WATER OPERATION AND MAINTENANCE

BULLETIN NO. 170

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IN THIS ISSUE. . .

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Reclamation personnel and water user groups for operating and maintaining project facilities.

Although every attempt is made to ensure high quality and accurate information, Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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Cover photograph: Application of shotcrete cover over geomembrane.

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DESCHUTES CANAL LINING DEMONSTRATION - CONSTRUCTION REPORT

By J. Jay Swihart
Bureau of Reclamation, USA

INTRODUCTION

New canals are typically lined with compacted clay, concrete, or geomembranes to reduce seepage losses. Older canals are often unlined and can have high seepage rates depending on the permeability of the native soils. Canals in the Northwestern United States have extremely high seepage rates because of the volcanic geologic conditions. Typical subgrade conditions (see figure 1) include fractured basalt, loose rock, and volcanic cinders (Gilbert and Carter, 1991)

Figure 1.—Typical existing canals consist of fractured basalt bottoms with sides of loose volcanic rock.

These volcanic soils are highly angular and can easily damage geomembrane liners (Morrison and Starbuck, 1984). Removal and replacement would require extensive blasting, which is cost prohibitive.

In some canal reaches, up to 50 percent of the irrigation water is lost to seepage. Reclamation estimates that unlined irrigation canals in the Upper Deschutes River Basin (central Oregon) lose 250,000 acre-feet of water per year through seepage (Reclamation, 1972). To put that loss in perspective, that's enough water for an additional 250,000 to 500,000 households (at 1/2 to 1 acre-foot of water per household per year).

This paper describes the construction phase of a 10-year canal lining demonstration project to evaluate the durability and effectiveness of different lining materials for reducing seepage from canals with high rates of water loss and severe angular subgrade conditions. Water saved through lining can enhance and stabilize riverflows; reduce irrigation water shortages; and benefit recreation, fish, and wildlife. This paper details the construction materials (geosynthetics, soil, concrete, shotcrete, elastomeric coatings, and sprayed-in-place foam), their installation, construction costs, and initial water savings. Durability, life-cycle costs, long-term water savings, and the costs of conserved water will be the subjects of future papers.

CONSTRUCTION

Prospective material suppliers were asked to submit proposals for new materials and installation techniques that could accommodate severe subgrades, form a watertight membrane, resist weathering, and resist animal damage and vandalism. Eighteen test sections have been installed to date (10 on the Arnold Canal and 8 on the North Unit Canal). To simulate full-scale construction, each test section ranged from 300 to 1,000 feet in length and 15,000 to 30,000 square feet in area. Tables 1 and 2 describe the test sections and include unit construction costs. The unit costs are Reclamation estimates including labor, equipment, materials, overhead, and profit. Costs not included are design costs and unlisted items, as well as allowances for remote job sites, cold weather, and limited access. Figures 2 through 8 show typical construction activities for the 18 test sections. More detailed construction, seepage, and cost information can be found in Reclamation Research Report R-94-06 (Swihart et al., 1994).

Table 1.—Arnold Canal test sections

Number	Lining material	Cost ($/square foot)
1	0.1-millimeter Petromat geocomposite with 3-inch shotcrete cover	2.06
2	30-mil VLDPE[1] with 3-inch shotcrete cover and 16-ounce geotextile cushion	2.14
3	Exposed 80-mil HDPE[2]	1.38
4	Exposed PVC[3]/geotextile geocomposite with 6-ounce geotextile cushion	1.05
5	Exposed 45-mil Hypalon with 16-ounce geotextile cushion	1.11
6	Exposed 36-mil Hypalon/geotextile geocomposite	1.03
7	40-mil PVC with 3-inch grout-filled mattress	2.36
8	3-inch grout-filled mattress	1.86
9-10	Exposed 60-mil VLDPE or HDPE with 12-ounce geotextile cushion and 3-inch grout-filled mattress on side slopes only	1.79

[1] VLDPE = Very low density polyethylene.
[2] HDPE = High density polyethylene.
[3] PVC =Polyvinyl chloride.

The 18 test sections were installed over a 17-month period, from November 1991 to March 1993. Some construction difficulties were encountered because of the short construction window. Because these canals are in use from mid-spring through mid-fall, all construction activities (as well as routine operation and maintenance activities) must be performed in a few weeks in early spring and late fall. The weather is often uncooperative during these times. Although some test section installations had excellent weather, others experienced rain, snow, and freezing temperatures.

