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Bureau of Reclamation

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INFORMATIONAL ROUTING

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Memorandum

To: Regional Director, Amarillo, Texas
Attention: 400

From: Chief, Division of General Research

Subject: Flow Capacities of Southwest and Southern System Aqueducts - Canadian River Project

Hydraulic performance tests of the Canadian River Project, Southwest Aqueduct, and a portion of the Southern System Main Aqueduct were performed in May 1975. Hydraulic gradient values were measured between pumping plant No. 9 and regulating tank No. 2 along the Southwest Aqueduct because the gradient was excessively high at the upstream end of this reach during three-pump operation. Also, the hydraulic gradient was abnormally high in the Main Aqueduct at regulating tank No. 6. Both of these aqueducts convey potable water from the Lubbock Treatment Plant.

Immediately following the capacity tests, the test hydraulic gradient profiles were plotted on graph sheets for comparison with design hydraulic gradients. The hydraulic gradient graphs were completed at the Canadian River Municipal Water Authority (CRMWA) Office at Lubbock, Texas. Originals of the graphs were retained at the CRMWA Office and duplicates were furnished to this office.

When the test gradient values were plotted for the Southwest Aqueduct, from pumping plant No. 9 to regulating tank No. 2, it was apparent that the existing gradient slope was excessive for three-pump operation. Flow resistance of this aqueduct reach resulted in a gradient elevation at surge tank No. 12 that caused water spill at the top of the tank. Discharge for three-pump operation, as measured by Pitometer velocity traverse at station 774+00, was 8.46 ft^3/s compared to a design discharge value of 9.6 ft^3/s. Although nearly all portions of the pipeline in the test reach exhibited hydraulic friction resistance greater than design allowance, the reach between the station 1006+00 blowoff structure and the station 1030+00 air valve structure, had a severe friction head loss.

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After elimination of questions about possible reference elevation inaccuracies, CRMWA personnel drained a portion of the Southwest Aqueduct and inspected the interior of a major portion of the 27-inch-diameter pipeline upstream of station 1030+00 and a portion of the reach downstream of this station. No reason for the severe friction head loss upstream of station 1030+00 was discovered except for a soft, relatively thin deposit on the concrete flow surface. Roughness of mortar-filled pipe joints was observed; however, this roughness has existed since construction and would not have contributed to a change in friction head of the aqueduct. The inspection indicates that the flow surface deposit must be the cause of the abnormally high frictional resistance of the tested portion of the Southwest Aqueduct.

The maximum flow test of the Main Aqueduct between regulating tank No. 6 and the Slaton turnout structure yielded results similar to those of the Southwest Aqueduct. That is, nearly all reaches between structures had a hydraulic gradient greater than the design gradient and a severe head loss existed in the pipeline between the station 8621+95 and the station 8663+74 air valve structures. The measured rate of flow in this portion of the Main Aqueduct was 7.36 ft^3/s compared to a design value of 8.6 ft^3/s. A subsequent test by CRMWA personnel in August 1975 yielded similar results and narrowed the severe head loss down to the reach between the station 8621+95 air valve structure and the station 8632+28 blowoff structure. The station 8621+95 structure is the first air valve structure downstream of regulating tank No. 6.

The May 1975 capacity test of the main aqueduct between the Slaton turnout and regulating tank No. 7 revealed that the test hydraulic gradients of pipeline reaches between air valve structures were nearly the same as design gradients. However, the reach from the Slaton turnout to the station 9107+09 air valve structure had a gradient slightly greater than design. The measured rate of flow downstream of the Slaton turnout was 4.47 ft^3/s compared to a design value of 5.6 ft^3/s, but the reduced rate of flow can partially be attributed to the high resistance to flow immediately downstream of the regulating tank No. 6.

When CRMWA personnel drained and inspected a portion of the Southwest Aqueduct near station 1030+00, a sample of the soft, grayish brown deposit on the pipeline flow surface was obtained and analyzed. The analysis revealed that the deposit contained a high percentage of aluminum oxide. At that time, persons concerned with the reduced conveyance capacity of the aqueducts, downstream of the Lubbock Treatment Plant, were not convinced that the thin deposit would cause the abnormally high resistance to flow revealed by the tests.

