EXH. RJR-24C
DOCKET UE-22___/UG-22___
2022 PSE GENERAL RATE CASE
WITNESS: RONALD J. ROBERTS

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, Respondent.	Docket UE-22____ Docket UG-22____

TWENTY-THIRD EXHIBIT (CONFIDENTIAL) TO THE
PREFILED DIRECT TESTIMONY OF

RONALD J. ROBERTS

ON BEHALF OF PUGET SOUND ENERGY

REDACTED VERSION

JANUARY 31, 2022

From:	Criswell, Gordon D
To:	Brown, Shannon; Atwood, Nancy; Shawn Davis; Hagel, Josh; "Barnes, Michael (Mike.Barnes@northwestern.com)"; Wenke, Steve; Johanson, Mike
Cc:	Criswell, Gordon D; Dennehy, Neil J; Borsheim, Richard R; Lebsack, Dale; Obie, Damon D; Rork, John; "Arya Behbehani (Arya.Behbehani@pgn.com)"; "Mari Willis"; "Sullivan, Mary Gail"; Soyars, Darrell; Jensen, Steven; "Tucker, Jeff"; Wheatley, Eric; Brian Faist - Merchant; Brett Greene - Merchant; Richard George; Susan Hill; Tom Nilan
Subject:	Colstrip Dry Disposal Project - Response to Owners Information Request
Date:	Tuesday, January 26, 2021 1:09:25 PM
Attachments:	Attachment 1 - Dry Disposal Technical Overview.pdf Attachment 2 - Dry Disposal System Description.pdf Attachment 3 - Dry Disposal Preliminary Schedule 1-14-21.pdf Attachment 4 - Dry Disposal Project Payment Points 1-14-21.pdf Attachment 5 - Dry Disposal Project Summary of Costs 1-14-21.pdf Attachment 6 - Dry Disposal Project Technology Evaluation.pdf

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In addition to the information previously provided on the Colstrip 3&4 Dry Disposal project, and to follow-up on the remaining information requests, we are providing the following information:

- **Include a technical overview of the system (description/process schematic) to better understand the key components of the system**
  - Attachment 1 contains a technical overview and process schematic of the Dry Disposal project
  - Attachment 2 contains the Dry Disposal System description which provides more information on the key components of the system

- **Include a project schedule that highlights major milestones and project cost payment points**
  - Attachment 3 contains a project schedule that highlights major milestones
  - Attachment 4 contains project payment points known as of 1/14/21

- **Include a current summary of costs that details line items and anticipated timing of costs incurred, including costs already incurred, contingencies, and assumptions of contingencies**
  - Attachment 5 contains of summary of costs that details line items, costs incurred, and contingencies

- **Provide a description of the available technologies that were examined for feasibility**
  - Attachment 6 contains an evaluation of the available technologies. Key points from this evaluation include:
    - Per the Settlement, non-liquid material is defined as meeting the Paint Filter Test (24.5% moisture)
    - The transportable moisture limit (18.4%) is when the material behaves as a solid and will not liquify during transport and placement in the final disposal area
    - Colstrip's experience with pumping paste has not been reliable and has high O&M costs, therefore trucking was identified as the preferred disposal method.
    - During bench scale tests, it was determined that vacuum filtration could not meet the transportable moisture limit

        - Pressure filtration was determined to be the preferred technology and trucking was selected as the disposal method. Based on Colstrip's experience with pumping paste, the trucking disposal method was determined to be the most cost-effective overall and more reliable (the Settlement called for an 85% availability of non-liquid disposal)
        - Preliminary high-level cost estimates from this Technology Evaluation were for a simple filtration unit and did not include the complete design that was needed to incorporate the building, process tie points, detailed process implementation, and availability requirements

- **Review the potential of readdressing the Settlement conversion date**
    - This review effort is underway

As we previously identified, we expect to have the final Dry Disposal budget numbers by the end of February. Let me know if you have any questions.