Note: Information in this paper concerning commercial products and firms may not be used for advertising purposes and is not an endorsement by Reclamation.

Table 2.—North Unit test sections		
Number	Lining material	Cost ($/square foot)
1	Polyurethane foam with Futura 500/550 protective coatings	4.33
2	Polyurethane foam with Geothane 5020 protective coating	3.92
3	Exposed 6-ounce woven geotextile with Geothane 5020 protective coating	2.64
4	Exposed 6-ounce nonwoven geotextile with Geothane 5020 protective coating	2.64
6	3-inch-thick, steel-fiber reinforced shotcrete	1.59
7-8	3-inch-thick, polyfiber reinforced shotcrete	1.47
9	3-inch-thick, unreinforced shotcrete	1.33

Figure 2.—Arnold Canal test sections 1 and 2. Application of shotcrete cover over geomembrane.

PONDING TESTS

Seepage rates were determined by ponding tests both before and after canal lining. Pre-construction seepage rates are shown in table 3, and the anticipated seepage rates based on geologic conditions are shown in table 4 (Reclamation, 1948).

The seepage rates for both Arnold Canal test ponds fall within the expected range. However, the North Unit seepage rate is higher than expected and suggests the presence of localized fissures or sinkholes.

Figure 3.—Arnold Canal test sections 3 through 6. Installation of exposed geomembrane liner.

Figure 4.—Arnold Canal test sections 7 through 10. Installation of grout-filled mattress.

Figure 5.—North Unit Canal test sections 1 and 2. Spray application of polyurethane foam and coatings.

Figure 6.—North Unit Canal test sections 3 and 4. Application of protective coating to geotextile.

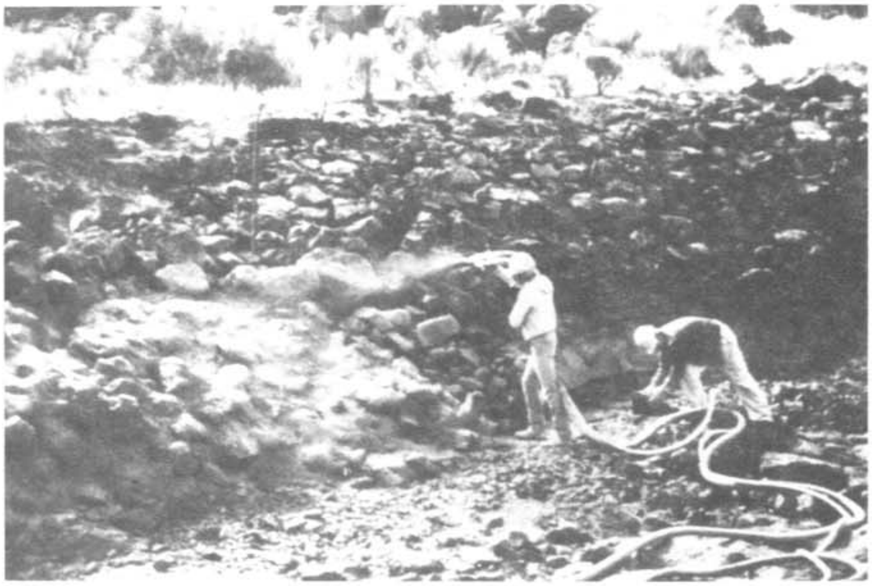

Figure 7.—North Unit Canal test sections 6 through 9. Application of 3-inch shotcrete lining.

Figure 8.—North Unit Canal test sections 6 through 9. Completed canal section with 3-inch shotcrete lining.

Table 3.—Pre-construction seepage rates	
Test pond	Seepage rate (cubic feet/square foot/day)
Arnold Pond A	0.64
Arnold Pond B	1.40
North Unit Pond	4.20

Table 4.—Seepage rates based on geologic conditions	
Geologic conditions	Seepage rate (cubic feet/square foot/day)
Canal with concrete lining	0.07
Canal in clay and clay loam	0.41
Canal in volcanic ash	0.68
Canal in sand and volcanic ash	1.20
Canal in sand and gravelly sand	2.20

Post-construction ponding tests were performed on each of the 10 Arnold Canal test sections (see figure 9). The average seepage rate was 0.07 cubic foot/square foot/day with minimal differences between the 10 test sections. This post-construction seepage rate is one to two orders of magnitude lower than the pre-construction seepage rates. Post-construction ponding tests on the North Unit test sections are scheduled for spring or fall 1994.

