WATER OPERATION AND MAINTENANCE

BULLETIN NO. 140

June 1987

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 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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Division of Water and
Land Technical Services
Engineering and Research Center
P O Box 25007
Denver CO 80225

Cover photograph:

Hungry Horse Dam —
Hungry Horse Project, Montana.

CONTENTS

Water Operation and Maintenance Bulletin

No. 140

June 1987

ATTENTION

CLARIFICATION

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Bulletin No. 137, September 1986 Issue

"A Programmed Approach to Chemical Weed Control"

The September 1986 Water Operation and Maintenance Bulletin No. 137 included an article titled "A Programmed Approach to Chemical Weed Control," which appeared on page 19. Although not intended, it could be inferred that two herbicides (ammate and Krenite) are being used in a manner for which they are not approved. The use of "ammate" (ammonium sulfamate) and "Krenite" (posamine) in irrigation canals is inconsistent with EPA (Environmental Protection Agency) registration of these materials and the instructions on the product labels.

Irrigation systems are for multiple use with water being supplied for crops, livestock, and municipal purposes. These herbicides ARE NOT SPECIFICALLY REGISTERED FOR USE IN IRRIGATION DITCHES. Therefore, any person applying the pesticide must assume it is UNSAFE for such use.

Both CIVIL AND CRIMINAL PENALTIES FOR MISUSE of pesticides can be applied under the Federal Insecticide, Fungicide, and Rodenticide Act.

SOP's (STANDING OPERATING PROCEDURES)

The Guide for Preparation of SOP's (Standing Operating Procedures) for Dams and Reservoirs was released for distribution in July 1986.

Bureau of Reclamation SOP's for dams and reservoirs are prepared to establish in one primary controlled document — with associated supporting documents — the complete, accurate, current, and structure-oriented operating instructions for each storage reservoir and its related structures. The purpose is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions also will permit responsible persons knowledgeable in reservoir operation, but unfamiliar with the conditions at a particular dam, to operate the dam and reservoir during an emergency situation and at times when regular operators cannot perform their normal duties.

The SOP is prepared primarily for operating personnel located at or nearest to the dam and their immediate supervisors who are assigned the responsibility for the physical operation and maintenance of the dam. As a minimum, the SOP should contain all information and instructions necessary for operators to perform their duties.

This Guide gives the requirements for preparing an SOP:

- Preliminary pages
- Emergency Preparedness Plan
- Communications Directory
- General information and instructions concerning administration of the dam, and SOP distribution and its revisions
- Electrical, mechanical, and structural information as to detailed descriptions and instructions for operation and maintenance of the dam and its appurtenant structures and equipment
- Special instrumentation at the facility — if instrumentation installations are significant, the chapter would include such items as the extent of installed instrumentation, monitoring, and maintenance requirements
- Detailed instructions and information on all aspects of reservoir operation
- Contain drawings, maps, photographs, charts, copies of selected supporting documents, and related reference material that complete the SOP

Copies of the Guide are for sale from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield, Virginia 22161. A limited number of copies are available free from the Bureau of Reclamation, D-822, PO Box 25007, Denver, Colorado 80225.

PREVENTIVE MAINTENANCE[1]

By Becky Ohlde

Saves Time and Money — Assures Smooth Sailing

Preventive maintenance can extend the life of your irrigation equipment, but more importantly, can save you repair time and parts money while keeping your system up and running during the critical irrigation times next summer.

"Following a reasonable routine in putting the irrigation system away for the winter can save money and increase the reliability of that system for next season," says Richard Black, extension irrigation engineer, Kansas State University, Manhattan, Kansas. "The main point is to do those things that freezing would damage before the first hard freeze."

Here are some useful tips on repairing and maintaining irrigation equipment through the off-season:

PUMPS

Winterization of the gear head on vertical turbine pumps is critical, says Howard Hogan, Western Land Roller, Hastings, Nebraska. "Run the gear-head when the oil is cold to pump the cold oil over the bearings and gears. This can be done the day after shutdown."

In the spring, the oil should be changed and fresh oil used.

"If a water-cooling coil is used with the gear-head, it must be drained to keep it from freezing," he says.

Hogan suggests that oil reservoirs in the electric motor on the pump should be checked to make sure they are full. "This is done to make sure the bearings are covered with oil. Because the bottom bearing is sealed, you will need to turn the motor by hand to get cold grease on it," he says.

Again, in the spring, drain the oil and put in fresh. He also recommends lubricating the bottom bearing.

There is not much winterization for the below-ground portion of vertical turbine pumps. However, there is need for special care in the spring. "Then it's necessary to run oil down into the pump a week before it's used," he says.

"Water-lubricated pumps equipped with pre-lube tanks must be drained before freezing weather," he says. "Before starting in the spring, water should be run down the line shaft for about one minute per hundred feet of pump setting."

Store centrifugal pumps indoors in the winter, suggests DeLynn Hay, extension irrigation specialist, University of Nebraska-Lincoln. "Store in an operating position to keep the bearing grease distributed evenly. Otherwise, the grease will collect on the lower bearing, leaving the upper bearings uncovered."

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[1] Reprinted with permission from the Editor from the Fall 1986 issue of Irrigation Age.

Hay also said to keep grease between the center of the impeller and the pump case to prevent rusting.

"Make sure the pump is turning freely before you start it next spring," Hay says. "A sudden start could break off an impeller eye if it's rusted to the pump case."

Hay says to fill bearings with new grease and loosen the packing gland. "If excessive water has been leaking out the packing gland, it should be removed. Remove packing and clean the stuffing box. Put in new packing and leave the packing gland loose for adjustment next spring."

Any openings on the pump should be covered or closed with hail screen.

ENGINES

Electric motors and controls require very little maintenance, says DeLynn Hay. "For maximum protection, drain oil-lubricated motors just before shutdown and refill them with rust-inhibiting oil. Run the motor until the oil is distributed over the bearings. Next spring, drain, flush and refill the motor with new oil."

Because moisture condenses in oil during temperature changes, Hay suggests running for a short time once a month during periods of non-use. This helps to redistribute the oil.

"On motors requiring grease-type lubrication, change the grease after shutdown," Hay says. "Run the motor for a few minutes to relieve bearings of any excess grease."

Hay also suggests making sure the motor is screened from rodents. "Check switch boxes, too, for missing knock-out plugs. Mice can get into switch boxes and follow the conduit into electric motors. Electrician's putty works well for sealing small openings," Hay says. The control box should also be locked in the "off" position.

On internal combustion engines, special attention should be given to lubrication, the cooling system, ignition, engine openings and the fuel system. Use the operator's manual. If one is not available, Hay says, "Drain the crankcase oil while the engine is still warm. Then drain and flush the cooling system. Refill the crankcase with new oil, replace the oil filter and refill the cooling system with water, rust inhibitor and antifreeze."

If the engine will not be used during the winter, a low-priced methanol-type antifreeze may be used.

"When you've refilled the crankcase and cooling system, run the engine a few minutes so the fresh oil reaches all the parts and the antifreeze and water can mix," he said.

Spark plugs should be pulled, cleaned, and regapped. "Pour two ounces of engine oil into the hole for each spark plug and then put the plugs back. Run the engine to distribute the oil over the cylinder walls and valve mechanism."

Hay suggests removing the distributor cap and placing a small amount of oil on governor weights. Weatherproof masking tape can be used to seal the space where the distributor cap joins the distributor housing. Tape can also be used to seal the air cleaner inlet, exhaust outlet, and crankcase breather tube.

"If it's possible, remove the air cleaner; clean it, refill it with the proper oil and store it," Hay says.

Fuel should be shut off at the tank of these engines. "All the lines and the carburetor should be drained," he says. "If LP gas is used, drain the vaporizer-regulator — both fuel and water lines. For diesels, drain the fuel tank and the filter."

He says to also remove the battery and store it, fully charged, in a cool, dry place.

CENTER PIVOT SYSTEMS

To protect a system against wind damage, pivots should be braked or secured so they cannot roll, says Hay. "Park the system on a well-drained area, parallel with the prevailing wind direction."

Hay suggests that gearboxes be inspected for moisture accumulation and for regreasing.

"Check all automatic water drains to make sure there isn't any sand present, causing them to stick," he says. "Sand can get into the automatic drain, preventing the valves from opening and draining water from the sprinkler pipe." The system end cap can also be removed and cleaned.

Sand also accumulates in the sand trap and Hay recommends that the trap be removed, the system flushed, and the trap replaced. "Also, drain all water-carrying lines," he says.

Depending on manufacturer's instructions, cylinder pistons should be covered with grease or retracted into the cylinder, Hay says.

"Oil- and air-driven units should be pressurized and checked for leaks of oil or air without the water source engaged," he suggested. "Filters on water-, oil- and air-driven systems can also be cleaned or replaced."

Chains should be coated with protective oil to prevent rusting and stiffness. Check for loose bolts and wear on any moving parts. Tires should also be checked for wear, and inflated to the recommended pressure for the winter season.

SPRINKLER HEADS, NOZZLES

Before storing, check sprinkler heads for wear and need for replacement. Special attention should be paid to bearing washers, spring tension, and bent oscillating arms.

"Bearing washers should be replaced if there is an indication of serious wear," says Hay. "If the angle of water contact by the jet with the arm isn't correct it will change the turning characteristics of the sprinkler."

"I tell farmers to get up on a pick-up when the pivot is at an angle so they can see everything, and take note of sprinkler problems," says KSU's Black.

Hay suggests that sprinkler nozzles be checked for wear by using a properly sized drill bit. "Nozzles which have worn 1/16-inch larger than specified should be replaced."

CHEMIGATION SYSTEMS

Black recommends that chemigation tanks be drained and washed at the end of irrigation season.

"The injector pump should be stored inside," he says. "Make sure there isn't any liquid in the pump that could freeze. The oil level should be checked and oil added, if needed."

Because electric solenoid valves can go bad, Black advised checking them to make certain the valves are working correctly.

Chemigation hoses should be disconnected, drained, and stored; and calibration devices, such as flow meters, should be cleaned.

"Recirculating pumps should be drained and lubricated," says Black. "Other mechanical mixers should be cleaned, and the oil ports on the motors should be checked and filled, if necessary. Air ports on these motors can get chaff on them from harvest so they should be cleaned off with an air hose."

GEAR DRIVES

Gearboxes on center pivot final drives should be inspected to make sure all water is drained out. "Refill the oil port to the proper level with oil," says Bob Snoozy, Lindsay Manufacturing, Lindsay, Nebraska.

Some companies, says Snoozy, have suggested hour levels when the oil should be changed. "Check the owner's manual for these suggested levels."

"After all of this is done, look for loose nuts, bolts and screws and any abnormal wear points," he suggested.

GATED PIPE

Deterioration of pipe gaskets can be a big problem. "Removing the gaskets from the couplers could lengthen their useful life," says Bob Fingeret, Hastings Irrigation Pipe, Hastings, Nebraska. "Clean off sand and silt and store them in a dry place."

He warns against hanging gaskets on a peg or nail, which can cause them to lose their shape.

"If you can't remove the gaskets, then pack the pipe with couplers to the north so the sun doesn't shine on the gasket," he says. "Gaskets can deteriorate easily if exposed to sunlight."

Fingeret suggests the pipe should be stored where it is protected from livestock, vehicular traffic, and wind. "Store the pipe with the gates closed to protect the gate seals from deterioration by sunlight," he says. "Secondly, place the pipe with the gates turned up. Rodents that get into the pipe during the off-season are less likely to gnaw on the gate seals if they have to reach up to get at them."

In the spring, gates should be checked for looseness. If they are loose, they should be replaced.

