WTS 4 Appendix 2

Consulting Engineer's Report on Providing Flow
to the Lewis River Bypass Reach from the Swift No. 2 Canal

Report

Swift No. 2 Hydroelectric Project

Consulting Engineer's Report on Providing Flow to the Lewis River Bypass Reach from the Swift No. 2 Canal

Prepared for

Cowlitz Public Utility District

Prepared by

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Contents

Introduction

This report, which was prepared by Lee DeHeer of CH2M HILL, is in response to a request from Cowlitz Public Utility District (PUD) to address issues relating to providing flow into the bypass reach of the Lewis River immediately downstream of the Swift No. 1 (owned by PacifiCorp) and adjacent to Swift No. 2 (owned by Cowlitz PUD). This bypass reach is currently dewatered because, since construction in the late 1950s, flows from the Swift No. 1 powerhouse discharge directly into the Swift No. 2 canal. Swift No. 1 and Swift No. 2 operate in tandem as peaking plants and, as a result, are regularly offline for at least 8 hours each day and sometimes for more than 24 consecutive hours. Consistent with design specifications, the water level in the Swift No. 2 canal remains stable at about elevation 603.

It is our understanding that PacifiCorp and Cowlitz PUD (licensees) are currently engaged in a collaborative relicensing process for Swift No. 1 and Swift No. 2 as well as for PacifiCorp's Yale and Merwin projects. Participants in the relicensing process asked the licensees to evaluate several options for delivering up to 400 cfs to the bypass reach. The potential options include siphoning water from the Swift No. 2 canal (PacifiCorp and Cowlitz PUD 1999). Siphoning water from the canal would effectively draft (fluctuate) the canal when Swift No. 1 and Swift No. 2 are not operating in such a way as to offset the draft.

It is also our understanding that Cowlitz PUD has stated that any fluctuation of the water level in the canal would seriously compromise the stability of the embankments and thus the safety of the project. The Washington Department of Fish and Wildlife (WDFW) has reportedly requested "quantitative information reporting the effect on water levels in the power canal that would result from those water delivery options…" and "…an engineering design of the siphon with projected velocity profiles in the siphon vicinity to facilitate an unbiased evaluation of this concern for canal stability..." (WDFW 2002). The Cowlitz Tribe, through their Technical Advisor from Steward and Associates, has reportedly asked for a description of the potential effects of the water delivery options on the stability of the embankments in the power canal (Steward and Associates 2001).

This report responds to WDFW's and the Cowlitz Tribe's requests.

Canal Description

The Swift No. 2 canal is approximately 16,700 feet long with a bottom width of approximately 100 feet. The north side of the canal has been excavated into the hillside. The south side of the canal consists of zoned earth dikes. The earth dikes that form the canal and forebay vary in height up to approximately 80 feet and are constructed of four zones. According to the construction drawings, the canal bottom was blanketed with silty sands with low permeability (Zone 1). The upstream or canal side of the dike consists of a well-graded silt, sand, and gravel mixture (Zone 2). The interior core of the dike consists of well-graded sand and gravel (Zone 3). The downstream, or land side of the dike, was constructed of basalt produced from required excavations (Zone 4). The cut slopes on the north side of the canal are on a slope of 1.5 horizontal-1 vertical while the interior dike slope on the south side of the canal is 2H:1V.

Canal History

The following information was taken from construction records and project files.

The canal was first filled in early December 1958. Project personnel noted seepage through the canal embankment immediately and determined it to be greater than anticipated in the design. To evaluate the source and severity of the seepage, the canal was drained in late December 1958. At that time many sink holes and seepage areas were noted (Ayers et al. 1959).

In July 1959 the canal was drained and inspected again. "This was done in easy stages...so that the water would not be drawn out of the canal banks too fast and cause sloughing" (Evans 1959a). Project personnel again found many sink holes and cracks and agreed to schedule the repairs at a later date. The consultant "…recommended only one more canal drain this year." It was also stated that "…the water has a tendency to cause bank sloughing when it drains out of the dikes that is not good for the stability of the fill material" (Evans 1959a). The canal was drained and repaired in September 1959 (Evans 1959b).

When unusual leakage from the canal was discovered in May 1973, Cowlitz PUD declared an emergency and authorized draining and repairing of the canal. "Approximately 2,600 feet of trench was dug along the upstream toe of the canal embankment and cracks and holes that were revealed by the trench were repaired, and a 140-foot-wide section of the canal dike was removed in order to repair tunnels that were found to extend under the dike. The cause of the unusual leakage which required repair corrections was the washing of material of the canal bottom and embankments into openings in the cavernous lava structure which underlies portions of the canal *[emphasis added]*…. Filling of the canal began on 14 July and was completed on 2 August. The length of time required for the repairs was 66 days (29 May to 2 August). The cost of the repair of the canal damage [was] $724,451" (CH2M HILL 1975). If the same situation occurred in 2001, upstream of the check structure, the repairs alone would have cost $2.9 million. In addition, replacing 66 days (120,546 megawatt hours assuming an average water year) of generation from Swift No. 1 and Swift No. 2 at $30 MWh would have cost $3.6 million.