Figure 9.—Post-construction ponding tests.

CONCLUSIONS AND FUTURE STUDIES

At this point, the 18 alternative lining materials and installations can only be compared on the basis of initial construction costs ($1.03 to $4.33 per square foot) and short-term seepage rates (essentially zero).

A truly meaningful comparison should be based on both effectiveness (long-term seepage rates) and life-cycle costs. Life-cycle costs will include initial construction costs, maintenance costs, and design life (durability). The long-term effectiveness and durability of these 18 test sections will be addressed in a series of "Durability Reports" to be published over the next 10 years. The first durability report (after 1 to 2 years service) will likely be available by fall 1994.

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ACKNOWLEDGEMENTS

Collaborators in this study included the Bureau of Reclamation, Oregon Water Resources Department, basin irrigation districts, and several geosynthetic manufacturers. The various participants provided funding, labor, materials, and expertise. Reclamation's funding was obtained under the Upper Deschutes River Basin Water Conservation Project study, which seeks to reduce water losses and thereby improve instream flows and irrigation water supplies.

Finally, the author thanks the other co-investigators for their invaluable contributions on this project:

Jack Haynes, Bureau of Reclamation, Boise, Idaho;

Alice Comer, Bureau of Reclamation, Denver, Colorado;

Eric Glover, Bureau of Reclamation, Boise, Idaho;

Bill Morrison, Bureau of Reclamation, Denver, Colorado

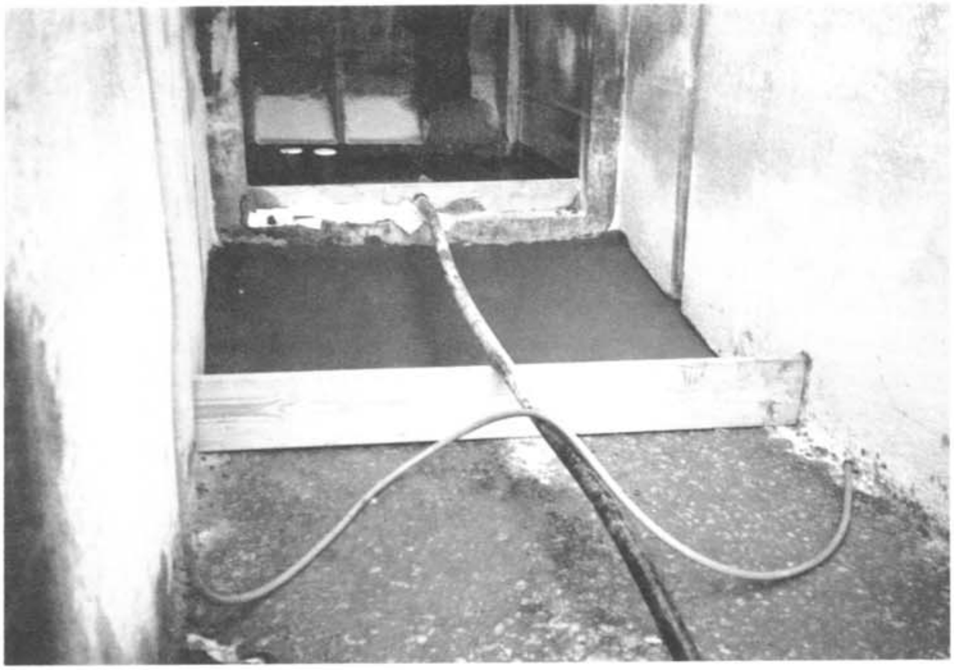
SLIDE GATE AIR SLOT FOR CAVITATION DAMAGE

by William L. Bouley

When the Mirdan Canal headworks first went into operation, no one anticipated that cavitation damage could occur downstream from the two 5- by 6-foot-high pressure slide gates. The Designers' Operating Criteria cautioned minimum gate openings of 1 inch to reduce the possibility of cavitation damage. The Twin Loups Irrigation and Reclamation District personnel strictly adhered to this minimum gate opening criteria. In spite of the strict adherence to the operating criteria, erosion of the floor concrete and cavitation damage were observed immediately downstream from the gates after the second season of use. Rather than repair the area with materials that could be periodically removed by the cavitation process, the District personnel opted to eliminate the potential for the cavitation process to occur.