A paper titled, "Loss in Capacity of a Large Diameter Water Pipeline," published as paper No. 2-3C, in the Proceedings, American Water Works Association (AWWA) Ninety Fifth Conference (1975), described a problem almost identical to the decreased capacity of the Canadian River Project aqueducts that convey treated water. The paper described investigations of a London, Ontario, Canada water supply line that revealed the reduced carrying capacity of a 42-inch-diameter, 5-mile-long precast concrete pipeline to be due to a deposit on flow surfaces. The deposit was about 2 mm in thickness and contained about 40 percent aluminum oxide. The sample taken from the Southwest Aqueduct contained 18.4 percent aluminum (35 percent aluminum oxide) and the flow surface deposit was estimated to be 1 mm thick. The high aluminum oxide content of the deposit in the London, Ontario pipeline was attributed to use of liquid alum as a coagulant during water treatment. The description of the Ontario pipeline deposit appeared to be identical to the deposit in the Southwest Aqueduct. There are other similarities of conditions in the Ontario and Canadian River Project Systems. The paper stresses the fact that the troublesome deposits occurred downstream of rechlorination and fluoridation of the water.

Efforts to remove the deposit from the Ontario pipeline by a redissolving process were not successful. The decision was made to "pig" clean the pipeline as a last resort to restore carrying capacity. The paper was written before the "pig" cleaning was done and results of the cleaning were not presented. We sent a letter of inquiry to the principle author of the AWWA Proceedings paper in February 1976 asking for information about the effectiveness of the "pig" cleaning and whether or not changes were made in the water treatment process to avoid reoccurrence of the alumina deposit. No reply to our letter of inquiry has been received.

Onsite investigations by CRMWA and the exceptionally pertinent paper cited above lead to the conclusion that relatively thin soft deposits containing a large percentage of aluminum oxide are responsible for a majority of the reduced capacity of the Southwest Aqueduct. The same type deposit is possibly the cause of reduced capacity in the main aqueduct between regulating tank No. 6 and the Slaton turnout. Even though "pig" cleaning of these pipelines will be troublesome and expensive, this type of cleaning seems to be the only practical method of restoring capacity of the pipelines.

During the two-pump and three-pump operation tests of the Southwest Aqueduct, the pressure head created by each operating pump in pumping plant No. 9 was measured. The total measured discharge has been divided by the number of pumps to determine approximate single-pump discharge. The pressure head measured across each pump has been adjusted by the addition of the difference between discharge velocity head and suction velocity head to determine total head. The tabulation below presents total head and discharge values obtained in 1975 and the pump manufacturer's discharge values at corresponding total heads.

Two-pump Operation

Mfg. pump No.	Total pump head (ft)	One-half total flow (gal/min)	Mfg. test discharge (gal/min)	Discharge change from Mfg. test
DC-501257 (plant pump No. 3)	110	1,517	1,710	-11%
DC-501255 (plant pump No. 4)	110	1,517	1,690	-10%

Three-pump Operation

Mfg. pump No.	Total pump head (ft)	One-third total flow (gal/min)	Mfg. test discharge (gal/min)	Discharge change from Mfg. test
DC-501258 (plant pump No. 2)	122	1,266	1,420	-11%
DC-501257 (plant pump No. 3)	122	1,266	1,460	-13%
DC-501255 (plant pump No. 4)	122	1,266	1,450	-13%

The tabulation shows that the discharge capacities of the pumps have decreased since the manufacturer's tests were performed. The capacity decreases are probably due to seal ring wear. However, the May 1975 capacities of the pumps are very close to the original required rated total head and rated discharge point shown on the Crane Company, Deming Division, test curve sheet for each pump. The 1975 pump capacities were near the original requirements because the pumps had more than required discharge capacity at rated head when tested by the manufacturer.

We know that Mr. John Williams, General Manager, CRMWA, is anxious to receive information contained in this letter. I will appreciate efforts of your office required to relay this information to Mr. Williams.

HOWARD COHAN

Copy to: Chief, Division of Water O&M, E&R Center

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