PUMP PERFORMANCE CHECKLIST[2]

Whether you use your pumps for agricultural, construction, industrial, or sewage applications, keeping them in shape can help reduce costs and boost profits by cutting fuel consumption, reducing parts replacement costs, and minimizing pumping time on every project. A pump that lets you down when you need it most causes obvious losses of time and money. Not so obvious, but every bit as costly, are losses you can incur with pumps that operate at less-than-peak efficiency.

A pump laboring under the handicap of a suction line air leak, a corroded discharge line, or a clogged impeller gulps excessive amounts of energy, takes longer than necessary to do the job, and subjects parts to undue stress, causing premature wearout.

How high can the losses run? A 6-inch gasoline-driven, self-priming centrifugal pump operating at 25 percent less than peak efficiency through an 8-hour day uses approximately 8.8 gallons more fuel than a pump which is operating efficiently. At $1.10 per gallon over a 40-hour week, that is $48.40 per week lost, and that figure does not include added personal costs. Multiply the possible hidden losses by the number of pumps you have in operation and you see why it pays to keep your pump in top working order.

Centrifugal Pumps: Look for the following signs of inefficiency which indicate that your pump is costing you more to operate than it should:

There is a noticeable difference in pump flow.–Has the discharge flow visibly decreased? Is it taking your pump longer to do the same job than it used to? The slowup might be caused by a collapsed suction hose line, a leaking gasket, plugged suction line, a damaged or worn impeller or wear plate.

Your pump is not repriming as rapidly as it once did.–Is the seal leaking, is all hardware at gaskets tight, is the suction check valve sealing properly, is the cut water section of volute badly worn or recirculating port clogged?

Your pump is making exessive noise.–Does it sound like a bunch of marbles rattling in a can? This may be cavitation and could be caused by too high of a suction lift, too long a suction hose, a clogged strainer or collapsed suction hose lining, plugged suction line or combination of all these. Maybe the bearings are going out.

Your pump is clogging frequently.–The suction check valve may be clogged, and improper strainer may be too large or small, or the strainer may be in mud plugging the suction side.

Your pump is overheating.–Very likely the flow of liquid into or out of the pump is being restricted. Improper impeller clearance could be slowing repriming or the suction strainer may be clogged.

[2] Information furnished by and printed with the permission of the Gorman-Rupp Company, P O Box 1217, Mansfield, Ohio 44901.

Checklist to Improve Pump Performance and Profits

Regardless of the pump you own, you will find the following 9-point checklist helpful. Although this list is not a complete guide to pump inspection and service, it does cover the more common conditions that can impair pump efficency.

Suction Line

1. Check for air leaks.–Using a vacuum gauge, make sure that the suction line, fittings, and pipe plugs are airtight. Most pumps have a tapped hole for easy connection of a vacuum gauge. Use pipe dope to seal gauge threads and pipe plugs. Replace leaky seals and badly worn hoses.

2. Check the suction hose lining.–The rubber lining in a suction hose can pull away from the fabric, causing partial blockage of the line. If the pump develops a high vacuum but low discharge, the hose lining may be blocking suction flow. Replace hose.

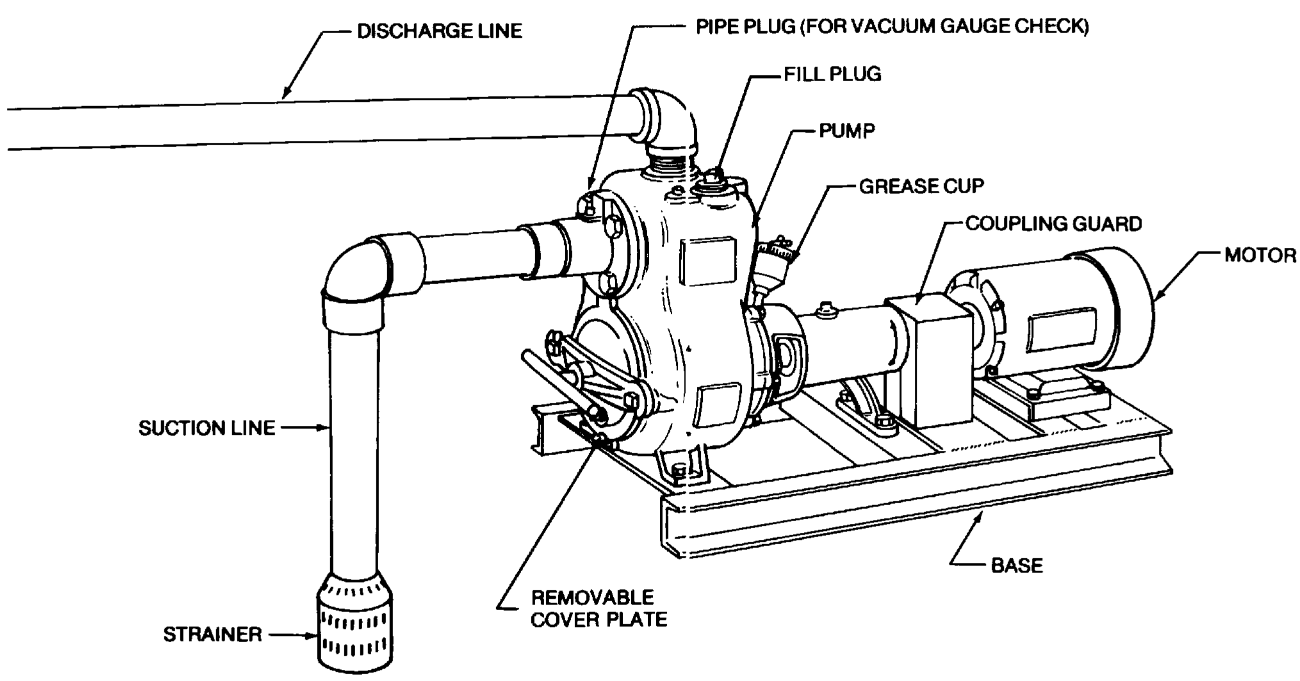
3. Check the suction strainer.–Frequent inspection and cleaning of the suction strainer is particularly important when pumping liquids containing solids. Proper size strainer should prevent pump from clogging.

Pump

4. Check impeller vanes, wear plate, or wear rings.–The removable cover plate on many pumps permits quick, easy inspection of the impeller and wear plate. These components should be inspected every 6 months or sooner, depending on pump application. They are subject to faster wear when pumping abrasive liquids and slurries. Wear plates and wear rings can be replaced without replacing expensive castings.

5. Check impeller clearance.–If the clearance between impeller and wear plate or wear rings is beyond recommended limits, pumping efficiency will be reduced. If the clearance is less than that recommended, components will wear excessively. If tolerances are too close, rubbing could cause an overload on the engine or motor. Check the impeller clearance against pump manual specifications and adjust if necessary.

6. Check the seal.–Most pumps are equipped with a double seal lubricated under pressure — with a spring-loaded grease cup — or an oil-lubricated tungsten titanium carbide seal for long, trouble-free service. If your pump has a single seal and it is lubricated with the water being pumped, sand and other solids can cause rapid wear. Check and replace the seal if worn. Replace seal liner or shaft sleeve if it has scratches.



General Pump Diagram

7. Check bearings.–Worn bearings can cause the shaft to wobble. Eventually, the pump will overheat; and sooner or later, it will freeze up and stop. Replace bearings at the first sign of wear.

8. Check the engine or motor.–The pump may not be getting the power it needs to operate efficiently. The engine may need a tuneup or the motor may need service.

Discharge Line

9. Check operating condition.–Check air release devices, valves, check valves, and shock control devices for proper operation. Old discharge lines are subject to internal rusting and pitting, which cause friction loss and reduce flow by as much as 15 percent. Replace badly deteriorated line.

A word about submersible and diaphragm pumps:

If your submersible pump operates but at a reduced capacity, it could be caused by a worn impeller, excessive impeller clearance, low or incorrect voltage, or it could be running backwards. Too high of a discharge head, a clogged or kinked hose, or a clogged strainer could also be responsible for reduced flow. Use an amperemeter and voltmeter to determine if the pump is getting the proper power it needs to operate efficiently. Ampere readings are in operation manual.

If your diaphragm pump is not pumping as it should, check diaphragm, suction and discharge check valve flappers and seats; replace if worn. Check suction hose and fittings for leaks. Check plunger rod for proper adjustment.

See figure 1 for information on winter storage.

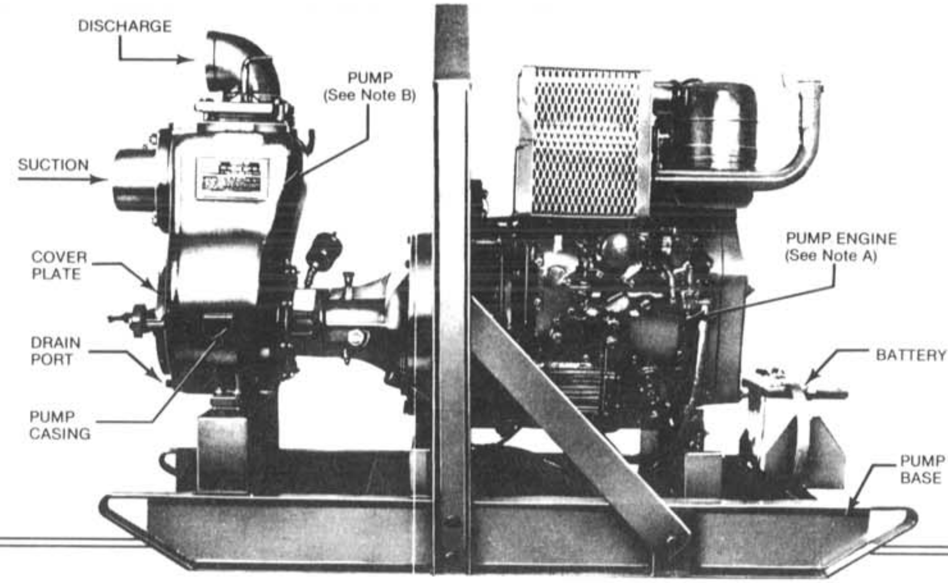
The purpose of this bulletin is to provide maintenance and storage information to those individuals who find it necessary to remove their Gorman-Rupp pumps from service for extended periods of time during the cold winter months.

By following these few and relatively simple procedures, you can help to ensure more hours of trouble-free operation and also extend the working life of your pump.

NOTE A: For maintaining and storing pump motors, engines and engine batteries, refer to manufactures owner/operator manual for proper procedures.

NOTE B: Before operating or performing maintenance on any Gorman-Rupp pump, be sure you have read the following:

- Gorman-Rupp operators manual
- Engine or Motor Manufacturers operators manual
- Gorman-Rupp Pump Safety Handbook
- All warning tags, labels, stickers and all other literature provided concerning safe and proper operation.



GORMAN-RUPP

WINTER STORAGE GUIDE

STORAGE PROCEDURES FOR GORMAN-RUPP PUMPS

(1) Remove any exterior dirt or grime by thoroughly cleaning with steam or high pressure hose and cover any exposed metal with touch-up paint.

(2) Flush suction and discharge lines, pump casing and impeller of all solids by pumping clear liquid for a short time (approximately one-half minute) before final shutdown. At this time, check for leaks and replace worn gaskets.

(3) Drain the pump casing and all suction and discharge lines. If the casing drain port becomes clogged, insert a stiff wire or rod into the port and agitate the liquid. If solids remain in the casing or impeller vanes, remove the coverplate or disassemble the casing and flush away any remaining material.

(4) If complete draining is not possible, pour a small amount of antifreeze into the casing and rotate the pump shaft to ensure coverage and mixing.

(5) "Fog" or spray the interior of the casing with a commercially available petroleum aerosol to prevent rust and corrosion.

(6) If the pump has an oil-lubricated type seal, drain the oil in the seal cavity and refill with 30-weight non-detergent motor oil.

