Appendix J
Effluent Pump Station

TECHNICAL MEMORANDUM

Salmon Creek Treatment Plant Effluent Pump Station Hydraulics and Phasing Analysis for the Phase 5A Project—Columbia River Outfall and Effluent Pipeline

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Introduction

Implementation of the Phase 5A Project—Columbia River Outfall and Effluent Pipeline will significantly change hydraulic conditions associated with effluent discharge from the Salmon Creek Treatment Plant (SCTP). Under normal operating conditions the new effluent system will continue to operate as a gravity line, and under certain conditions, when the river level and or effluent flow is high, effluent pumping will continue to be required. The following documents the impacts of the new effluent pipeline and outfall on the effluent pump station. This technical memorandum identifies effluent pump station improvements through buildout capacity of the new effluent pipeline.

Existing Effluent Pump Station

The existing effluent pump station consists of a below grade wet well with an elevated slab at grade. Four vertical line shaft pumps with above-grade discharge piping are mounted on top of the wet well. The facility also houses two fire water pumps, and two non-potable plant water pumps. Space within the existing effluent pump station is limited, with little or no room for additional effluent pump expansion within the existing facility. Figures 1 and 2 show the existing pump station configuration.

The effluent pump station wet well receives effluent flow by gravity over a weir from the ultraviolet (UV) disinfection facility to the east through a UV effluent channel. The existing UV facility was constructed with a wall pipe cast into the wall to allow for a future parallel UV channel expansion to the south, with flow from the existing and future channel proposed to pass over the existing weir to reach the effluent pump station wet well. To the north of the existing effluent pump station, the grade slopes away quickly toward Salmon Creek. Space is available to the west of the existing effluent pump station for expansion, but this was not considered during this evaluation because future pump station capacity can be accomplished by replacing existing pumps within the confines of the existing pump station.

The existing effluent pumps curves are not suitable for the hydraulic conditions of the new effluent pipeline. The new effluent pipeline has a larger diameter than the existing effluent pipeline, so the dynamic losses through the new effluent pipeline and outfall are substantially lower than the existing system at all flow rates. As a result, all four of the existing pumps will require replacement when the new effluent pipeline is put into service.