Damaged concrete removed from downstream canal invert. Pipe is to divert gate leakage away from work area.

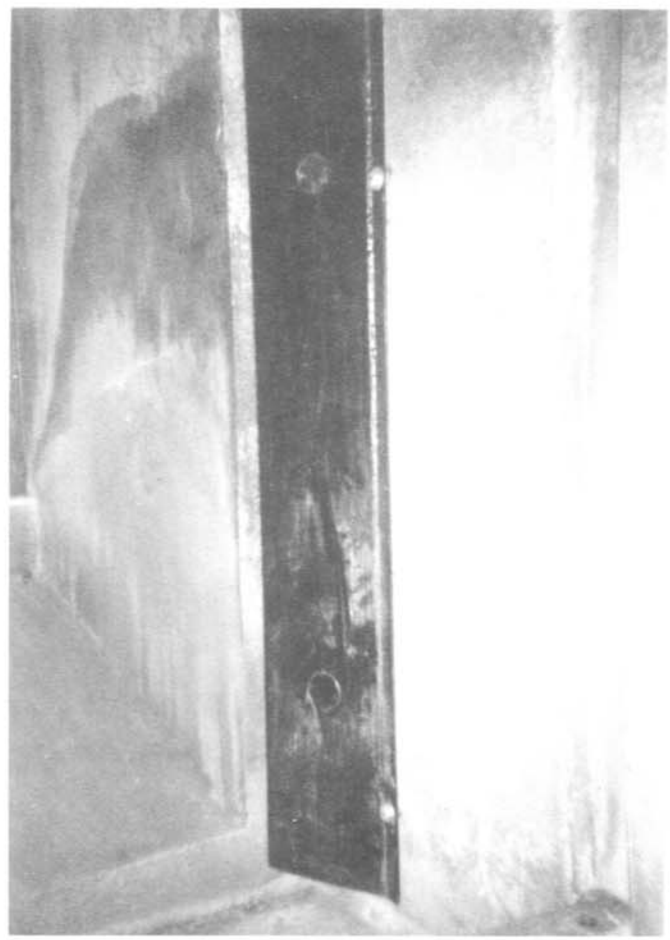
Ron Wolf, the District Manager; Dave Ritchie, the District Superintendent; and their staff developed a steel air slot to be installed in the vertical corners adjacent to each gate. The air slot consists of steel plates bent to form a tube that fits the gate frame corner. The tube is attached to the concrete with anchor bolts. Openings for the anchor bolts are fitted with steel plugs to allow removal of the air slot if necessary. The air slot stops 6 inches short of the top and 3 inches short of the bottom of each side of the gate frame. This design allows air to be drawn from the top air vent above each gate corner, through the air slot, to the bottom portion of the gate frame. Negative cavitation pressures cannot occur with the atmospheric air flow coming through the air slot.



Concrete placement in downstream canal invert.

The impact area downstream from the gate made a 1-foot vertical drop from the gate sill. The eroded concrete was removed, and a smooth transition was created in the concrete floor from the sill to the Mirdan Canal invert 8 feet downstream.

Top portion of air slot. Note air vent above air slot.