Thanks,
Gordon Criswell

TALEN ENERGY

PATERSON & COOKE

Worley
energy | chemicals | resources

Paste Plant Dewatering Project

SYSTEM DESCRIPTION SUMMARY

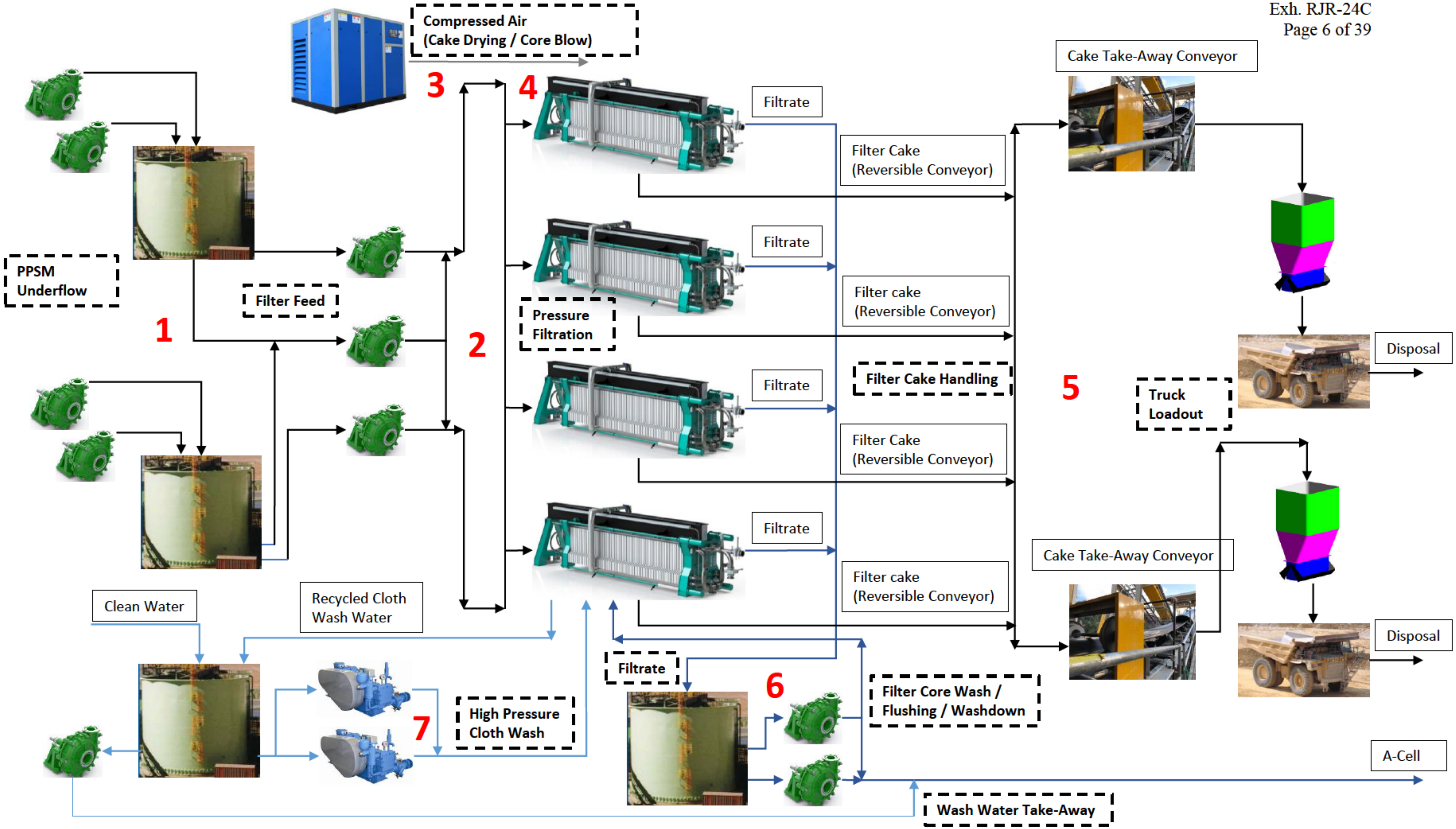
JANUARY 12, 2021

System Process Design Steps

1. Thickener underflow pumps located in the 3&4 Paste Plant will pump thickened scrubber slurry(approximately 60% solids) from the PPSM's to either of two agitated filter feed tanks. One filter feed tank and agitator will be operating, while the other tank and agitator will be standby for maintenance operations.
2. One operating filter feed pump will draw thickened scrubber slurry from the operating filter feed tank and pump the slurry to the recessed chamber pressure filters. Two of the filters will be operating and two will be standby. The filter feed pump will only feed one of the two operating filters at a time. When not feeding a filter, the pump will recirculate slurry to the feed tank. To reach the target cake moisture, the filtration cycle will have a form step followed by an air blow drying step.
3. An air compressor will provide compressed air to the filter air receiver. The filter cycles will be staggered to allow the air receiver to be recharged for the air blow drying step for the second operating filter.