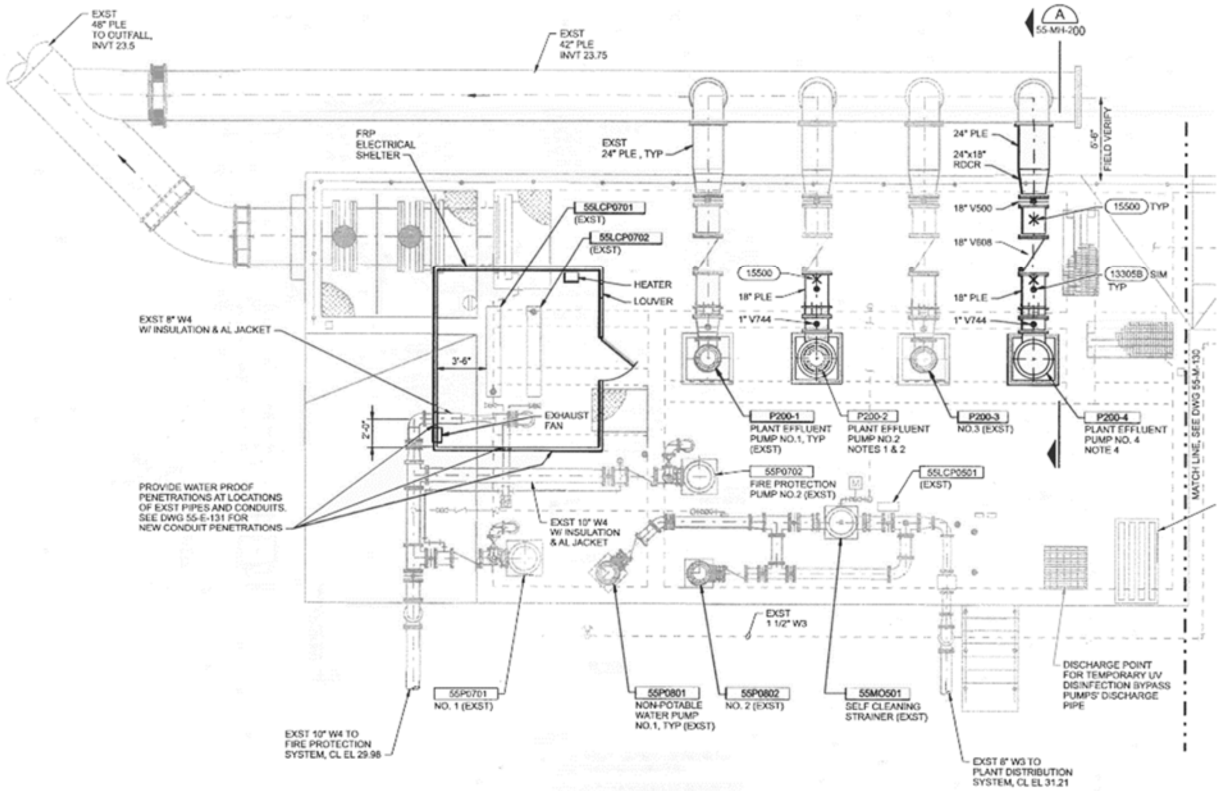

Figure 1. Effluent Pump Station Configuration Plan

Existing Pump Station Plan

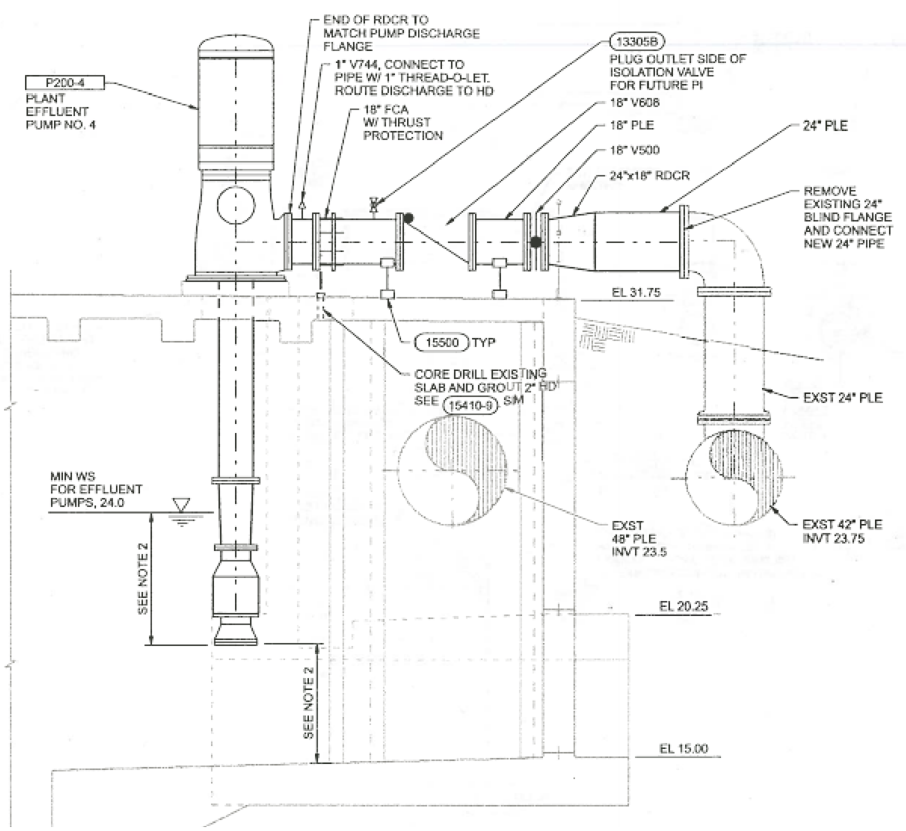

Figure 2. Effluent Pump Station Configuration Section

Existing Pump Station Section

Design Criteria

The new Columbia River outfall and effluent pipeline has been sized for future capacity flows through year 2066.

Flow Projections

Flow projections were developed by BHC Consultants (February 2016). Table 1 below summarizes BHC predicted flows with the Battle Ground equalization basin.

Table 1. BHC Flow Projections
Forecasted flow (mgd)

	2016		2036		Buildout (2048)		2066	
	AAF	**PHF**	**AAF**	**PHF**	**AAF**	**PHF**	**AAF**	**PHF**
Salmon Creek flows	7.5	19.0	20.7	38.0	23.7	47.4	31	62

AAF = average annual flow

mgd = million gallons per day

PHF = peak hour flow

Table 2 shows flows using BHC flow projections and adjusting the average annual to peak hour factor from 2.0 to 2.2 as well as eliminating the Battle Ground equalization basin and applying phasing as set out in the 2004 *Salmon Creek Wastewater Management System Wastewater Facilities Plan/General Sewer Plan* (CH2M). The Battle Ground equalization basin was not included to be conservative in case it is removed in the future. Minimum effluent flow rates shown below are based on historical 2016 plant flow data in 15-minute intervals. Minimum observed flows were 21 percent of average annual flow rates.

Table 2. Flow Projections
Forecasted flow (mgd) without battleground equalization basin

Design Phase	Year	Minimum Flow (mgd)*	AAF (mgd)	PHF (mgd)
4	2016	1.6	7.5	22
5	2022	2.1	10	29
6	2030	3.4	16	37
7	2036	4.3	20.7	44
8	2048	5	23.7	55
9	2066	6.5	31	72

AAF = average annual flow

mgd = million gallons per day

PHF = peak hour flow

*minimum flows = 21% of AAF

Effluent Pipeline and Outfall

The effluent pipeline and outfall have been designed as cement lined and coated 48-inch-diameter welded steel pipe. Hydraulics calculations were performed based on the proposed facilities shown in the CH2M 30 percent design drawings dated November 2017. There are two sections of piping that have material selection options between HDPE and cement-lined and coated welded steel pipe. These material selection options are located between Stations 68+69 and 46+47 as well as between Stations 41+50 and 19+22. For the pumping analysis, the scenario that creates the largest required pump head is when these material sections are constructed with HDPE. Even though HDPE piping is smoother than cement-lined welded steel pipe, the reduced internal diameter of the proposed HDPE piping material results in a larger head loss than for cement-lined welded steel pipe. As a result, the hydraulic data below for pump sizing assume that HDPE piping is selected for pipeline sections that have material options. Table 3 shows pipeline hydraulic data and roughness assumptions.

Table 3. Pipeline Hydraulic data
Hydraulic data for proposed pipeline materials

Pipe Size & Material	Inside Diameter (inches)	Absolute Roughness - ε (feet)
48-inch-diameter Welded Steel	48	0.0004 [a]
48-outside-diameter HDPE (IPS SDR 32.5)	44.869	0.000005 [b]

[a] Steel pipe absolute roughness per AWWA M11—equivalent to Hazen Williams of 135.

[b] HDPE pipe absolute roughness per AWWA M55—equivalent to Hazen Williams of 154.

AWWA = American Water Works Association

The proposed outfall configuration is a 48-inch-diameter cement-lined and coated steel pipe with ten 16-inch diffuser risers at 16-foot spacing; each riser is fitted with an elastomeric check valve port. See Figure 3 for the conceptual configuration from the 30 percent design drawings.