NOTE: If upon draining the seal cavity you find any significant amount of water (more than 1 teaspoon) preceding the oil, or if the oil is emulsified (mixed with water, indicated by a creamy appearance), there may be a seal leakage or failure. In either case, have the seal checked and replaced if necessary before the next pumping season.

(7) If the bearings are oil-lubricated, drain the oil from the pedestal and refill with 30-weight non-detergent motor oil.

(8) Lubricate all grease fittings.

(9) Seal suction and discharge ports against the intrusion of foreign objects by covering them with tape or port plugs.

(10) If possible, store the unit indoors in a clean, dry area.

(11) Rotate the pump shaft approximately once a month during storage to ensure that lubricant covers the bearings and so that the pump will not take a set and "freeze up".

ADDITIONAL STORAGE PROCEDURES FOR GORMAN-RUPP SUBMERSIBLE PUMPS

(1) Remove all debris from strainer.

(2) Clean the power cable, taking care to remove all grease, oil, tar, etc., that may deteriorate the cable jacket.

(3) Drain the oil from the seal cavity and motor housing and refill with proper oil as noted in the operators manual.

NOTE: If you find any water in the motor housing or more than 1 teaspoonful in the cavity, then the pump must be disassembled and checked for leakage — this should be done by an authorized Gorman-Rupp distributor.

(4) Store in an upright position in a clean, dry area.

Figure 1

OUTLET WORKS BYPASS PIPE FAILURE

Mason Dam — Baker Project, OREGON

By Vern Yocom[1]

September 19, 1986, the river outlet works at Mason Dam was shut down to permit an underwater inspection of the stilling basin. The 12-inch outlet works bypass sleeve valve was opened for a discharge of approximately 20 ft^3/s. At approximately 7:30 a.m., September 20, 1986, a hydromet reading at the Project Office in Boise indicated a sudden drop in discharge, then an increase to 26 ft^3/s. The dam tender was requested to check the situation.

On arriving at the dam, he observed that the tunnel access door was open with approximately 26 ft^3/s flowing from the tunnel (photographs 1, 2, and 3). Notification of the emergency was implemented immediately in accordance with the requirements of the SOP (Standing Operating Procedures). Regional personnel were at the dam in the afternoon to assess the situation. It was quickly discovered that the 12-inch bypass sleeve valve was apparently closed and could not be opened. It was also discovered that the sleeve valve only had approximately 5 feet of head on it from the tunnel; therefore, it was concluded that the tunnel was only partially flooded. Plans were initiated immediately to have the regional dive team study the situation to possibly access the flooded portion of the tunnel and shut off the upstream guard valve. As an alternative, a bulkhead gate for the intake structure was located and readied for shipment if required.

Monday, September 22, the Regional Director determined that the attempt to shut off the upstream guard valve must be accomplished by commercial divers. The district contracted the work to "Can Dive Company" of Vancouver, Washington. They were successful in shutting off the flow on September 23, 1986.

Inspection of the bypass piping and sleeve valve revealed the following damage:

a. 12-inch Sleeve Valve (refer to drawing 569-D-46)

1. The stem nut (part 37) had backed off the operating stem, allowing rapid movement of the sleeve (part 4) to the closed position (photograph 4). The hole through the stem and nut for cotter pin (part 46) was clean (photograph 5). The cotter pin could not be found.

2. Prior to disassembly, and with approximately 5 feet of head on the sleeve valve, the flange connections on part 1 were all squirting water around their circumference (photograph 6). Disassembly of the sleeve valve revealed that the 7/8-inch stainless steel flange bolts (part 31) had stretched in the vertical portion of the sleeve valve connector (part 1), and bent in the horizontal inlet flanged connection to the connector (photograph 7).

Further inspection of the flange connections (photograph 8) revealed that the stainless steel flanges had warped inward as much as 3/16 to 1/4 inch from the water hammer hydraulic transient (photograph 9).

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[1] Vern Yocom is a General Engineer in the Water O&M Branch, Division of Water and Land Technical Services, Bureau of Reclamation, Engineering and Research Center, Denver, Colorado.

3. The coal-tar coating on the exterior of the connector (part 1) near the flanges, had cracked and chipped off in places (photograph 10). This condition could indicate stretching of the connector, due to the water hammer hydraulic transient.

4. There appeared to be no damage to the stem (part 13), sleeve (part 4), guide (part 2), cone (part 6), or seat (part 5).

5. The 7/8-inch studs connecting the bypass piping to the sleeve valve at the wall of the well, were also bent.

b. 12-inch Bypass Piping (refer to drawings 569-D-30, 569-D-31, and 569-D-164)

1. The original alignment of the bypass piping in the outlet tunnel (shown on drawings 569-D-30 and 569-D-31) was modified by drawing 569-D-164. This modification left a section of the pipe relatively unsupported near the downstream end of the tunnel.

2. Separation of the 12-inch bypass pipe occurred at the first downstream sleeve-type coupling exposed in the outlet works tunnel (photographs 11 and 12). The separation was possible when an unsupported 90° elbow (photograph 13) moved downstream 6 inches (photographs 14 and 15), disconnecting the sleeve-type coupling.

3. The 12-inch pipe buckled where it is embedded in the left wall of the tunnel (photographs 16 and 17).

4. The sleeve-type coupling and pipe support hanger directly upstream of the separated joint shows movement of approximately one-eighth inch in the downstream direction (photograph 18). There appears to be no further movement or damage of the pipe upstream from this point.

5. The section of 12-inch pipe buried in fill between the tunnel and sleeve valve house may also be damaged. There are two sleeve-type couplings and bends in the buried alignment.

The unsupported elbow undoubtedly created a weak point in the bypass system, which may have prevented a more adverse failure in the system at a point where the water could not be shut off. If the pipe system would not have separated at this point, the water hammer pressure could have fractured the casting of the 12-inch 150-pound or 8-inch 125-pound gate valves in the outlet works gate chamber.

Conclusions

Failure of the outlet works bypass pipe in the tunnel occurred as a result of a water hammer pressure wave created when the downstream regulating valve (sleeve valve) closed rapidly. Extensive damage was done to the sleeve valve and a section of the 12-inch bypass pipe located in the downstream area of the outlet tunnel.

Recommendations

a. Repair and/or modify the sleeve valve to eliminate vibration and provide a means to lock the sleeve on the operating stem.

b. Uncover the section of buried 12-inch bypass pipe between the tunnel and sleeve valve house for inspection. Replace as required.

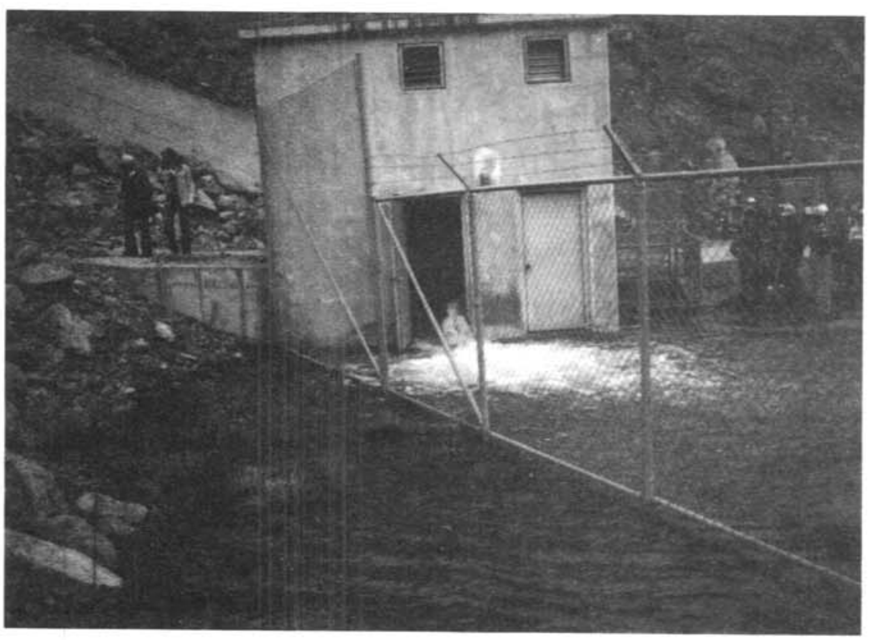
c. Remove damaged section of pipe from the downstream end of the tunnel and replace as required.

d. A rigid pipe support should be constructed at the 90° elbow to restrain the pipe against water hammer.

e. After the bypass system has been repaired and/or modified, the system should be pressure tested and inspected for integrity. The sleeve valve should then be test operated.

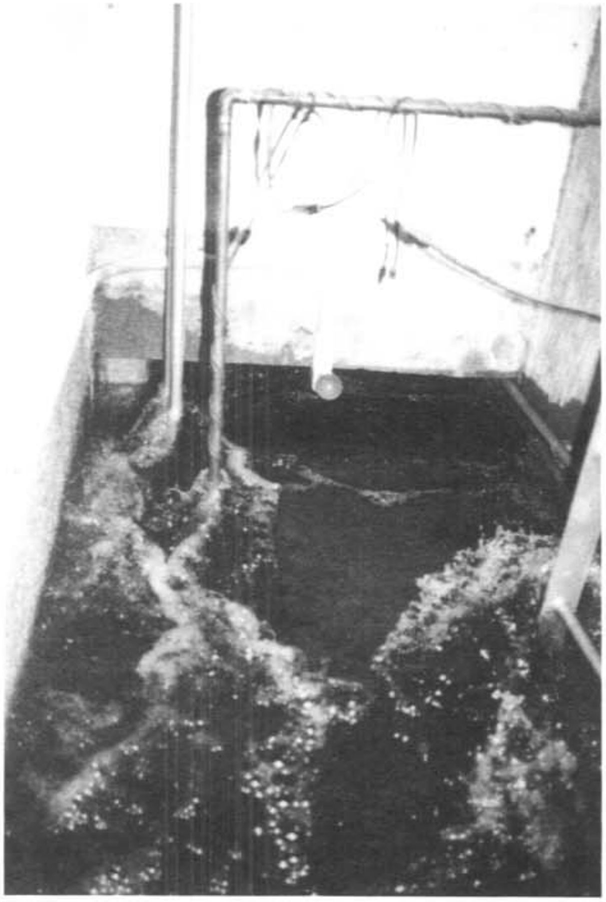
Photograph 1

Mason Dam — Outlet works tunnel access doorway. Approximately 26 ft^3/s flowing from flooded area of the downstream tunnel.



Photograph 2

Mason Dam — Flooded area around outlet works gatehouse.



Photograph 3

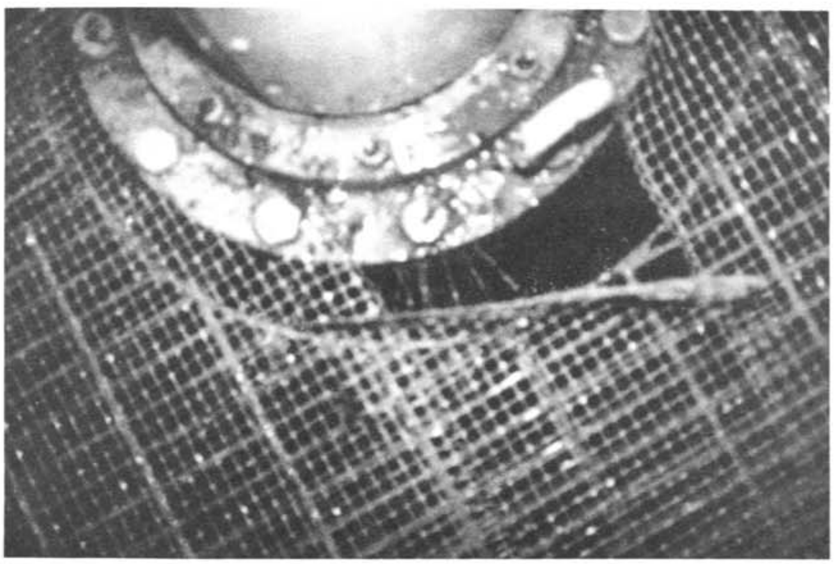
Mason Dam — Outlet works tunnel access. Note that water level is slightly below top of tunnel.