System Process Design Steps

4. After the air blow drying step, a core wash and core blow cycle push the slurry from the pressure filter core. The core wash slurry is recycled back to the operating filter feed tank through an air separator. When the core wash and core blow are complete, the pressure filters will open to discharge the dry filter cake onto their respective under-filter conveyor.
5. The under-filter conveyors are reversible to transfer the filter cake to one of two takeaway conveyors depending on which take away conveyor is operating. The takeaway conveyor will then transfer the filter cake to their respective truck load out bin which will be used to load haul trucks for material disposal.
6. During the filtration cycle, the filtrate will gravity flow to the agitated filtrate tank. The filtrate return pumps deliver the filtrate to the Clearwell Pond (A Cell). The filtrate pumps will also utilize the filtrate during the core wash cycle and for plant washdown and flushing lines and pumps.
7. The filter clothes are cleaned using a high-pressure cloth wash. The wash water tank will be filled with clean water to be used in the cloth wash cycle. The water then gravity flows to a small settling tank to allow solids to settle before the water is reused in the cloth wash system.


Compressed Air
(Cake Drying / Core Blow)
3
4
Filtrate
Cake Take-Away Conveyor
Filter Cake
(Reversible Conveyor)
PPSM
Underflow
Filter Feed
1
2
Filtrate
Filter cake
(Reversible Conveyor)
Pressure
Filtration
Filtrate
Filter Cake Handling
5
Truck
Loadout
Disposal
Filter Cake
(Reversible Conveyor)
Filtrate
Filter cake
(Reversible Conveyor)
Cake Take-Away Conveyor
Disposal
Clean Water
Recycled Cloth
Wash Water
Filtrate
6
Filter Core Wash /
Flushing / Washdown
High Pressure
Cloth Wash
7
A-Cell
Wash Water Take-Away

TALEN ENERGY

Talen Colstrip Ash Dewatering – Process Design

P&C Project No.: TEC-31-1079

A	Oct 18, 2020	Issued for client comment	CTS/JPK	JMH	-
Rev No.	**Date**	**Description**	**Prepared**	**Reviewed**	**Reviewed**
			Originator		**Client**

Document Title

System Description

Document Number						
Office Code	**Project Code**	**Area Code**	**Disc. Code**	**Document Type**	**Seq. No.**	**Rev No.**
31	**1079**	**00**	**PR**	**REP**	**003**	**A**

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TERMS OF REFERENCE

This work has been conducted by Paterson & Cooke for Talen Energy under Order Number 658081. The proposal for this work was presented in P&C Proposal 31-1079-00-PM-PRP-001 Rev A dated January 14, 2020.

CONTENTS

1. INTRODUCTION

1.1 Project Background

The Colstrip power plant in Colstrip, Montana consists of two active coal-fired generating units, Unit 3 and 4, each with about 740 megawatts of capacity. Talen Energy (Talen) operates the plant and is pursuing dewatering upgrades to the fly ash disposal system. The existing fly ash dewatering system for Units 3 and 4 currently relies on paste thickening and pipeline transport with hydraulic piston pumps. Talen has retained Paterson & Cooke and Worley to design a filter plant to allow truck transport and dry disposal of the resulting filter cake.

1.2 Document Scope

The purpose of this document is to define the overall operating philosophy and functional specification for the filter plant. This document should be read in conjunction with the filter plant Process Flow Diagrams (PFD's) and Piping & Instrumentation Diagrams (P&ID's) referenced.

1.3 Battery Limits

Item	Battery Limits
Fly Ash	From the discharge flange of the thickened fly ash pump box in the paste plant area to the discharge of the truck load out bin feeder.
Process water	Process water will be drawn from a point on the existing plant distribution system / ring main as required for flushing in plant pipelines.
Clean cloth wash water	Clean water will be delivered to the Cloth Wash Water Tank
Well water	Well water will be delivered to the Cloth Wash Water Tank
Good quality water	Good quality water for pump seals and/or cooling systems water will be drawn from a point on the existing paste plant distribution system / ring main.
Electrical	Excluded (by Talen or Worley)
Instrumentation	All instrumentation required within the above battery limits is included in the scope of work.