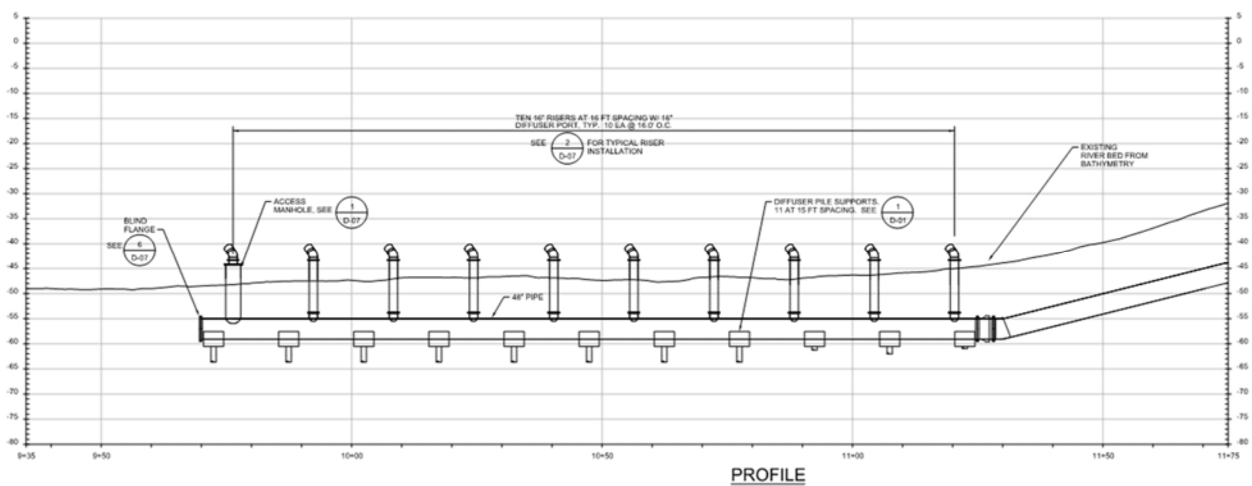

Figure 3. Diffuser and Manifold Configuration
Flow (mgd) versus head loss (feet)

The diffuser section will extend 144 feet long at an average water depth of approximately 42 feet below Columbia River Datum at low river stage. The head loss through the diffuser is based on ProFlex SW check valves. Head loss through the entire diffuser manifold, from the start of the 144-foot-long diffuser section and out through the diffusers, is shown in the Figure 4.

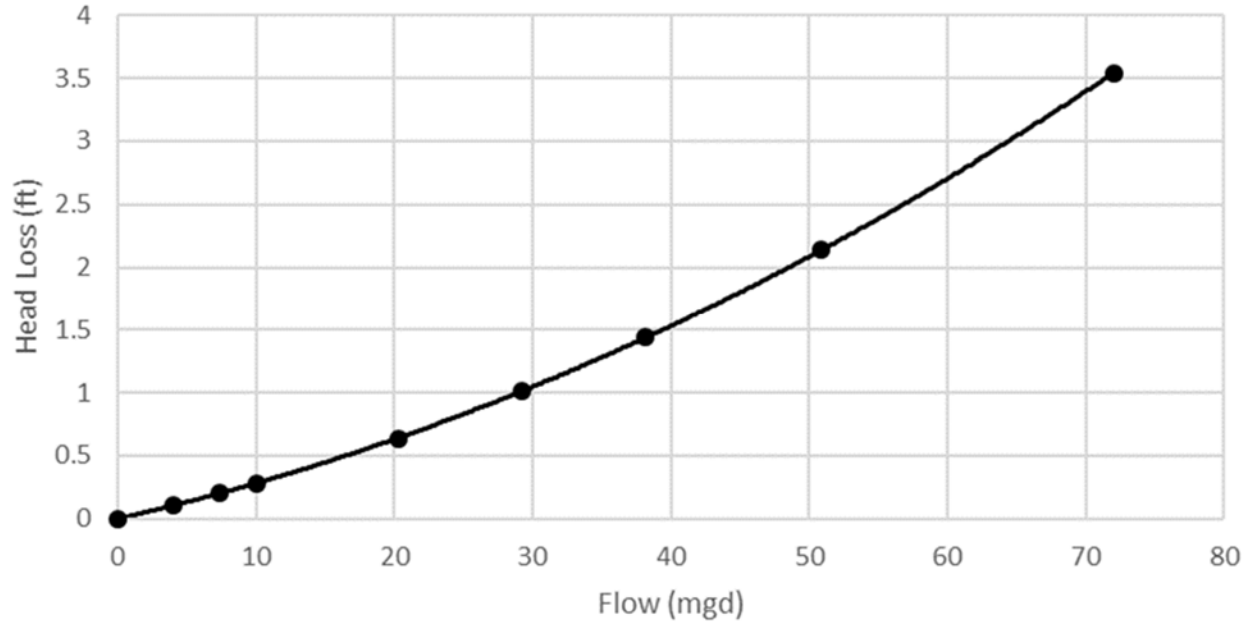

Figure 4. Diffuser and Manifold Head Loss
Flow (mgd) versus head loss (feet)

100-Year Flood River Elevation and Plant Datum

The effluent pump station is designed to convey peak hour design flows at the 100-year flood river stage. For the Columbia River, the 100-year flood stage at Salmon Creek is 25.6 feet (National Geodetic Vertical Datum of 1929 [NGVD29]. NGVD29 is also used for the exiting effluent pump station drawings. This memorandum uses NGVD29 unless otherwise specified.

Redundancy

The U.S. Environmental Protection Agency (EPA) requires that wastewater facilities meet the requirements for reliability and redundancy in their treatment components and associated equipment. To meet these criteria, the effluent pump station must be designed to convey the peak hour flow with the largest effluent pump out of service at the 100-year flood stage.

Hydraulics

Pressurized, full pipe pump station hydraulics were evaluated using AFT Fathom software. AFT Fathom performs steady state, incompressible, Newtonian fluid flow and energy analysis for pump and piping systems.

The hydraulic computer model, HYDRO, developed by CH2M, was used for the gravity flow, partially full pipe portion of the hydraulic analysis to determine pipe and diffuser sizing. HYDRO is a steady-state model that produces a hydraulic profile by calculating head loss through the individual element in the outfall alignment. This model was utilized to determine the amount of allowable gravity flow at different rivers stages. Some assumptions were made related to the new facilities, and the model is based on the 30 percent design documents. These assumptions must be revisited during design development in conjunction with more detailed alignment layouts, minor losses in valve and fitting details, and receipt of head loss data from proposed equipment vendors.