Discussion

Canal Drawdown

The rate at which the canal is drawn down is a very important consideration with respect to the stability of the dikes. The hydrostatic pore pressures in the interior of the dikes dissipate at a relatively slow rate because the embankment material on the canal side of the dikes is well graded and includes fine-grained soils. If the canal water surface elevation is lowered in less time than it takes for the pore pressures to dissipate, slope failure is likely to occur because of seepage occurring parallel to the slope and because the excess pore pressures have not had an opportunity to dissipate.

The Attachment shows several calculations related to volume in and drawdown of the canal. It is estimated that the canal volume varies from 3 million cubic feet per foot of depth at elevation 603, which is the normal water surface elevation in the canal, to 2 million cubic feet per foot of depth at elevation 583, which is the elevation of the bottom of the canal. A discharge of 100 cfs equals 8,640,000 cubic feet per day (24 hours). Therefore, the drawdown rate in the canal would vary from 2.9 feet per day at elevation 603 to 4.3 feet per day at elevation 584 for each 100 cfs discharged from the canal, assuming that there is no inflow.

Studies have indicated that saturated embankment slopes have experienced slope failure at drawdown rates as low as 0.3 and 0.5 foot a day (Sherard, et al. 1963). The drawdown rate that causes a slope failure in a particular embankment is dependent upon the embankment soil properties and the embankment slope. Drawdown rates of 1 to 2 feet per day are commonly accepted, unless experience shows that a slower rate is required to prevent a slope failure. The safe drawdown rate for the Swift No. 2 canal would have to be verified during a drawdown, but it is reasonable to assume that it would be no greater than 1 to 2 feet per day. If the canal drawdown rate is limited to 2 feet per day, a maximum of 50 to 70 cfs (depending on the elevation of the water surface) could be discharged into the bypass reach. If the drawdown limit is 1 foot per day, the maximum discharge would vary from 25 to 35 cfs.

Canal Refill

The silt, sand, and gravel mixture on the canal side of the dike (Zone 2) and the layer of silty sand on the canal bottom (Zone 1) provide the main seepage protection barrier for the canal. The Zone 2 material in the dikes is erodible and the Zone 1 material in the canal bottom is extremely erodible. If these materials erode to a significant extent, serious leakage problems could occur through the canal banks.

When refilling the canal, the flow velocity must be limited to 2 to 3 feet per second (Chang 1998) or less to prevent erosion of the silty sand layer in the bottom of the canal and the Zone 2 material in the canal side of the dike. It is difficult to estimate the length of time that it would take to refill the canal with this velocity limitation because the rate of filling increases as the depth increases at a constant velocity. However, since it took 19 days to refill the canal after the 1973 failure, this is a reasonable estimate of the length of time that it would take to refill the canal after it is emptied. The refilling would also have to be continuously monitored to be sure that erosion of the Zone 1 and Zone 2 materials does not occur.

Conclusions and Recommendations

I have reached the following conclusions and recommendations regarding the proposed use of the Swift No. 2 canal for providing flow into the bypass reach of the Lewis River adjacent to the canal. These conclusions and recommendations are based on my review of the existing information and my understanding of the operation of the Swift No. 2 canal.

1. Drawing down or fluctuating the water level in the Swift No. 2 canal could cause slope failures in the canal banks if the canal is drawn down too rapidly. In addition, frequent changes in the canal water surface elevation or significant drawdowns are likely to erode the channel bottom and side slopes. If it is determined through the relicensing process that providing flows in the bypass reach is necessary or appropriate given other options for fish and other resources in the Lewis River, every effort must be made to

avoid taking water from the canal in such a manner that fluctuates the canal elevation much below its historically full level.

2. If flows are provided to the bypass reach from the canal, assuming no inflow to the canal, the maximum drawdown rate should not exceed 2 feet per day. This recommendation is based on reasonable assumptions relative to the permeability and strength parameters of the soil in the embankment. It is possible that some localized failures may occur even at this drawdown rate. Therefore, it is also recommended that the canal be continuously monitored while the canal is being drafted and the rate of drawdown be adjusted if slumping of the dike banks is observed.

   The 2-foot-per-day drawdown constraint limits the discharge to a maximum of 70 cfs at higher water levels and a maximum of 50 cfs when the water surface is near the bottom of the canal. Therefore, it is not feasible to provide more than 70 cfs flow to the bypass reach from the canal while Swift No. 1 is not operating.

3. I recommend against using the Swift No. 2 canal to provide flow into the bypass reach of the Lewis River. It is my opinion that this plan could cause significant risk to the integrity of the canal. Providing bypass water from the Swift No. 1 reservoir would appear to be a better option that would not jeopardize the integrity of the Swift No. 2 canal.