Photograph 4

Mason Dam — Removing the sleeve valve operation and stem. Note that the sleeve is not attached to the lower end of stem.

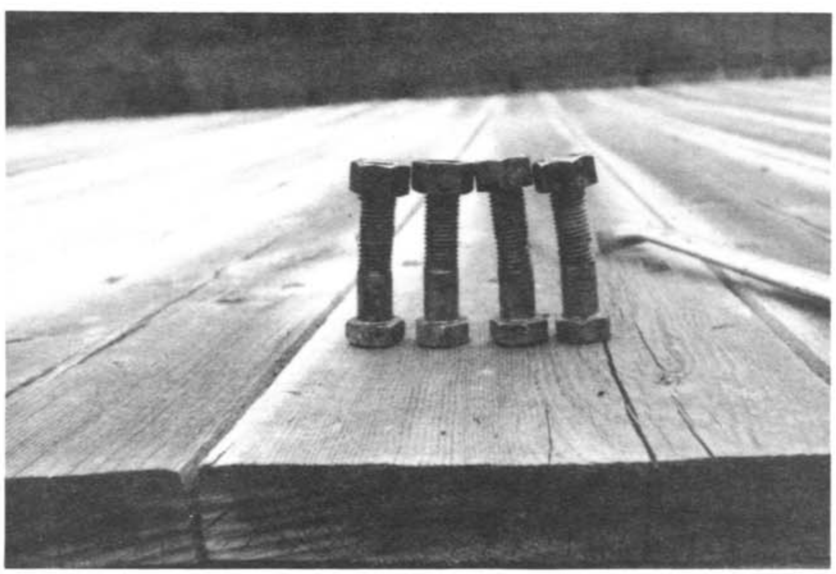
Photograph 5

Mason Dam — Sleeve valve stem and nut. Nut had backed off of stem, allowing the sleeve to slam shut. Cotter pin was not found.



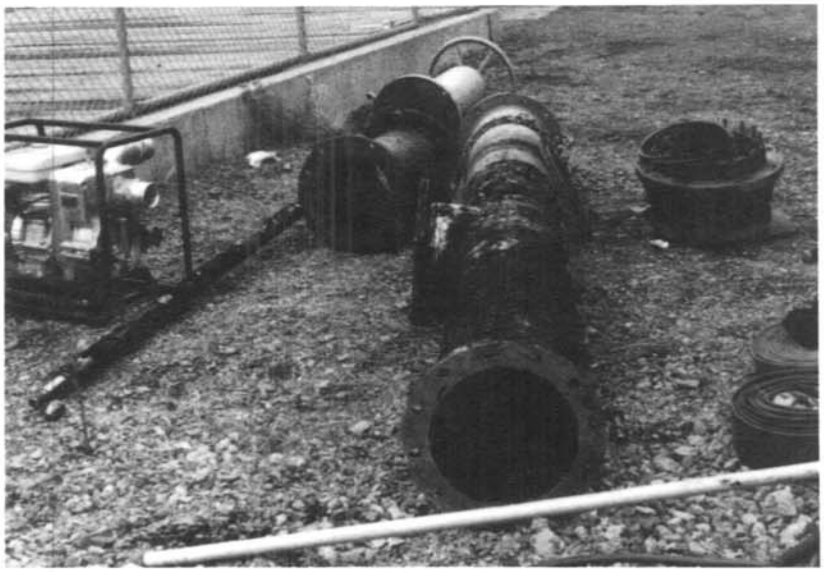
Photograph 6

Mason Dam — Sleeve valve flange located directly below operator. Note squirting water.



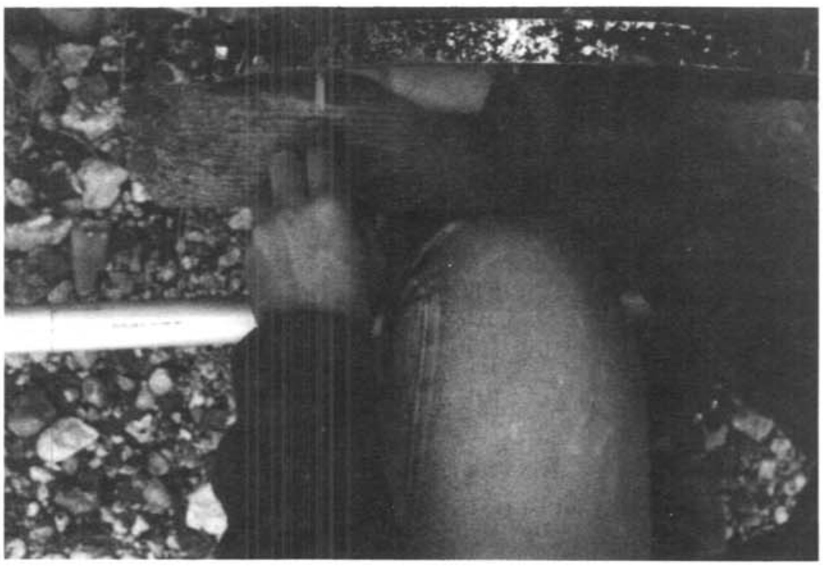
Photograph 7

Mason Dam — 7/8-inch stainless steel bolts from inlet flange to sleeve valve.



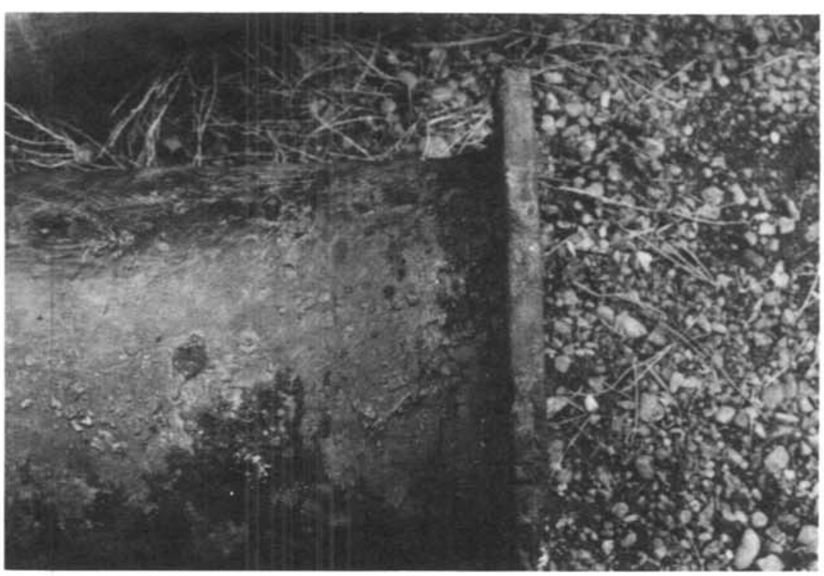
Photograph 8

Mason Dam — Sleeve valve as removed from the house.



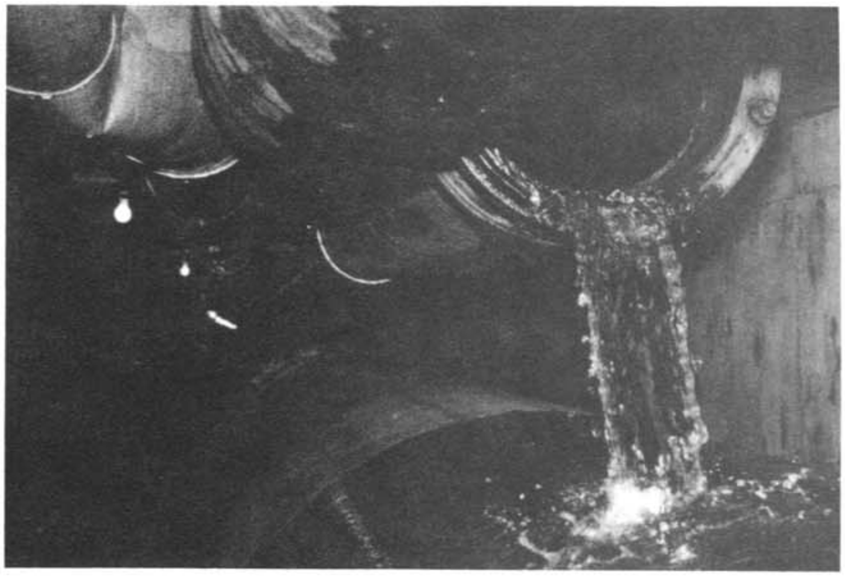
Photograph 9

Mason Dam — Warped flange on connector section of sleeve valve.



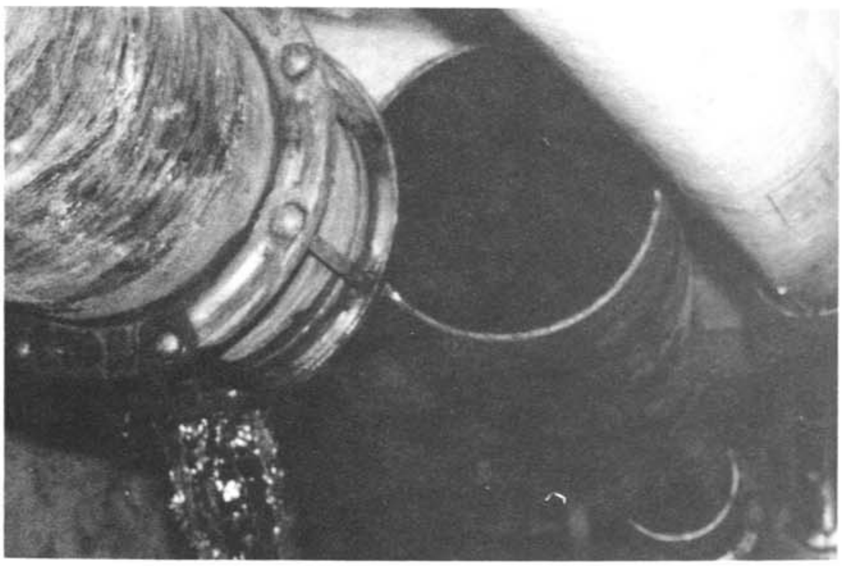
Photograph 10

Mason Dam — Sleeve valve connector section. Note cracked and chipped coal-tar coating.



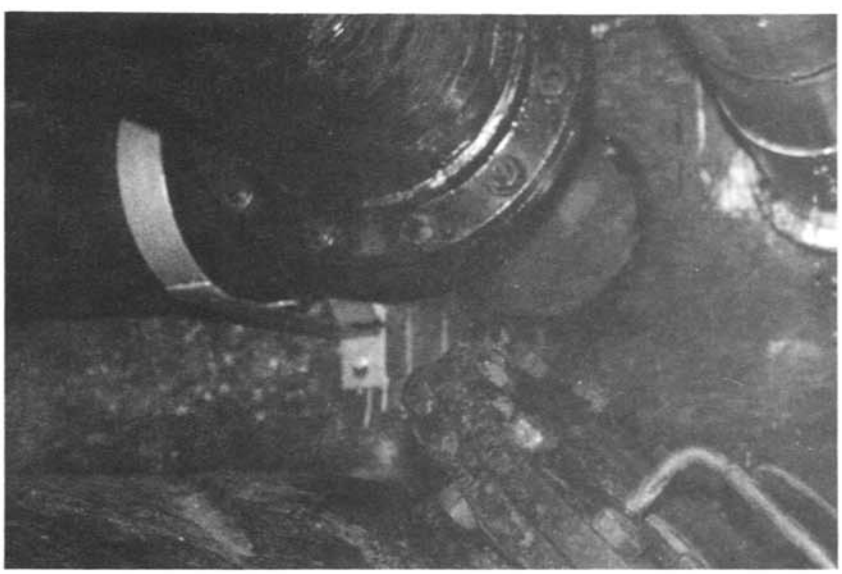
Photograph 11

Mason Dam — Separation of 12-inch pipe at sleeve-type coupling.