The HYDRO computer model calculates energy and hydraulic grade line elevations upstream and downstream of the hydraulic elements in system. The hydraulic analysis begins at the water surface datum elevation at the downstream end of the diffuser; hydraulic calculations proceed upstream from this datum elevation, one element at a time.

Model assumptions are as follows:

- 30% design documents pipeline alignment.
- 100-year flood elevation 25.6 feet (NGVD29) starting point.
- Lead PUMP ON level set point in wet well at elevation 25.7 feet (NGVD29).
- 48-inch outside diameter (OD) (44.869-inch inside diameter [ID]) HDPE (IPS SDR 32.5) pipe at all locations where steel or HDPE is acceptable. 48-inch ID steel pipe at all other locations.
- Diffuser losses were calculated at different flow rates per ProFlex SW check valve losses.
- Absolute roughness e = 0.0004 foot (steel).
- Absolute roughness e = 0.000005 foot (HDPE).
- Mannings n = 0.013 foot (steel).
- Mannings n = 0.010 foot (HDPE).
- Zero difference in specific gravity between discharge and receiving waters based on receiving waters at River Mile (RM) 96, salt water only reaches up Columbia River to around RM 50.

Gravity versus Pumped flow

Gravity effluent flow can be accomplished during typical hydraulic conditions. However, when river levels are high and/or plant effluent flows are high, effluent pumping is required. Figure 5 illustrates the relationship between river stage and gravity flow capacity for the proposed effluent pipeline and outfall configuration. Gravity flow data were obtained using HYDRO with effluent pump station water surface elevation at 25.68 feet. This corresponds to the lead effluent PUMP ON elevation set point. All flows above 36.7 million gallons per day (mgd) must be pumped regardless of river elevation.

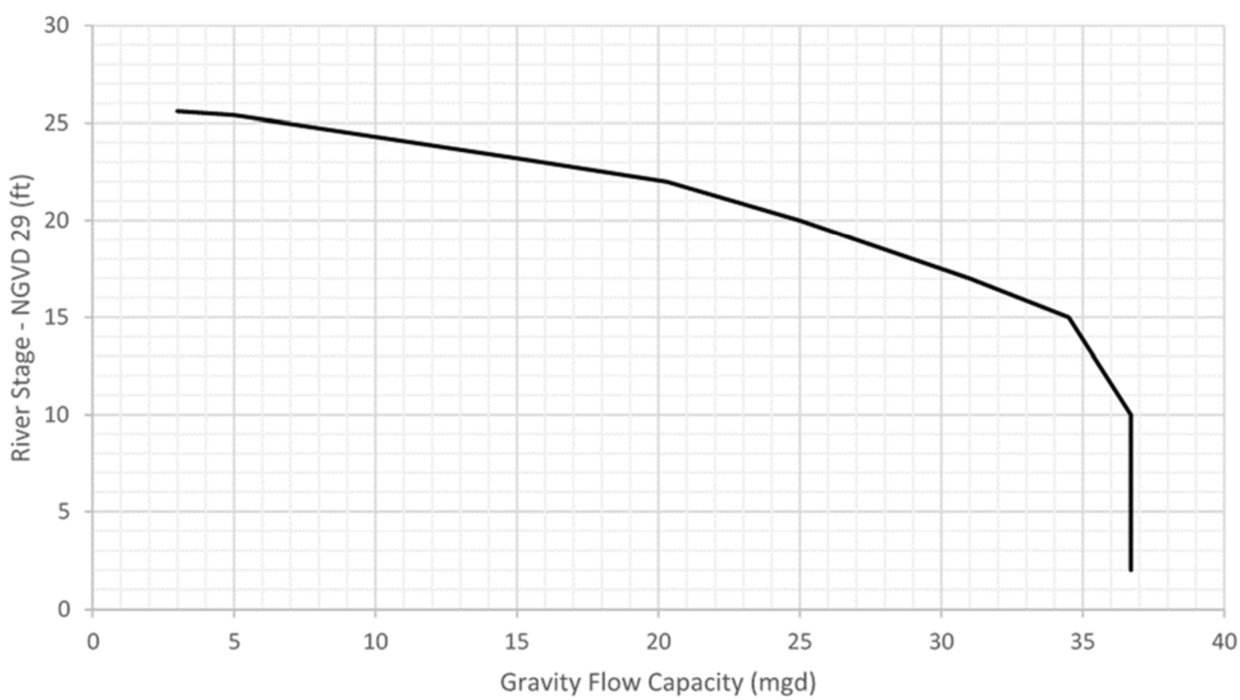

Figure 5. River Elevation versus Allowable Gravity Flow
Assumes effluent wet well hydraulic elevation = 25.68 feet

During the Columbia River 100-year flood stage condition (elevation 25.6 feet) the maximum gravity flow possible is 3 mgd. This maximum gravity flow can be increased if the lead effluent PUMP ON level set point is raised. By adjusting the set point up 0.7 foot (elevation 26.3 feet) the gravity flow would be increased to approximately 6 mgd. This may be required to avoid cycling effluent pumps during low flow/high river stage scenarios.

Figure 6 illustrates the frequency of gravity effluent flow versus pumped effluent flow for each facility plan phase. This figure also assumes that the effluent PUMP ON level is set at elevation 25.68 feet. Effluent pumping is only required when river levels are high or at peak hourly flow events.