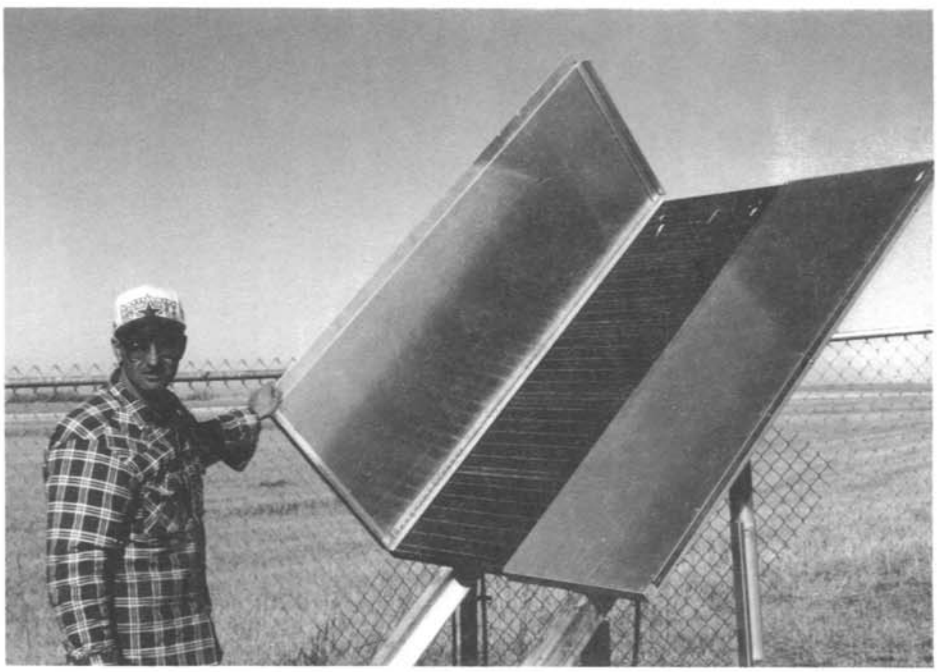
Bottom portion of air slot.

SOLAR PANEL PROTECTION[1]

The Lethbridge Northern Irrigation District's operations and maintenance manager, Kevin Morris, needed some type of protection for solar panels when they are inactive at remote self-cleaning screening sites. The panels are active over a long period of time from the end of October until spring start-up in mid May. It only makes good sense says Morris, to protect the expensive panels from birds, vandalism, and the elements.

Morris originally thought of having the shields made from steel plate but that idea was soon abandoned. Instead he opted for aluminum. Although aluminum does not provide protection from penetration of high caliber rifle bullets it does have advantages. The shields are light enough for one man to flip the covers in place. Unlike steel, aluminum needs no painting or other special protective coatings to prevent rust.

The covers are fabricated and welded in our own shop by Bill Richardson from 10 gauge aluminum sheeting, says Morris. We attach the covers by bolting the aluminum L frame to the metal solar panel frame. Full-length stainless steel piano hinges allow the covers a 270 degree rotation.



Kevin Morris flips back covers from solar panel.

[1] Reprinted with permission from the Editor. The Water Hauler's Bulletin, Volume 54, 1994.

"Since the covers can be opened and closed just about as easily as a cupboard door, our water supervisors close them in the evenings if a hail storm seems to be building. When we decide to build them we didn't really think of this type of temporary protection," concluded Morris.

For more information please contact Kevin Morris, Operations and Maintenance Manager, Lethbridge Northern Irrigation District, 334 - 13 Street North, Lethbridge Alberta Canada T1H 2R8. Telephone (403) 327-3302.

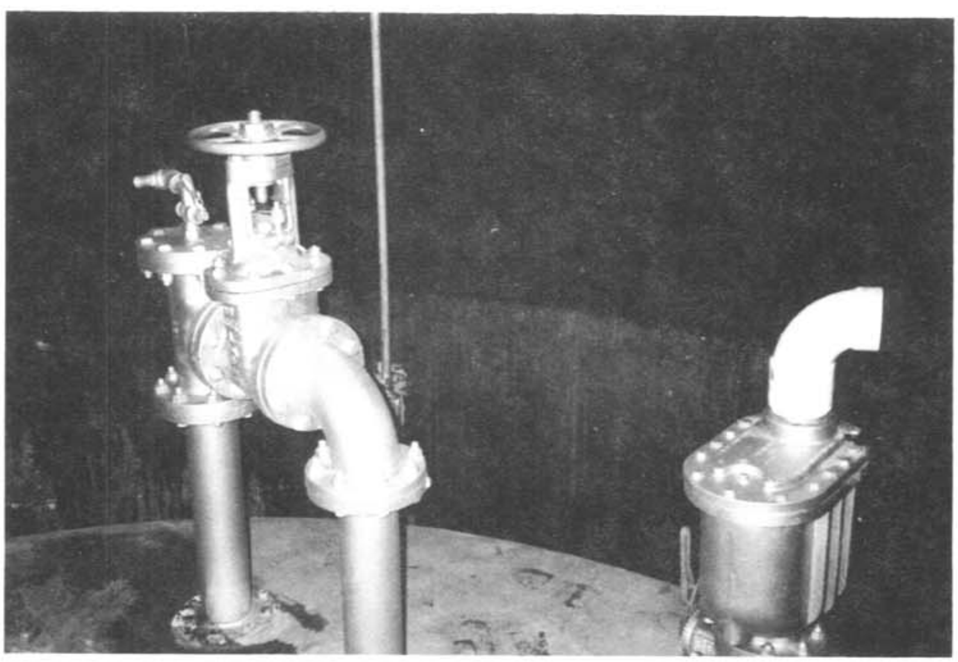
EDITOR'S NOTE: This section has been made available to allow Reclamation and district personnel to contribute and share their innovations with others.