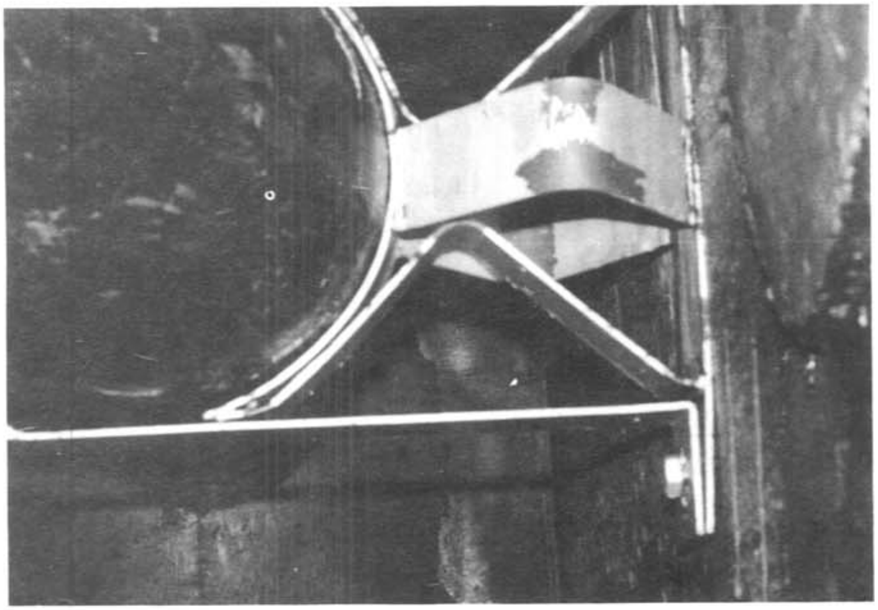
Photograph 12

Mason Dam — Separation of 12-inch pipe at sleeve-type coupling.



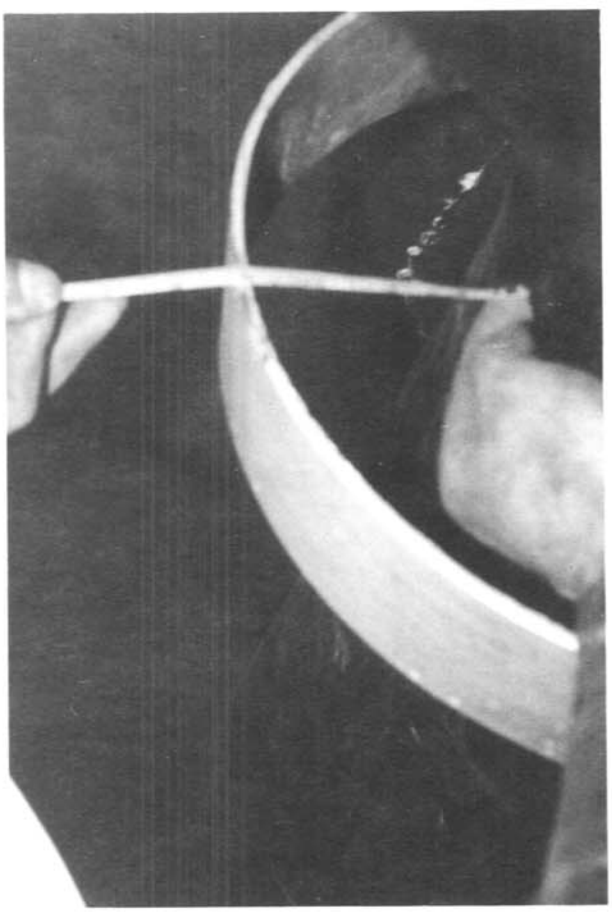
Photograph 13

Mason Dam — 90° elbow on 12-inch bypass piping. Note virtually no support against water-hammer thrust.



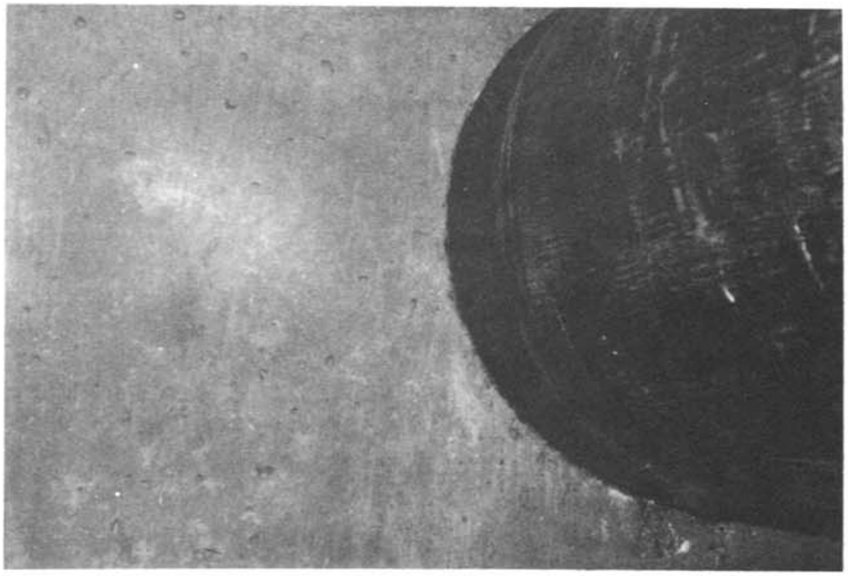
Photograph 14

Mason Dam — Bent pipe bracket downstream of 90° elbow.



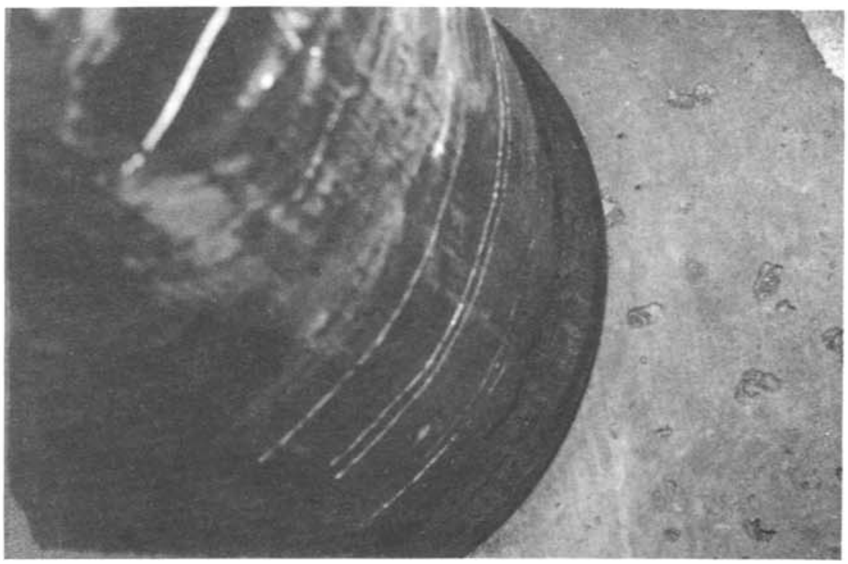
Photograph 15

Mason Dam — 6-inch movement of pipe downstream.



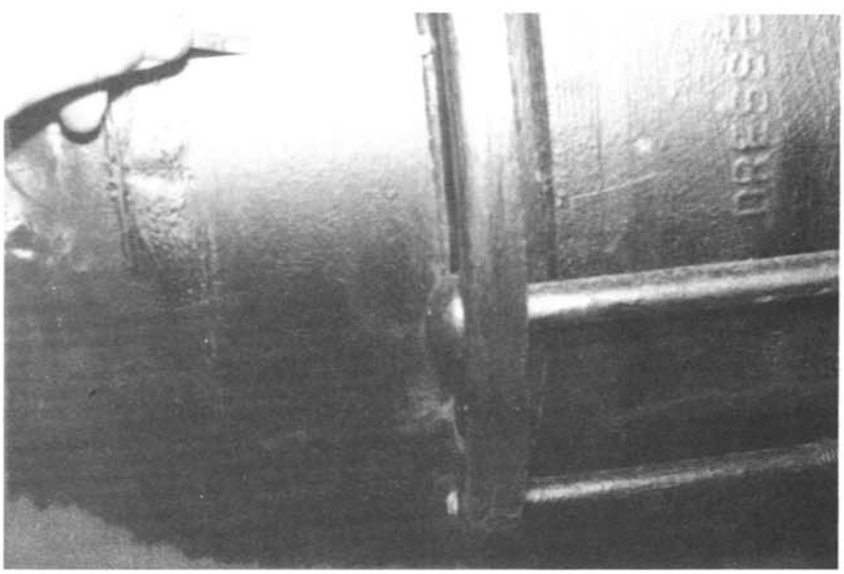
Photograph 16

Mason Dam — 12-inch bypass pipe. Note movement of pipe from wall.