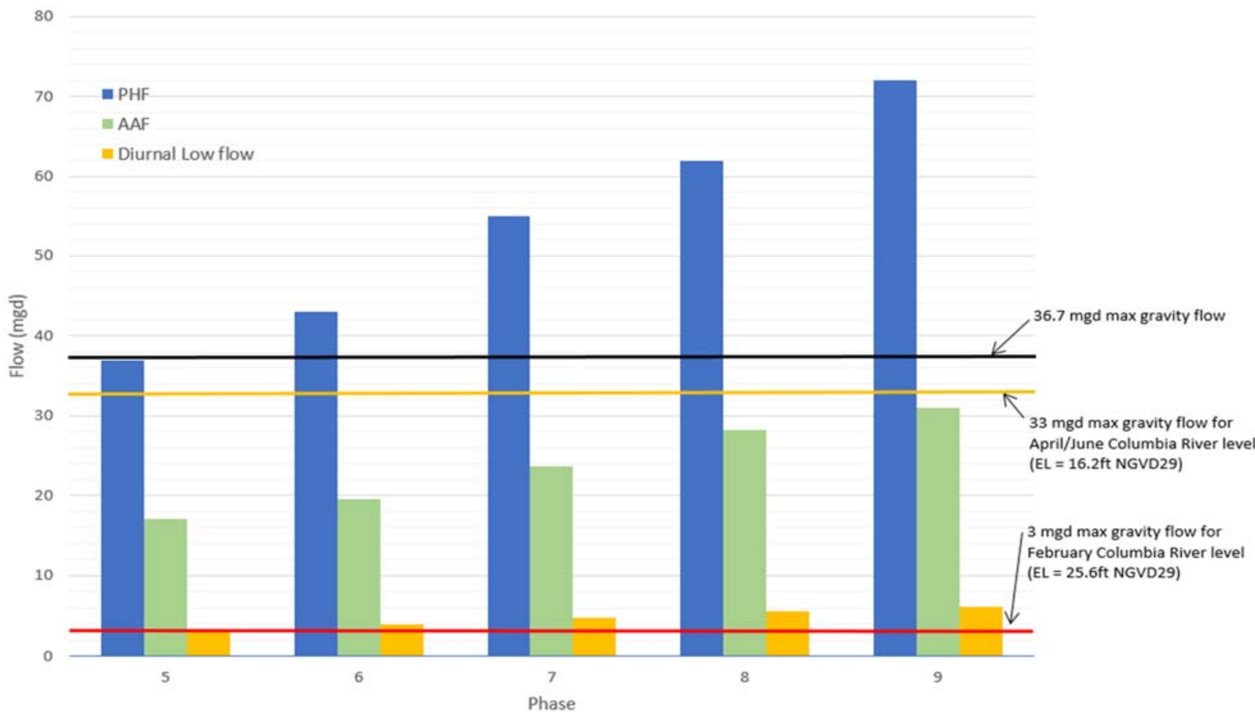

Figure 6. Effluent Flow by Phase with Gravity Flows at a Variety of River Elevations
Assumes effluent wet well hydraulic elevation = 25.68 feet

Pump Selection and Configuration

The general pump station configuration will remain as currently constructed. Four effluent pumps will replace existing pumps within the existing effluent wet well. However, the pumps will be replaced with larger 30-inch column size and discharge flange vertical line shaft pumps. The existing 24-inch pump discharge piping will be replaced with 30-inch piping. The existing pump station manifold is a 42-inch pipe with 42- by 24-inch reducing tees. To keep the existing manifold in service, the existing reducing tees will be reused and a 30-by-24 reducer will be bolted directly to the existing manifold at the connection to each pump to the manifold. The additional head loss of these fittings at buildout flow (velocities of 11.8 feet per second) is 0.36 foot. The existing 42-inch manifold will remain and connect to the new 48-inch outfall piping.

Figure 7 shows the new 48-inch-diameter effluent pipeline system curves with one or more effluent pumps operating during 100-year flood river elevation (elevation 25.6 feet) conditions. These system curves assume HDPE piping is used for the two sections of the effluent pipeline where pipe material options are allowed. The figure also shows the existing 30-inch-diameter effluent pipeline with one pump operating. The system curves below depict the static head associated with the PUMP OFF elevation (24.18 feet).