PROJECT INNOVATIONS

At a Review of Operation and Maintenance examination for Medicine Creek in Nebraska, two unique project innovations were observed.

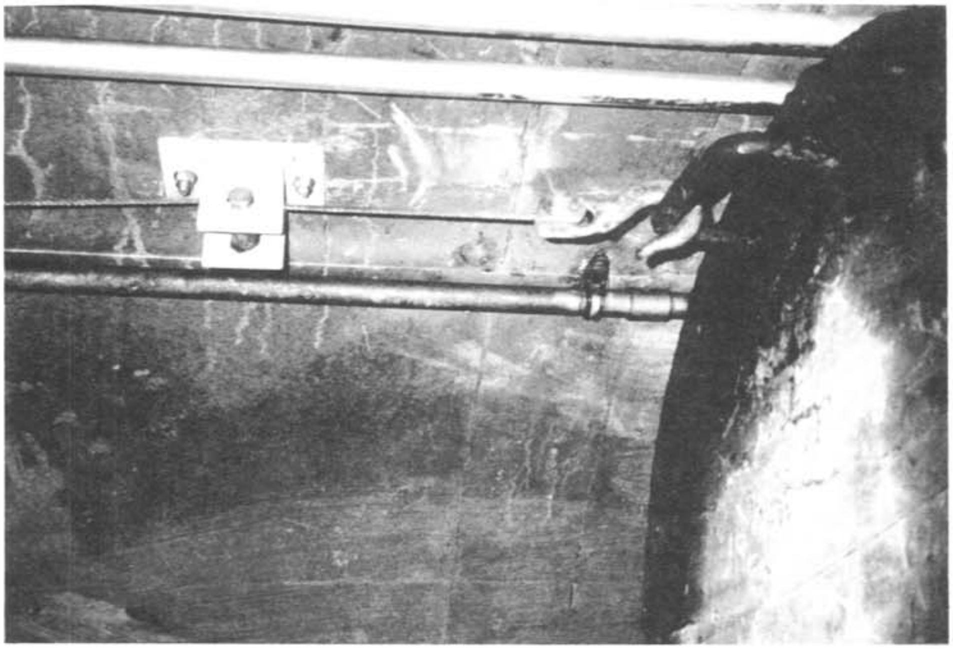
The air release/air vacuum valve assemblies in the upper gate chamber of the outlet works were modified to protect surrounding metalwork. During filling of the outlet works pipe, the valve assemblies tended to "burp" when releasing trapped air in the pipe. Some air assemblies are designed so water would sometimes spray upward through the valve assemblies and hit the deflector plate during filling operations. Once deflected, the water could shoot out in a circular path, getting surrounding metalwork wet. The air assembly supplied for Medicine Creek Dam did not have an outlet pipe to divert excess water.

To reduce wear on the metalwork protective coatings, a plastic elbow was installed by the McCook Field Office to deflect dispelled water. The plastic elbow directs any water to the concrete chamber wall, where it falls harmlessly into the gutter. The plastic elbow has a slip joint for easy removal.



Plastic elbow installed on valve assembly.

With limited staffing in field offices, Ron Brewster developed a means to open access hatches at Medicine Creek Dam. Using a "come-along" and two support brackets attached to the ceiling of his access tunnel, Ron can open access hatches by himself prior to maintenance or inspection activities. This procedure allows the pipe interior to be ventilated, improving air quality. Gas detection meters are also used by field office personnel to identify unsafe atmospheres in the pipe during these activities. Now all Ron needs is a volunteer to help reattach the water seal and retorque the connections for the hatch. Any takers?



View of "come-along" and support brackets attached to ceiling.

View of "come-along" hook attached to access hatch on right.

EDITOR'S NOTE: You never know what you will find after reservoir and tailwater levels recede.