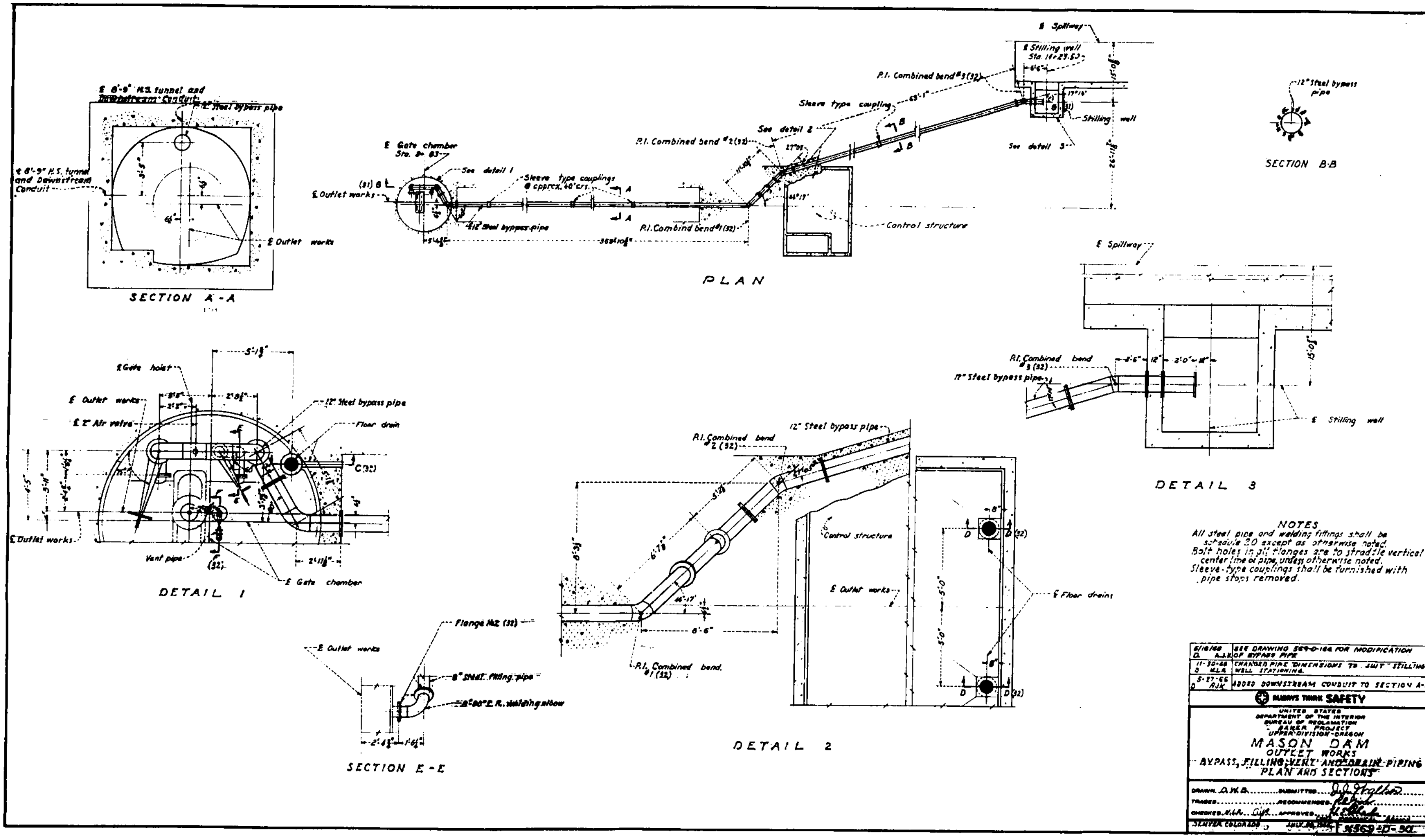
Photograph 17

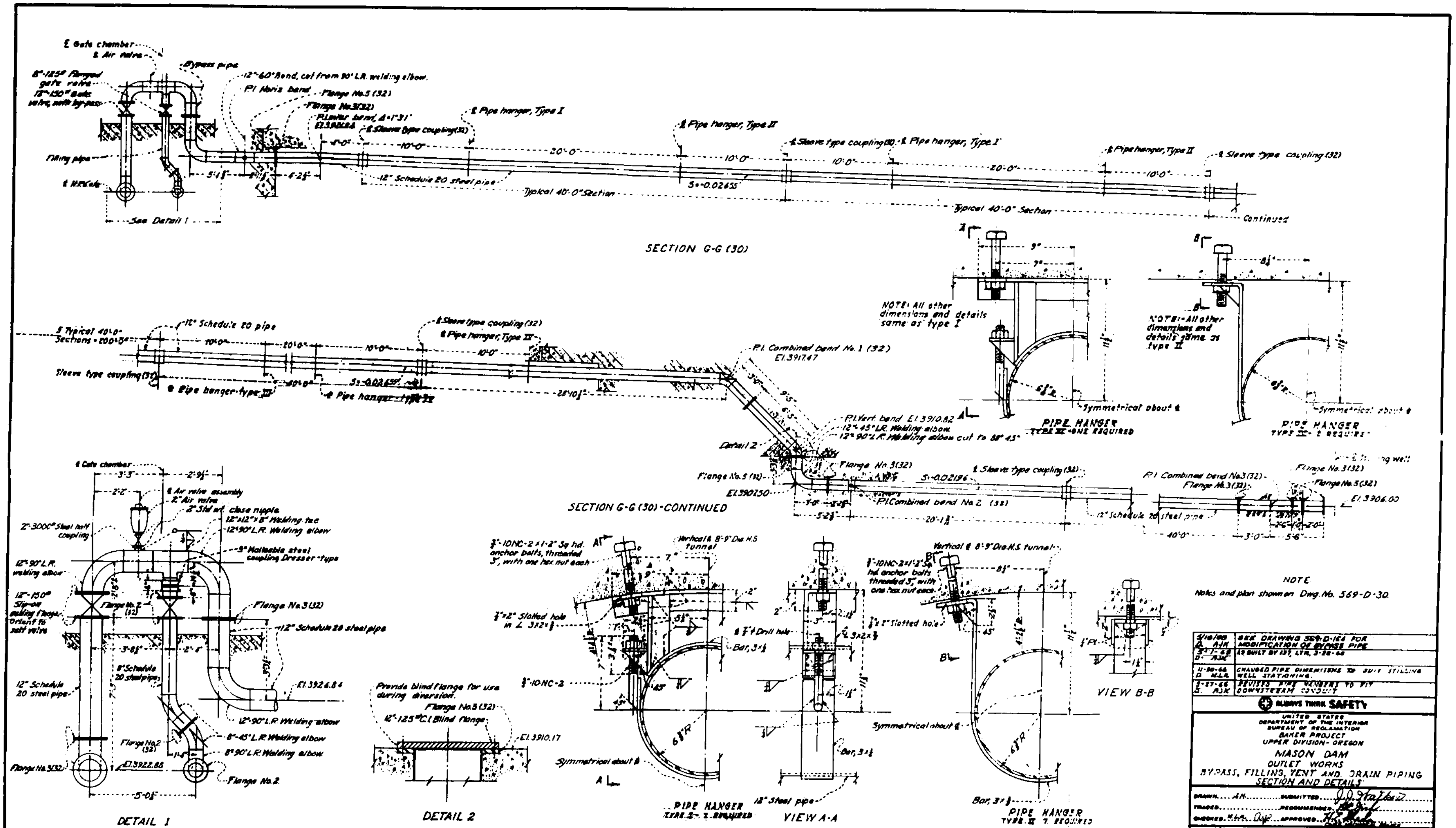
Mason Dam — 12-inch bypass pipe. Pipe is buckled at wall.

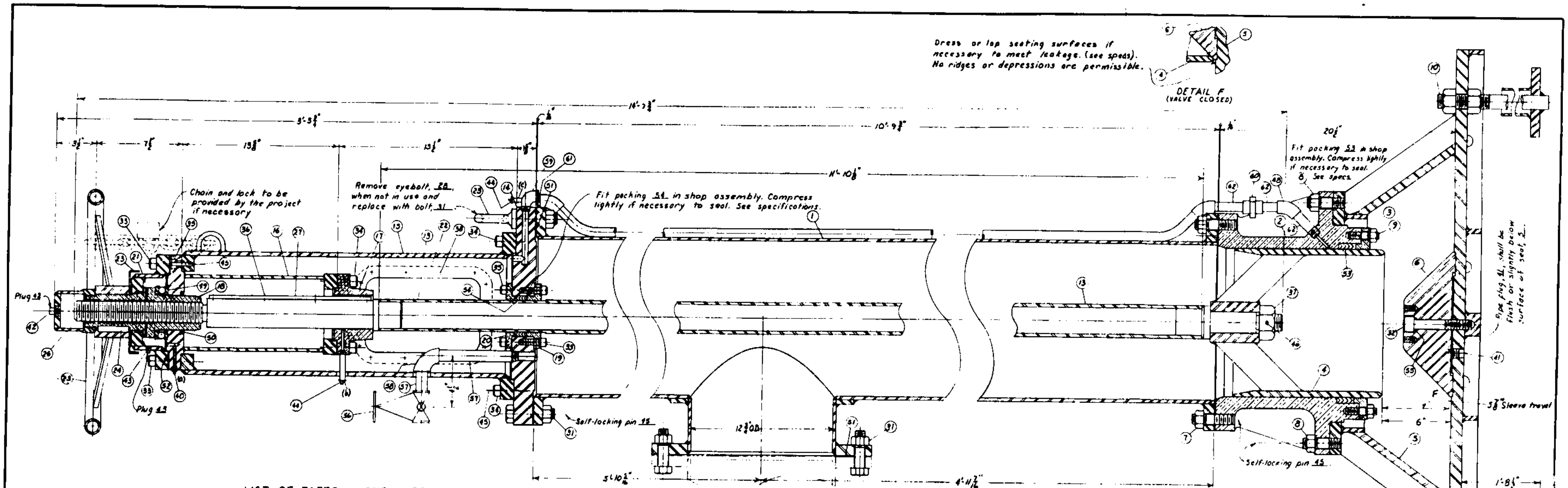


Photograph 18

Mason Dam — Sleeve-type coupling upstream of the one that separated.


SECTION A-A
PLAN
SECTION B-B
DETAIL 1
DETAIL 2
DETAIL 3
SECTION E-E
℄ Gate chamber Sta. 8+83
℄ Outlet works
See detail 1
Sleeve type couplings @ approx. 40' crs.
12" Steel bypass pipe
P.I. Combind bend #1 (32)
P.I. Combined bend #2 (32)
P.I. Combined bend #3 (32)
See detail 2
Sleeve type coupling
Control structure
℄ Spillway
℄ Stilling well Sta. 11+23.52
Stilling well
See detail 3
Floor drain
Vent pipe
℄ Gate hoist
℄ 2" Air valve
℄ Floor drains
Flange No. 2 (32)
NOTES
All steel pipe and welding fittings shall be schedule 20 except as otherwise noted.
Bolt holes in all flanges are to straddle vertical center line of pipe, unless otherwise noted.
Sleeve-type couplings shall be furnished with pipe stops removed.
SEE DRAWING 569-D-164 FOR MODIFICATION OF BYPASS PIPE
CHANGED PIPE DIMENSIONS TO SUIT STILLING WELL STATIONING.
ADDED DOWNSTREAM CONDUIT TO SECTION A-A
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BAKER PROJECT
UPPER DIVISION-OREGON
MASON DAM
OUTLET WORKS
BYPASS, FILLING, VENT AND DRAIN PIPING
PLAN AND SECTIONS
DENVER, COLORADO
569-D-50


SECTION G-G (30)
SECTION G-G (30) - CONTINUED
DETAIL 1
DETAIL 2
VIEW A-A
VIEW B-B
PIPE HANGER
NOTE
Notes and plan shown on Dwg. No. 569-D-30.
NOTE: All other dimensions and details same as type I
12" Schedule 20 steel pipe
Typical 40'-0" Section
Provide blind flange for use during diversion.
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BAKER PROJECT
UPPER DIVISION - OREGON
MASON DAM
OUTLET WORKS
BYPASS, FILLING, VENT AND DRAIN PIPING
SECTION AND DETAILS
DENVER, COLORADO, JULY 30, 1965
569-D-31



LIST OF PARTS – ONE SLEEVE VALVE

DRAWING NUMBER	PART NO.	NO. REQD.	DESCRIPTION	MATERIAL	MAT'L REF. NO.
569-D-47	1	1	Connector	Steel	*
"	2	1	Guide	Cast bronze	H36
"	3	1	Gland	Cast bronze	H36
"	4	1	Sleeve	Stainless steel 18-8	*
"	5	1	Seat	Stainless steel 18-8	AISI Type 304 or 304L
"	6	1	Cone	Stainless steel 18-8	*
"	7	12	Stud with one nut	Steel - stainless steel 18-8	*
"	8	8	Stud with one nut	Steel - stainless steel 18-8	*
"	9	16	Stud with one nut	Steel - stainless steel 18-8	*
"	10	4	Anchor bolt	Steel - stainless steel 18-8	*
	11				
	12				
569-D-48	13	1	Stem	Steel and stainless steel See detail	C7, C155, & *
"	14	1	Base plate	Steel	*
"	15	1	Stand	Steel	*
"	16	1	Carrier	Steel	*
"	17	1	Guide	Cast bronze	H36
"	18	1	Nut	Cast bronze	H36
"	19	1	Bushing	Cast bronze	H36
"	20	1	Gland	Cast bronze	H36
"	21	1	Cover	Steel	*
"	22	1	Cover	Steel	*
"	23	1	Shield	Steel	*
"	24	1	Key	Steel	*
"	25	1	Handwheel	Steel	*
"	26	1	Cap	Steel	*
"	27	1	Key	Steel	*
"	28	2	Eyebolt	Steel	*
	29				
	30				