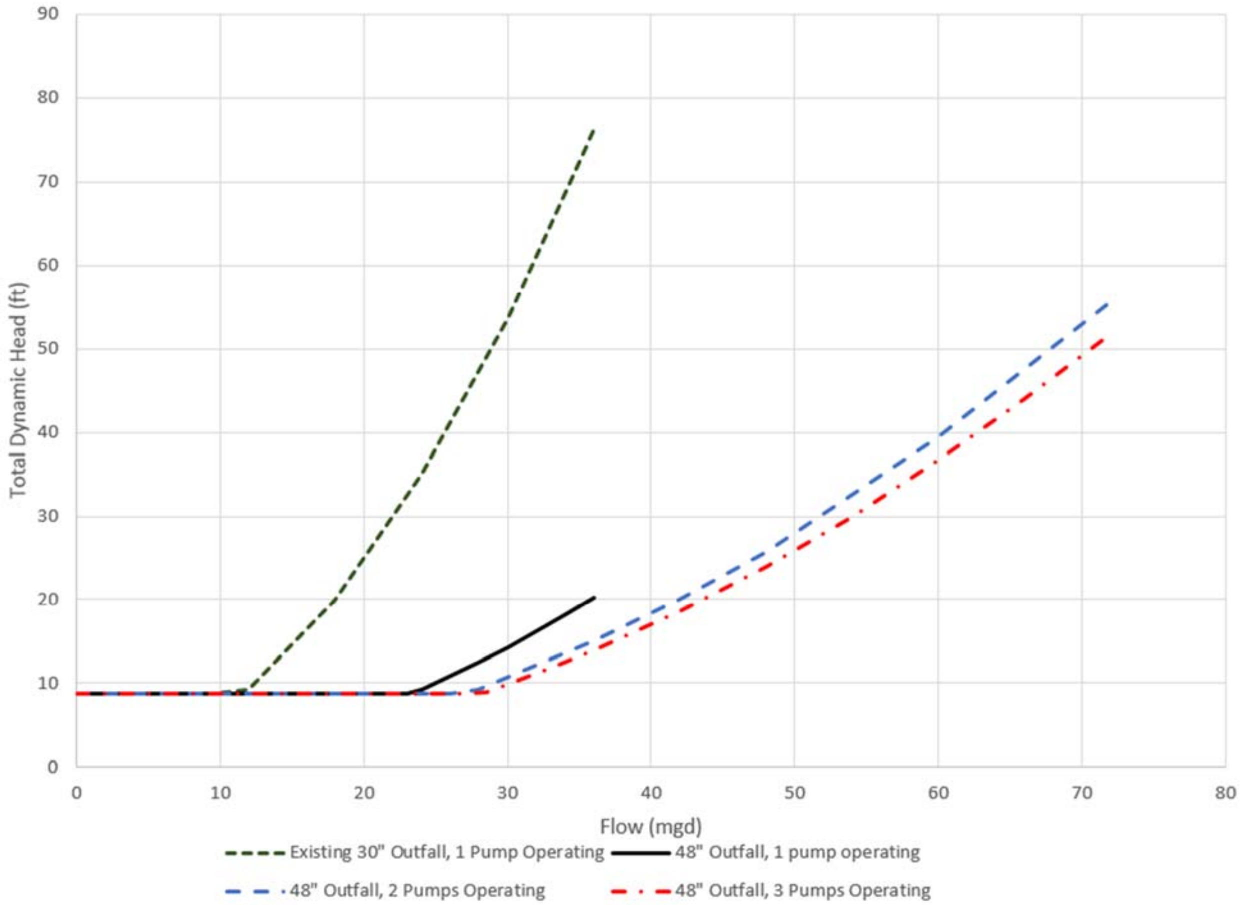

Figure 7. System Curves, New 48-Inch-Diameter and Existing 30-Inch-Diameter Pipelines
Assumes HDPE pipe sections

The minimum total dynamic head for the system curves shown in Figure 7 is 8.8 feet. This corresponds to a difference in the elevations of the centerline of the pump discharge piping (elevation 34.5 feet) and the LEAD PUMP ON elevation (25.7 feet). At this point, the effluent pumps lift the water up out of the wet well to discharge piping elevation where an air/vacuum valve will vent the pipe to atmosphere to avoid a vacuum condition and the liquid will flow by gravity through the effluent pipeline.

Table 4 shows the preliminary pump sections to be installed and commissioned with the new 48-inch-diameter effluent pipeline.

Table 4. Preliminary Pump Selections
Pump data

Item	Data
Pump make and model	Fairbanks Nijhuis 24-inch – 8312-30-inch
Total Number of pumps	4
Number Duty	3
Number Standby	1
Firm capacity (mgd)	3 pumps at 14.6 mgd each (43.8 total firm capacity)

Table 4. Preliminary Pump Selections
Pump data

Item	Data
Number of stages	2
Best efficiency point	89% @ 13.2 mgd
70% of best efficiency point capacity (mgd)	9.3
120% of best efficiency point capacity (mgd)	15.9
Motor size (horsepower)	75
Motor speed (revolutions per minute)	600
Pump column & discharge size (inches)	30
Pump bowl size (inches)	24
Discharge pipe and valve size (inches)	30

Figure 8 shows one pump operating at 100-year flood river elevation. Although the pump capacity at 50 percent speed is approximately 4 mgd, the minimum gravity capability at 100-year food conditions is lower yet (3 mgd). However, if the PUMP ON level is raised to elevation 26.3 feet, as stated above, the gravity capacity will be increased to 6 mgd. This overlap in gravity and minimum pump capacity will prevent effluent pump cycling and will provide a dead band between gravity and pumped effluent controls.

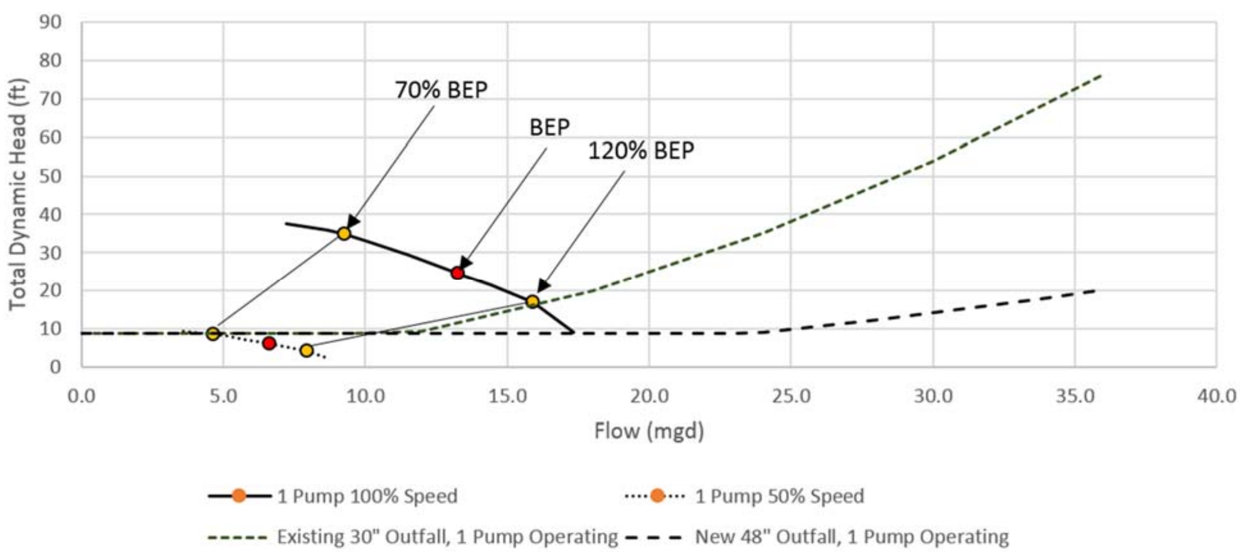

Figure 8. One Pump Operating
System curve assumes 100-year flood river elevation
BEP = best efficiency point

Figure 9 shows two pumps operating during 100-year flood river elevation conditions. The maximum capacity for two pumps running at 100 percent is approximately 33 mgd.