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Attachment

Swift No. 2 Power Canal Calculations—April 5, 2002

Attachment. Swift No. 2 Power Canal Calculations. April 5, 2002

Swift No. 2 Power Canal Surface Area at Normal Water Surface Elevation 603											
From Upstream End (Station 0+00) to Station 66+00											
Total Length =		16,600		feet							
Normal WSE =		603									
Invert elev. u/s =		583									
Depth =		20		feet							
Bottom width =		93		feet							
Side slopes =		1.75		/1	(Average - 1.5/1 on north side and 2/1 on south side)						
Top width =		163		feet							
Length =		6,600		feet							
Surface Area =		1,075,800		square feet							
Station 66+00 to 166+00 (Intake Structure)											
Assume Top width =		200		feet							
Length =		10,000		feet							
Surface Area =		2,000,000		square feet							
Total Surface Area =		3,075,800		square feet at elevation 603			185	feet average width			
Area reduction/foot of depth =		29,050		square feet at elevation 603							
								Hours to drawdown			Discharge
Elevation	Depth	V(U/S)	Top Width U/S	V(d/s)	Total Volume	Delta V	100 cfs	200 cfs	300 cfs	400 cfs	1 ft/day drawdown cfs
603	0	0	163	0	0						
602	1	1,064,250	159.50	1,982,500	3,046,910	3,046,910	8.5	4.2	2.8	2.1	35
601	2	2,105,400	156.00	3,930,000	6,035,556	2,988,647	8.3	4.2	2.8	2.1	35
600	3	3,123,450	152.50	5,842,500	8,966,103	2,930,547	8.1	4.1	2.7	2.0	34
599	4	4,118,400	149.00	7,720,000	11,838,549	2,872,447	8.0	4.0	2.7	2.0	33
598	5	5,090,250	145.50	9,562,500	14,652,896	2,814,347	7.8	3.9	2.6	2.0	33
597	6	6,039,000	142.00	11,370,000	17,409,142	2,756,247	7.7	3.8	2.6	1.9	32
596	7	6,964,650	138.50	13,142,500	20,107,289	2,698,147	7.5	3.7	2.5	1.9	31
595	8	7,867,200	135.00	14,880,000	22,747,335	2,640,047	7.3	3.7	2.4	1.8	31
594	9	8,746,650	131.50	16,582,500	25,329,282	2,581,947	7.2	3.6	2.4	1.8	30
593	10	9,603,000	128.00	18,250,000	27,853,128	2,523,847	7.0	3.5	2.3	1.8	29
592	11	10,436,250	124.50	19,882,500	30,318,875	2,465,747	6.8	3.4	2.3	1.7	29
591	12	11,246,400	121.00	21,480,000	32,726,521	2,407,647	6.7	3.3	2.2	1.7	28
590	13	12,033,450	117.50	23,042,500	35,076,068	2,349,547	6.5	3.3	2.2	1.6	27
589	14	12,797,400	114.00	24,570,000	37,367,514	2,291,447	6.4	3.2	2.1	1.6	27
588	15	13,538,250	110.50	26,062,500	39,600,861	2,233,347	6.2	3.1	2.1	1.6	26
587	16	14,256,000	107.00	27,520,000	41,776,107	2,175,247	6.0	3.0	2.0	1.5	25
586	17	14,950,650	103.50	28,942,500	43,893,254	2,117,147	5.9	2.9	2.0	1.5	25
585	18	15,622,200	100.00	30,330,000	45,952,300	2,059,047	5.7	2.9	1.9	1.4	24
584	19	16,270,650	96.50	31,682,500	47,953,247	2,000,947	5.6	2.8	1.9	1.4	23
583	20	16,896,000	93.00	33,000,000	49,896,093	1,942,847	5.4	2.7	1.8	1.3	22
							138.6	69.3	46.2	34.7	Hours
							5.8	2.9	1.9	1.4	Days
Discharge											
	cfs	sec/day		cfd	Drawdown						
	100	86,400		8,640,000	2.9	feet/day					
	200	86,400		17,280,000	6	feet/day					
	300	86,400		25,920,000	9	feet/day					
	400	86,400		34,560,000	12.8	feet/day					
From previous canal seepage studies:											
	Q	Hours		Seconds	Volume	d	Area	Elev.			
	cfs				cf	ft.					
3/19-22, 1978	0.9	80		288000	259,200	0.06	4,320,000	602			
8/8-10, 1978	10.8	60		216000	2,332,800	0.52	4,486,154	602.6			
4/8-10, 1976	4.01	46		165600	664,056	0.15	4,427,040	602.3			
	cfs	sec/day		cfd	Drawdown						
	100	86,400		8,640,000	1.9	feet					
	200	86,400		17,280,000	4	feet					
	300	86,400		25,920,000	5.9						
	400	86,400		34,560,000	7.8	feet					

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