UNDETAILED PARTS

PART NO.	NO. REQ'D	DESCRIPTION	USED WITH PARTS	MATERIAL *
31	24+1	3/4"-9UNC-2A x 3 1/2" Hex. hd. bolt with hex nut	1, 14	Stainless steel 18-8
32	1	3/4"-9UNC-2A x 4 1/2" Socket hd. cap screw	5, 6	Stainless steel 18-8
33	8	5/8"-11UNC-2A x 3 1/2" Socket hd. cap screw	15, 16, 21	Steel
34	16+1	5/8"-11UNC-2A x 2" Socket hd. cap screw	14, 15, 16, 17	Steel
35	10+1	1/2"-13UNC-2A x 1 1/2" Socket hd. cap screw	14, 15, 16, 19, 20	Stainless steel 18-8
36	4	1/4"-20UNC-2A x 3/4" Socket hd. cap screw	13, 27	Steel
37	1	1 1/2"-6UNC-2B Heavy hex. nut	13, 46	Stainless steel 18-8
38	28+3	#10-24NC-2 x 1/2" Pan hd. mach. screw	15, 22	Steel
39				
40	1	1/8"-27NPT x 1/4" Hydraulic grease fitting	16	Alemite #1606L or equal
41	1	1/2"-14NPT Hex. socket pipe plug	5	Brass
42	1	1/2"-14NPT Sq. hd. pipe plug	26	Brass
43	1	1/8"-27NPT Sq. hd. pipe plug	16, 21	Brass
44	2	1/8"-27NPT x 2 1/2" Hydraulic grease fitting	17, 56	Alemite #1684 or equal
45	9	1/4" Dia x 2" long self-locking pin	1, 2, 3, 14, 15, 16, 17	Beryllium copper
46	1	1/4" Dia x 3" long cotter pin	13, 37	Brass
47				
48	1	1/2"-14NPT-3000# 45° Elbow	62	Stainless steel 18-8
49	1	Ball thrust bearing	16, 18	SKF #916 or equal
50	1	Seal (3" shaft x 3 1/2" bore x 1/2")	16, 18	Garlock Klozure No. [illegible] or equal
51	3	14" I.D. x 16" O.D. x 1/8" Ring gasket	1, 2, 14	Cloth inserted rubber
52	1	6 3/4" I.D. x 7 3/4" O.D. x 1/8" Ring gasket	16, 21	Garlock Cork Fiber sheet [illegible] or equal
53	1 Set	[illegible] V-type packing for use with water [illegible]	2, 3, 4	[illegible]
54	1 Set	[illegible] V-type packing for use with water [illegible]	13, 14, 19, 20	[illegible]
55	1	[illegible] O-Ring	6, 32	Synthetic rubber [illegible]
56	1	1/4"-125# Globe valve	57	Bronze
57	1'-6"	1/4"-Schedule 40 pipe	14, 56, 58	Steel
58	1	1/4"-18NPT-2000# 90° Elbow	57	Steel
59	1	1/4"-18NPT-90° Street elbow	14	Steel
60	1	1/2"-14NPT-3000# Union	62	Stainless steel 18-8
61	1	1/2" x 1/4" Bushing	1, 44	Steel
62	1 ft.	1/2" Schedule 80 Cold drawn, seamless pipe		Stainless steel 18-8

MATERIALS - SPECIFICATIONS AND MINIMUM PHYSICAL PROPERTIES

MAT'L. REF. NO.	MATERIAL	ULT. TENS. STR. #/□"	YIELD POINT TENS. #/□"	% ELON. IN 2"	% RED. IN AREA	SPEC. NUMBER	REMARKS
C7	Steel	70,000	40,000	20	40	—	—
C155	Corrosion resisting steel (stainless steel 18%Cr. 8%Ni.)	75,000	22,000	28	45	● QQ-S-763c	Bars and Forgings
H36	Aluminum bronze casting	65,000	25,000	20	—	● QQ-B-671b	Type 1, Class 1 as cast

* Contractor to furnish suitable, high class, commercial materials.

● Federal specifications.

NOTES

Packing, parts 53 and 54 shall be suitable for use with water in contact with stainless steel and shall be supplied with a mica finish. Graphite packings will not be acceptable.

The mark numbers are to be placed on the parts according to the instructions in the specifications. Mark numbers for undetailed parts shall have the same prefix number as detailed parts, followed by the proper part number.

All welding and stress relieving shall be completed before finishing except as noted.

The following parts shall be stress relieved 5, 15, 16 and 21.

Coat threads on stainless fasteners with white lead and oil or with some other suitable thread lubricant at assembly.

LIST OF DRAWINGS

ASSEMBLY - LIST OF PARTS 569-D-46
CONNECTOR - GUIDE - SLEEVE - SEAT - CONE .. 569-D-47
STEM - BASE PLATE - STAND - CARRIER 569-D-48

2-8-68 D. AVV	5 7/8" SLEEVE TRAVEL WAS 5 5/8"

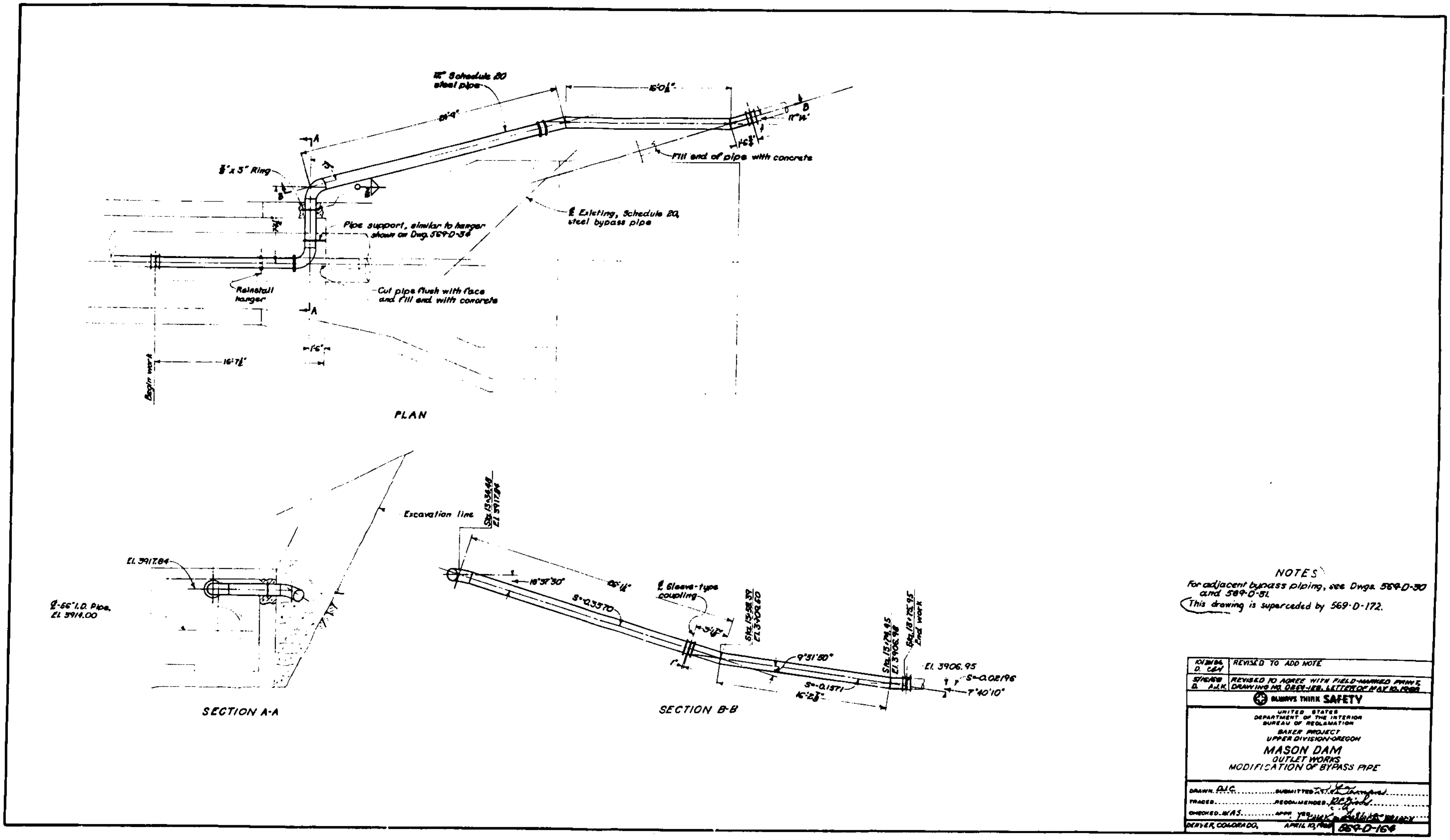
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BAKER PROJECT
UPPER DIVISION - OREGON

MASON DAM
SPILLWAY AND OUTLET WORKS
12" SLEEVE VALVE
ASSEMBLY - LIST OF PARTS

DRAWN R.M.G.-K.W.M. SUBMITTED [signature]
TRACED .... RECOMMENDED [signature]
CHECKED [signature] APPROVED [signature]
CHIEF DESIGNING ENGINEER

DENVER, COLORADO AUGUST 5, 1966 SHEET 1 OF 3 | 569 D-46


PLAN
SECTION A-A
SECTION B-B
Schedule 80 steel pipe
Fill end of pipe with concrete
℄ Existing, Schedule 20, steel bypass pipe
Pipe support, similar to hanger shown on Dwg. 569-D-34
Cut pipe flush with face and fill end with concrete
Reinstall hanger
Begin work
Excavation line
El. 3917.84
℄ Sleeve-type coupling
End work
El. 3906.95
NOTES
For adjacent bypass piping, see Dwgs. 569-D-30 and 569-D-31.
This drawing is superceded by 569-D-172.
REVISED TO ADD NOTE
ALWAYS THINK SAFETY
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
BAKER PROJECT
UPPER DIVISION-OREGON
MASON DAM
OUTLET WORKS
MODIFICATION OF BYPASS PIPE
DENVER, COLORADO
569-D-164

SPOTLIGHT ON HUNGRY HORSE PROJECT

History

An often-told story relates the ordeal of two husky freight horses lost in the rugged Montana wilderness. Tex and Jerry pulled logging sleighs in the Flathead River's South Fork area. During the severe winter of 1900-01, they wandered away from their sleigh and struggled for a month in belly-deep snow, unable to find food. They were found almost starved and so weak that considerable care and feeding were required before they were strong enough to be led back to civilization, prompting the observation that this was "mighty hungry horse country."

The name "Hungry Horse" was given to a mountain, a lake, and creek in the area, and later to the dam and town located a short distance downstream.

At the time of completion in 1953, Hungry Horse Dam was the fourth largest and fourth highest concrete dam in the world. The dam, an arch-gravity-type structure, has a crest 2,115 feet long. The crest elevation is 3565 feet above sea level.

Hungry Horse is a key project in the U.S. Department of the Interior's long-range program for multiple-purpose water resources development in the vast Columbia River drainage basin. Hungry Horse Dam and Powerplant, authorized in 1944 and completed in 1953, were constructed by the Bureau of Reclamation on the South Fork of the Flathead River in northwestern Montana. The project was authorized to help prevent the recurring spring floods on the Columbia and Flathead Rivers and to help alleviate the annual winter power shortage in the Pacific Northwest.

The cost of the Project was $102 million. Except for $24.6 million allocated to flood control and navigation, the entire project cost will be repaid to the Federal Treasury, with interest, through the sale of hydroelectric power. Just over 1.1 billion kilowatt-hours of electricity was generated at Hungry Horse in fiscal year 1981. Commercial power produced at the dam repays the largest portion of project costs. Downstream plants also repay shares of the cost, in recognition of the benefits they receive through the use of water storage.