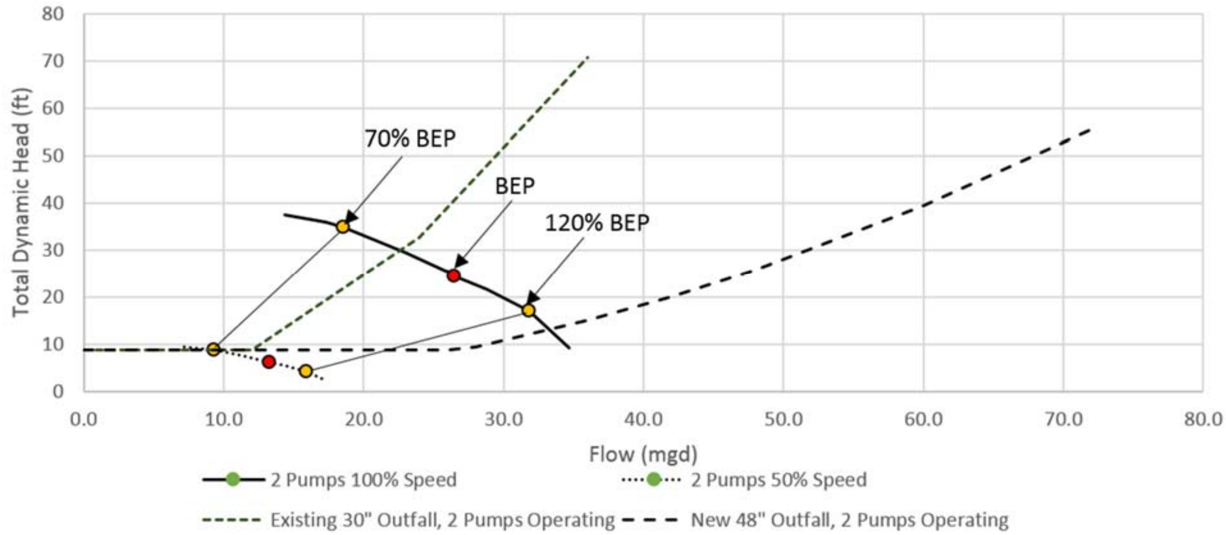

Figure 9. Two Pumps Operating
System curve assumes 100-year flood river elevation
BEP = best efficiency point

Figure 10 shows three pumps operating during 100-year flood elevation conditions. Maximum capacity of three pumps running at 100 percent is approximately 43.8 mgd with pump turn down approximately 15 mgd at 50 percent speed. This pump operating envelope is within the recommended 120 to 70 percent best efficiency point (BEP) flow range as shown.

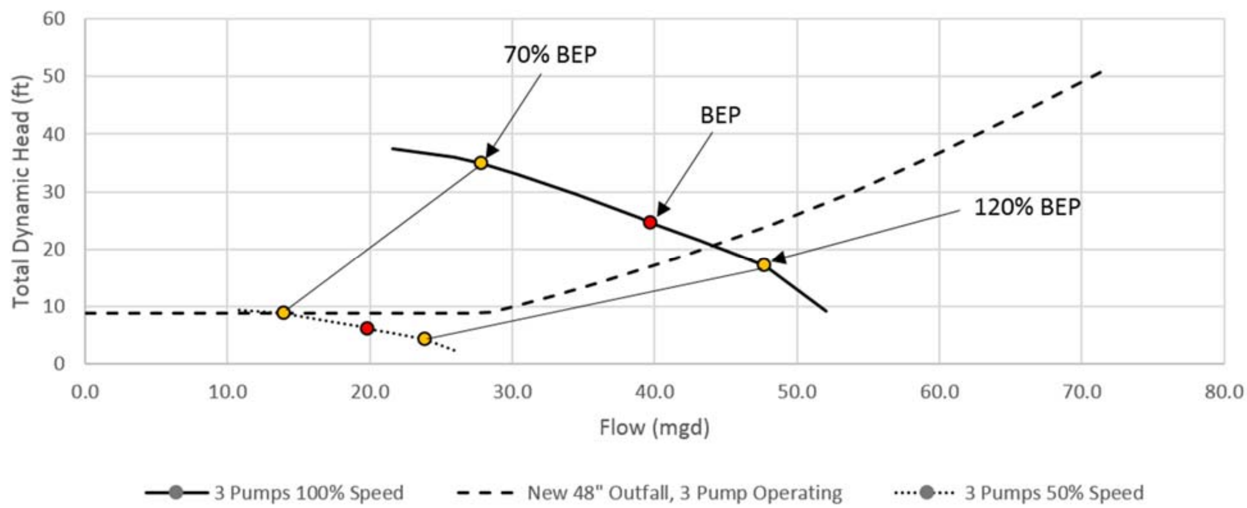

Figure 10. Three Pumps Operating
System curve assumes 100-year flood river elevation
BEP = best efficiency point

Pump Station Phasing

The four existing pumps will be replaced with new vertical line shaft pumps. The initial pump replacements will be four equally sized pumps with a firm capacity of 43.8 mgd. This will give the effluent pump station enough capacity through facilities plan Phases 5 (PHF 36 mgd) and 6 (PHF 43 mgd).

Beyond 43.8 mgd, two of the four pumps will be replaced with two larger pumps to provide firm capacity of 51.7 mgd. This is slightly less than required by facilities plan Phase 7 (PHF 54 mgd) and will have to be implemented earlier than facilities plan Phase 7. At flow rates beyond 51.7 mgd, the two smaller pumps (the two remaining pumps from the initial pump installation) will be replaced with two new pumps. These new pumps be equal in size to the existing pumps and will result in having four equally sized pumps with a pump station firm capacity of 64.3 mgd.

To increase the pump station firm capacity from 64.3 mgd to 72 mgd (Phase 9), two pumps will be replaced with two new larger pumps. The two other pumps will have their impellers and motors replaced with larger units. The two larger pumps will require a replacement of the 30-inch pump discharge to 36-inch. Also, at this time the existing 42-inch manifold will require enlarging the branch outlet of the tees from 24-inch to 36-inch, for the two larger pump connections. Table 5 shows the proposed pump station phasing improvements and equipment sizing.