SHARKS AT CORALVILLE LAKE?

Story and photographs by Denise Yale[1]

Just when you thought is was safe to go back in the water, a 25-foot shark was found at Coralville Lake.

This particular shark does not pose any threat since it is 375 million years old. The shark fossil, along with other types of fossils, was discovered below the spillway after summer floodwaters receded in August.

The floodwaters carved a gorge measuring 120 feet to 200 feet wide. The deepest part is 25 feet and about 500 feet of bedrock is currently exposed.

The bedrock around Coralville Lake has been mapped by the district's geology department throughout the year so they already had an idea of what fossils were present, but the most recent fossil find below the spillway was a combination discovery between rangers, geologists and visitors.

"We contacted the geology department of the University of Iowa within the first several days after the water receded below the spillway," Park Ranger Gene Walsh said. "Geologists from the university, the Iowa Department of Natural Resources and people from the district office have explored the area."

All of the fossils that have been found are sea animals that lived in a shallow sea that covered most of Iowa during the Devonian period of the Paleozoic Era. This period lasted from 405 to 345 B.C. At that time, the bedrock below the spillway would have been under about 40 feet of water. Iowa was also located 30 degrees south of the equator and would have had a very tropical climate.

Most of the fossils are crinoids, brachiopods, horn corals, colonial corals, tribolites, and of coarse, the bony head plate of an ancient shark.

The shark fossil was discovered by a three-year-old boy on Labor Day. The boy pointed it out to one of the geologists who volunteered their time to answer questions from the public over the Labor Day weekend.

The fact that a child found the shark when trained geologists didn't doesn't surprise Walsh.

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[1] Reprinted with permission from the Editor. U.S. Army Corps of Engineers, North Central Division, Rock Island District. "Tower Times," Volume 15, October 1993.

"A child doesn't put blinders on," he said. "They can see things that we don't. He just pointed out something that looked different to him."

"The shark seems to excite the geologists the most. Looking at the size of the bone, they think it was about 20 to 25 feet long. They told us some of the sharks that would have been in this area could have been the size of a killer whale."

Geologists say that it is rare to find fossils of fish during the Devonian period because a lot of the fish had cartilage that breaks apart readily, but they found bony head plates and sometimes teeth.

"They said that the teeth are more readily found," Walsh said, "but, one of the geologists said he's only found six teeth in 14 years of searching."

In the middle of the churned-up bedrock sits a large lump of soil that amazingly did not wash away. It is estimated to be between 100,000 to 200,000 years old. The soil is very tightly packed and contains a lot of organic material. Walsh feels that if water had gone over the spillway much longer, it probably would have taken the clump of soil with it.

Park Ranger Gene Walsh points out some of the fossils that have been found below the Coralville Lake spillway.

Other curiosities include huge chunks of rock that resemble stonework on a fireplace mantle. Geologists say the rock was the result of a mud flat which dried out, cracked, and in time formed into rock. There is also a fault line that runs through the rock. These faults can run for miles underground, and some of them are several hundred feet deep.

Already the majority of calls for Coralville's fall field trips have been for fossil scavenger hunts and tours of the area. Almost every teacher has mentioned fossil tours as part of their plans. The University of Iowa has expressed an interest in developing a brochure for people to look the area over on their own and have talked about field trips with their geology classes. The fossil find has also gotten a lot of media coverage, both locally and nationally.

A crinoid fossil is just one of the fossils that have been found at Coralville Lake.

"We've counted more than 50,000 visitors to see fossils," Walsh said. "I'm sure it's actually over that because we don't catch everybody, and we're not always out there."

The fossils were found in an area that was the Lower Cottonwood Campsite before the flood. The campsites have been completely washed away. "It's ironic that it wasn't one of our most popular sites," Walsh said. "It never filled up unless it was a busy holiday weekend. We don't have any plans to restore the campsite at this time. The fossils are a much greater attraction. Most people want to see the area preserved as it is today."

This photo shows part of the fault line that runs through the area.

Plans are already being made to incorporate fossils into interpretive programs and possibly have local geologists give summer programs next year.

As the water continues to recede from the spillway, there's the potential of getting into older rock. Rangers, geologists, and visitors alike are looking forward to what new fossil treasures may be there.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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. Regional editorial staff contacts are as follows:

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