Spillway and Outlet Works

The spillway, at the time of its completion, was the largest "morning-glory" structure in the world. The facility, shaped somewhat like a morning glory flower, collects water just upstream from the dam, carries it through bedrock under the dam's right abutment, and returns it to the river approximately 550 feet downstream from the dam.

To control the operation of the reservoir when the water drops below the spillway crest, three outlet pipes are installed in the dam. Each pipe is 660 feet long and 8 feet in diameter, with a maximum discharge capacity of 4,680 ft^3/s. Water flows into the outlet pipes in the upstream face of the dam 365 feet below the crest and discharges through a valve house on the right bank of the river, downstream from the powerhouse and dam. The discharge is controlled by hollow-jet valves.

Powerplant and Switchyard

The turbines and generators are housed in a reinforced concrete building constructed across the river channel at the downstream toe of the dam. Four large vertical-shaft generators are turned by four turbines below the generator floor. Four penstock entrances in the upstream face of the dam carry water to the powerplant. With generators operating at maximum capacity, over 80 tons of water passes through each turbine every second.

The switchyard is located in the canyon 1,200 feet downstream from the dam. High-tension lines carry the power from the transformers, located on the downstream deck of the powerhouse, to the switchyard.

Power

The Project generates hydroelectric power which benefits a region from the Continental Divide west to the Pacific Ocean.

The dam stores water during the spring flood season for release when needed during the fall and winter. As the water passes through each dam and powerplant along the Columbia River System — from Hungry Horse in Montana to Bonneville in Washington State — it is used to generate about 4.6 billion kilowatt-hours of electricity as it travels through the system.

The powerplant's four generators produce an average of 1 billion kilowatt-hours of electricity annually. Much of this is "peaking" power, which is used to meet demand during high-use periods. A transmission system delivers the energy to the Bonneville Power Administration for marketing.

Reservoir

The dam forms a reservoir approximately 34 miles long, with a maximum width of 3-1/2 miles. The reservoir capacity is nearly 3.5 million acre-feet, equivalent to about 5,000 gallons for each person in the United States. The maximum depth of the reservoir is 50 feet, and its surface area is 37 square miles.

Flood Control

Hungry Horse Dam contributes significantly toward controlling floods on the Columbia River. The dam helps minimize floods in the Flathead Valley. It reduces peak discharges between the valley and Grand Coulee Dam by 10 to 25 percent and at Portland, Oregon, by about 5 percent. Hungry Horse Reservoir has a storage capacity of approximately 3 million acre-feet which can be used for flood control.

Recreation

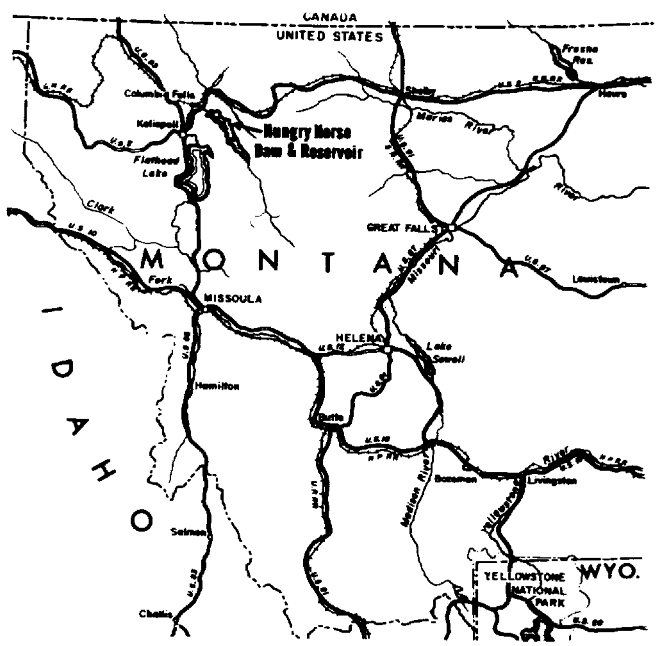
The reservoir offers excellent opportunities for fishing, boating, water skiing, and swimming. The surrounding mountains are popular big-game hunting areas. The U.S. Forest Service administers the recreational development of the reservoir area and has constructed many campgrounds and picnic areas around the reservoir.

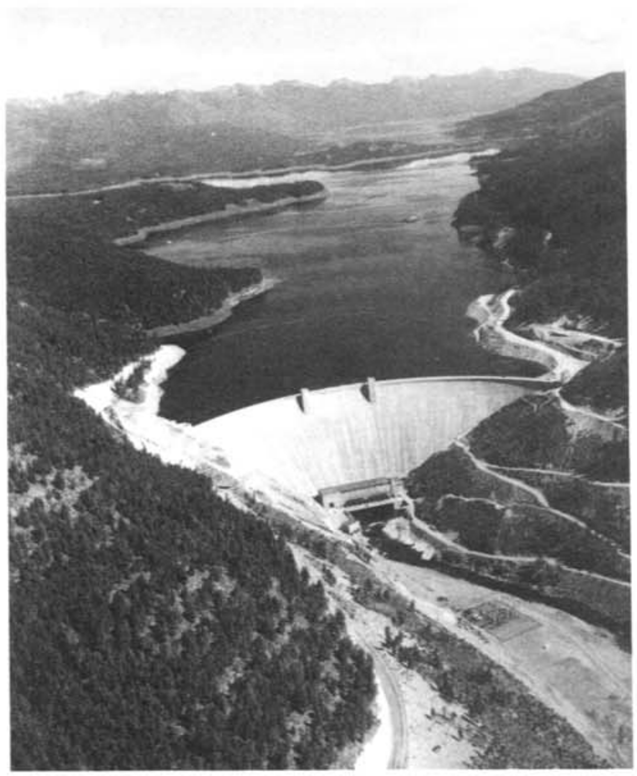
Visitors

The public is welcome at the Hungry Horse Project. Free self-guided tours of the dam and powerplant feature an animated display and tape-recorded talks.

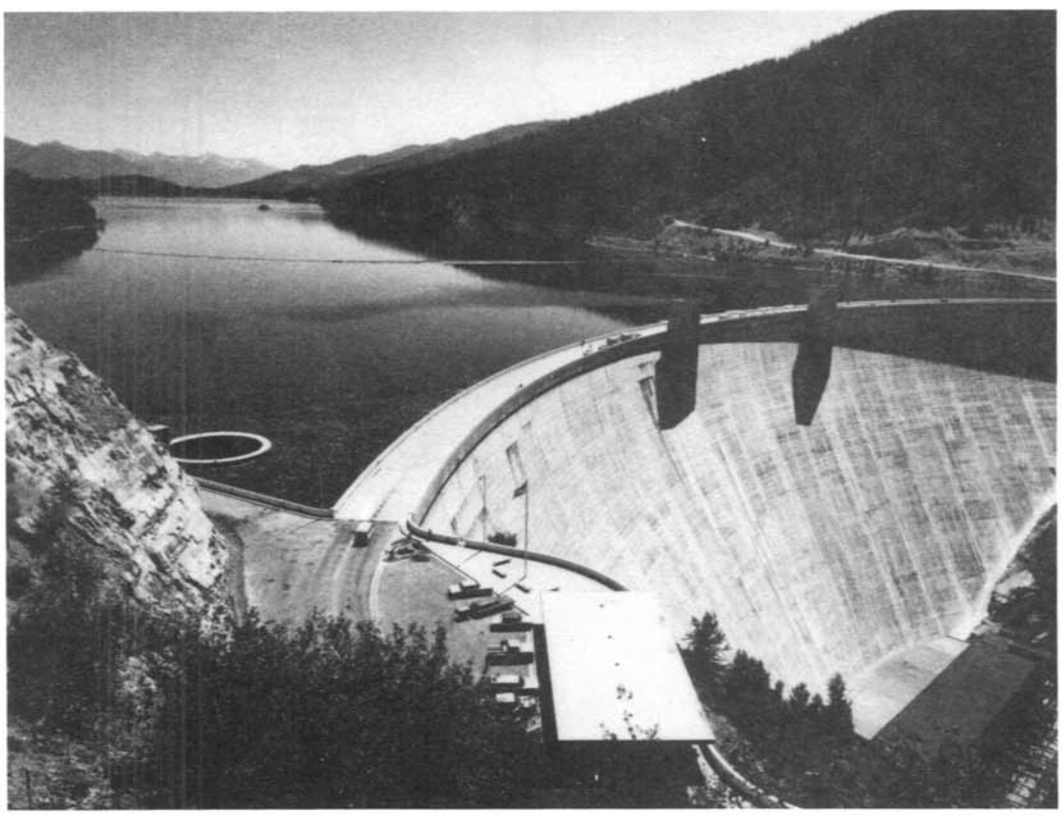
A 30-foot-wide highway across the crest of the dam is open to public travel.

Except in winter, visitors may travel completely around the 34-mile-long reservoir over nearly 115 miles of Forest Service roads.





Hungry Horse Dam, aerial view 1953.



Hungry Horse Dam and visitors center 1967.

DIGEST STATEMENT

TWIN BUTTES DAM — FOUNDATION SEEPAGE

Project:	San Angelo Project
State:	Texas
Type:	Zoned earthfill
Completed:	1963
Function(s):	Irrigation, M&I, flood control
Crest length:	42,460 feet
Hydraulic height:	128 feet
Active capacity:	632,214 acre-feet
Surface area:	23,508

Design characteristics: Twin Buttes Dam is a 42,460-foot-long, 141-foot-high zoned earthfill dam. The foundation of the dam is a caliche clay gravel complex. Zone 1, including the cutoff trench, consists of selected clay, silt, and sand. Zone 2 consists of selected sand and gravel. A drainage blanket and toe drain were also constructed. The dam includes an uncontrolled ogee crest spillway and an outlet works.

Evidence: After several dry years subsequent to completion, a large inflow event in August 1971 caused the reservor level to rise, which then caused seep areas to appear downstream of the dam. Despite improvements in the drainage network below the dam, water tables continued to rise with cropland, an airport, and a racetrack facing inundation by the seepage water.

Incident: No dramatic failure occurred. However, continually rising water tables caused problems in cultivated fields and threatened to inundate the airport and racetrack. The water tables continued to rise despite numerous efforts by Reclamation and the contractor to improve the drainage. High pore pressures were observed in the structure. The criticality was high.

Causes: SEED (Safety Evaluation of Existing Dams) examinations conducted in 1980 and 1984 concluded that the seepage was through the caliche clay gravel complex. The natural impervious cover of this formation was disturbed upstream where borrow areas removed the cover. This allows the seepage to resurface below the dam. It is speculated that dissolution of the caliche may pose a safety problem for the dam and the high pore pressures are a threat to the stability of the dam. No seepage is occurring through the main embankment.

Remedy: In addition to the drainage construction, an extensive grouting program below the toe was initiated in 1976 from station 282+00 to station 133+00. In 1982, 60 pressure-relief wells spaced 50 feet apart were installed in lieu of finishing the grouting program. In June 1981, a 10.2-foot operating restriction was imposed but was removed by the Acting Commissioner's faxogram dated April 24, 1985.

Conclusion: Better geologic exploration prior to construction may have prevented this problem. The grouting program and relief wells have been effective in reducing seepage from the reservoir. Observation wells and flumes will be monitored to evaluate the seepage problem and the remedial actions. Water quality samples are being taken to analyze the dissolution of the caliche question.

Twin Buttes Dam

Ponded water at racetrack is being drained by 4-inch outlet pipe. Intake is near white flags and pipe crosses road under tamped area in foreground. Water in track has dropped considerably during the summer of 1975.

9/11/75

Twin Buttes Dam

Flume measuring flow in ditch No. 1. Flow is 6.6 ft^3/s which is close to maximum capacity. Flume will be replaced.

9/11/75

GPO 853-533

Mission of the Bureau of Reclamation

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.