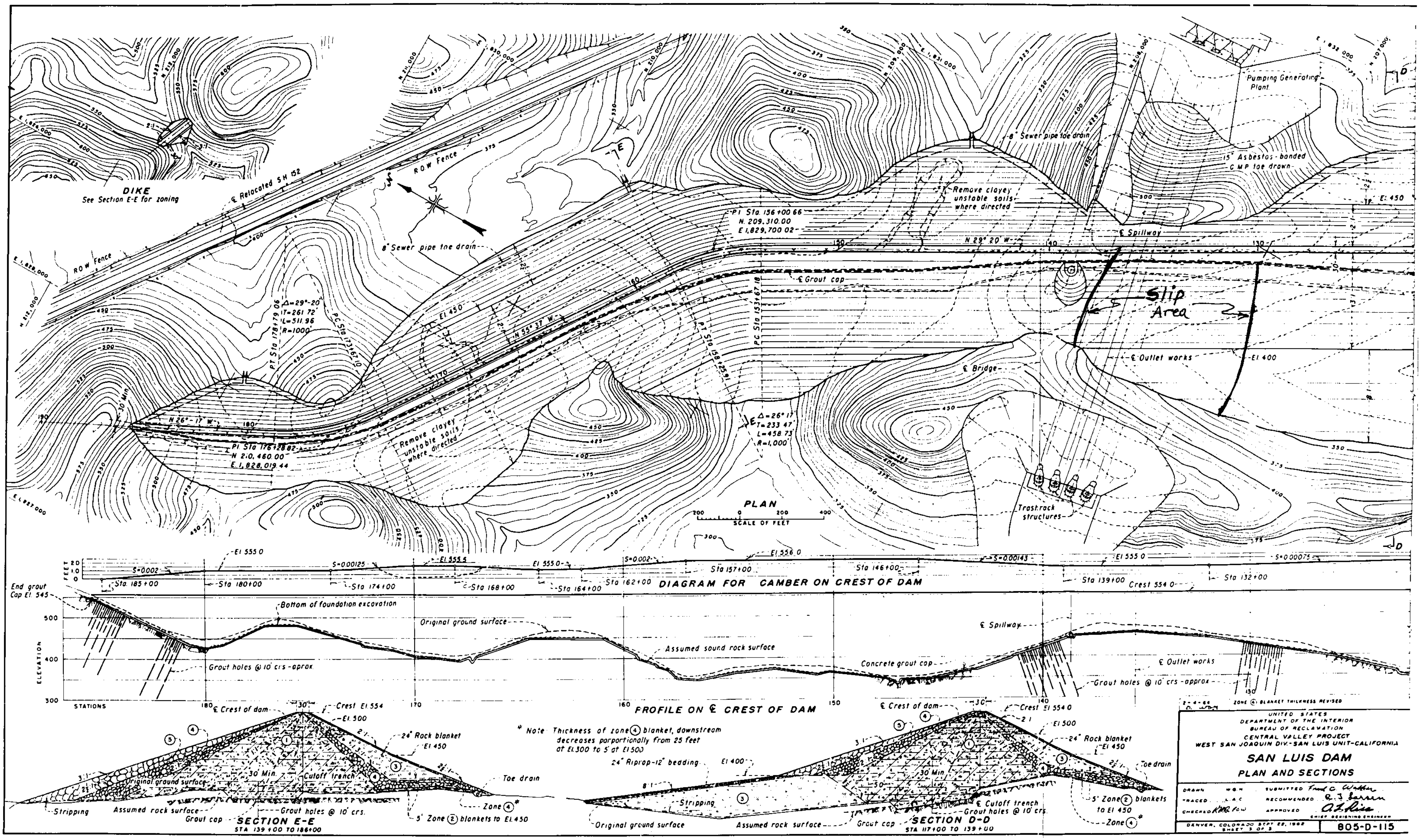
4. Piezometers were installed in other drill holes to monitor pore pressures.

5. An evaluation of other areas for potentially unstable areas was conducted.

6. A battery of soil tests including index testing, vane shear testing, and a review of historic testing data recovery were conducted.

7. A more detailed investigation was performed by a panel of consultants from the Bureau and the California Department of Water Resources. As a result of the above, a 2,100-foot-long stability berm was constructed, and the embankment was reconstructed from the slide elevation up to the crest.

Construction of the stability berm.



DIKE
See Section E-E for zoning
Relocated S H 152
ROW Fence
8" Sewer pipe toe drain
Pumping Generating Plant
15" Asbestos-bonded C M P toe drain
Remove clayey unstable soils where directed
Spillway
Grout cap
Slip Area
Outlet works
Bridge
Trashrack structures
PLAN
SCALE OF FEET
DIAGRAM FOR CAMBER ON CREST OF DAM
End grout Cap El. 545
Bottom of foundation excavation
Original ground surface
Assumed sound rock surface
Concrete grout cap
Grout holes @ 10' crs - aprox
PROFILE ON CREST OF DAM
* Note Thickness of zone 4 blanket, downstream decreases porportionally from 25 feet at El 300 to 5' at El 500
24" Riprap-12" bedding
24" Rock blanket
Cutoff trench
Toe drain
Stripping
Assumed rock surface
Grout cap
SECTION E-E
STA 139+00 TO 186+00
SECTION D-D
STA 117+00 TO 139+00
5' Zone 2 blankets to El 450
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
SAN LUIS DAM
PLAN AND SECTIONS
DENVER, COLORADO SEPT 25, 1962
805-D-115

The purpose of this Bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

Advertise your district's or project's resourcefulness by having an article published in the Bulletin! So let us hear from you soon.

Prospective material should be submitted through your Bureau of Reclamation Regional Office.

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The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

A free pamphlet is available from the Bureau entitled "Publications for Sale." It describes some of the technical publications currently available, their cost, and how to order them. The pamphlet can be obtained upon request from the Bureau of Reclamation, Attn D-822A, P O Box 25007, Denver Federal Center, Denver CO 80225-0007.