Table 5. Pump Station Phasing

Proposed pump station phasing and equipment sizing

Facilities Plan Phase	**Phase 5**	**Phase 6**	**Phase 7**	**Phase 8**	**Phase 9**
Phase Years	**2020–2029**	**2029–2035**	**2035–2047**	**2047–2057**	**2057–2066**
Design Phasing Years	**2020–2035**		**2035–2045**	**2045–2056**	**2056–2066**
Pump station firm capacity (gpm) [mgd]	30,400 [43.8]		35,900 [51.7]	44,650 [64.3]	50,700 [73]
Small Pumps (two)					
Make Model	Fairbanks Nijhuis 24” - 8312-30”			Fairbanks Nijhuis 30” - 8312-30”	Fairbanks Nijhuis 30”- 8312-30”
Flow/pump (gpm) [mgd]	10,145 [14.6]		8,700 [12.5]	14,880 [21.4]	15,630 [22.5]
Total dynamic head (feet)	20.7		27.0	42	52.6
Motor speed (rpm)	600		600	600	600
Motor horsepower	75		75	200	250
Bowl Size (inches)	24		24	30	30
Pump column & discharge size (inches)	30		30	30	30
Discharge pipe and valve size (inches)	30		30	30	30
Large Pumps (two)					
Make Model	Fairbanks Nijhuis 24” - 8312-30”		Fairbanks Nijhuis 30”- 8312-30”		Fairbanks Nijhuis 30” - 8312-36”
Flow/pump (gpm) [mgd]	10,145 [14.6]		18,500 [26.7]	14,880 [21.4]	19,380 [28]
Total dynamic head (feet)	20.7		30.0	42	54
Motor speed (rpm)	600		600	600	600
Motor horsepower	75		200	200	300
Bowl size (inches)	24		30	30	30
Pump column & discharge size (inches)	30		30	30	36
Discharge pipe and valve size (inches)	30		30	30	36

gpm = gallons per minute

rpm = revolutions per minute

Replacing only two pumps at a time helps with the capital costs and construction sequencing; however, in two instances the installed pumps will be over 20 years old when they are finally replaced, requiring additional maintenance and upkeep of older equipment.

Figure 11 shows the effluent pump capacity by phase and year.

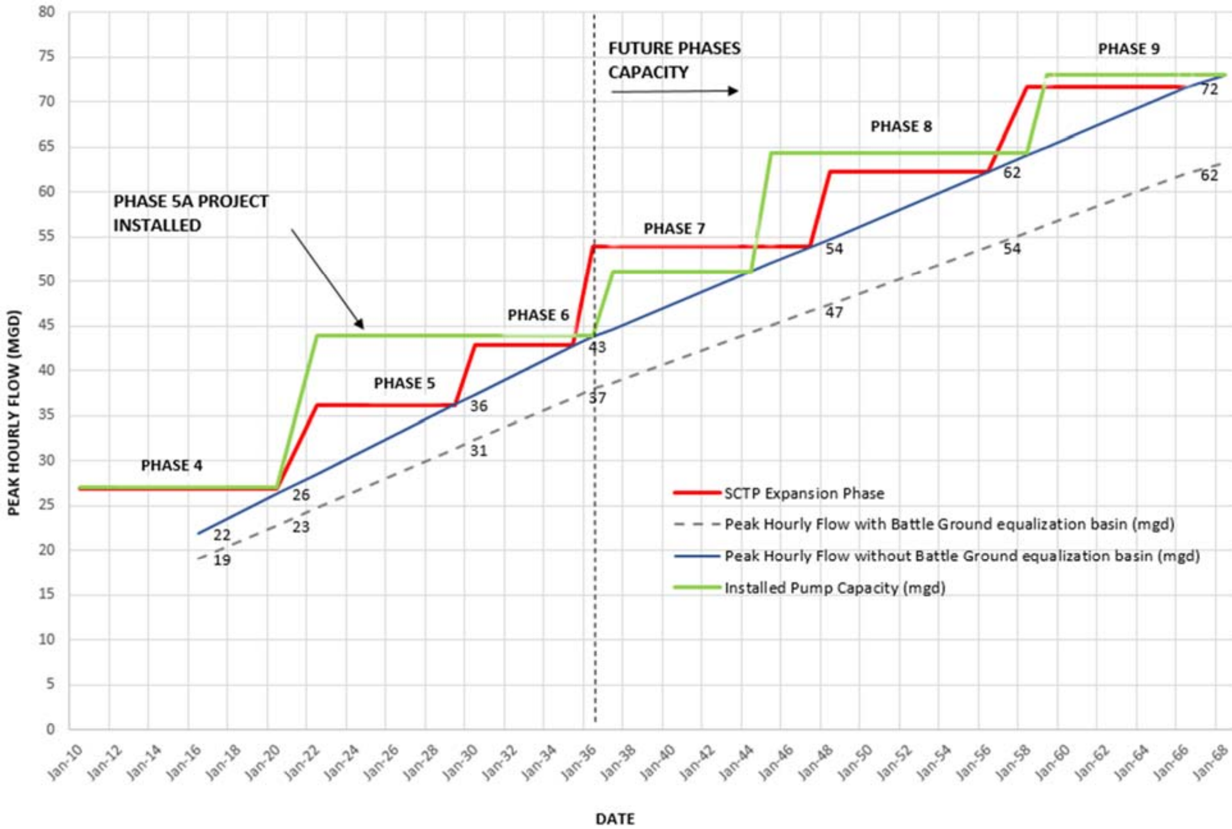

Figure 11. Effluent Pump Phasing Capacity
Pump station capacity by year

Electrical Modifications

Existing effluent pump conduits and conductors as well as the layout for pump variable frequency drives and motor control centers will require electrical evaluation during final design to determine if they can be reused for Phase 5B. The emergency generator will also be evaluated to ensure it can provide enough power for the new effluent pumps.

Control System Modifications

No modifications are anticipated to the existing effluent pump controls. Existing level sensors will remain. PUMP ON level set points should be adjusted as described above to ensure trouble free transition between gravity and pump effluent flow and prevent pump cycling during low flow high river conditions.

Construction Constraints

The pumps will be replaced one at a time to keep the pump station in service as all times. Pump replacement may be constrained during the dry weather season to ensure that gravity effluent flow is possible.