1.4 Reference Documents

Table I: Reference Documents

Title	Document Number	Abbreviation
Talen Colstrip Ash Dewatering – Process Design: Design Criteria	31-1079-00-PR-DCB-001	P&C 01
Colstrip Ash Dewatering – Process Flow Diagrams (P&C):		P&C-02
▪ Filtration: Filter Feed	31-1079-10-PR-PFD-0001	
▪ Filtration: Pressure Filter 1 and 2	31-1079-10-PR-PFD-0002	
▪ Filtration: Pressure Filter 3 and 4	31-1079-10-PR-PFD-0003	
▪ Filtration: Filtrate and Wash	31-1079-10-PR-PFD-0004	
▪ Filter Cake Loading	31-1079-20-PR-PFD-0005	
▪ Air and Process Water	31-1079-30-PR-PFD-0006	
▪ Core Blow Air Separators	31-1079-30-PR-PFD-0007	
Colstrip Units 3SP Fly Ash Dewatering P. & I.D. (Worley):		WO-01
▪ Thickener Underflow Pumps	10676 M3-1795 (SHT 5)	
▪ Filter Feed Tank #1	10676 M3-1795 (SHT 6)	
▪ Filter Feed Tank #2	10676 M3-1795 (SHT 7)	
▪ Filter Feed Pumps	10676 M3-1795 (SHT 8)	
▪ Recessed Chamber Filter #1	10676 M3-1795 (SHT 9)	
▪ Recessed Chamber Filter #2	10676 M3-1795 (SHT 10)	
▪ Recessed Chamber Filter #3	10676 M3-1795 (SHT 11)	
▪ Recessed Chamber Filter #4	10676 M3-1795 (SHT 12)	
▪ Dirty Wash Water Settling Tank and Wash Water Tank	10676 M3-1795 (SHT 13)	
▪ Clean Filtrate Tank	10676 M3-1795 (SHT 14)	
▪ Clean Water Pumps	10676 M3-1795 (SHT 15)	
▪ Under Filter Reversible Conveyors	10676 M3-1795 (SHT 16)	
▪ Cake Loading System #1	10676 M3-1795 (SHT 17)	
▪ Cake Loading System #2	10676 M3-1795 (SHT 18)	
▪ Air System	10676 M3-1795 (SHT 19)	

1.5 Definitions

Process moisture content definition:	$\frac{M_s}{M_s+M_w+M_{salt}}$
	M_s = mass of tailings solids
	M_w = mass of water
	M_{salt} = mass of the dissolved salts
Solids	Suspended solids

1.6 Units

US customary units are used throughout the report. Where applicable units are also presented in metric as per industry standard.

%m	percentage by mass (solids concentration)
$(kg/h)/m^2$	kilograms per hour per square meter
$(lb/h)/ft^2$	pounds per hour per square foot
amsl	above mean sea level
ft	feet
hp	horsepower
psi	pounds per square inch
ACFM	actual cubic feet per minute
stph	US short tons per hour

The following abbreviations are used:

P&C	Paterson & Cooke
PPSM	Paste Production Storage Mechanism (commonly termed thickener)

2. DESIGN CRITERIA

The detailed design criteria used for the design of this system is shown in PC-01. The most pertinent aspect to the design of the system is the tonnage throughput and the thickener underflow concentration. The solids throughput is 97 stph, and the thickener underflow concentration ranges from 40%m to 60%m.

3. PROCESS DESCRIPTION

Thickener underflow pumps (3-SP-P-530A/B/C/D) (one operating and one standby for each PPSM) will pump thickened tailings to either of two agitated filter feed tanks (3-SP-T-531A/B). One filter feed tank and agitator will be operating, while the other tank and agitator are a standby. When the operating tank or agitator needs maintenance the thickener underflow will be redirected to the standby filter feed tank. Each filter feed tank has an approximately one hour residence time at 60%m underflow concentration.

One operating filter feed pump (3-SP-P-540A/B/C) will draw thickened tailings from the operating filter feed tank and pump the slurry to the recessed chamber pressure filters (3-SP-FP-501A/B/C/D). Two of the filters will be operating and two of them will be standby. The filter feed pump will only feed one of the two operating filters at a time. When not feeding a filter the pump will recirculate slurry to the feed tank. To reach the target cake moisture of 18%m, the filtration cycle will have a form step followed by an air blow dry step.

Air compressors (3-SP-G-560A/B), one operating and one standby, provide compressed air to the filter air receiver (3-SP-TG-560). The filter cycles will be staggered to allow the air receiver to be recharged for the air blow step for the second operating filter. Compresses air is also drawn from the filter air receiver for instrument air, dried through an instrument air dryer (3-SP-DY-561) and fed to the instrument air receiver (3-SP-TG-561). This instrument quality air is then used for the valves and instruments.

After the air blow dry step, a core wash and core blow cycle push the slurry core from the pressure filter. The core wash slurry is recycled back to the filter feed tank through an air separator (3-SP-CY-531A/B) above the operating filter feed tank. The air separator removes the compressed air from the slurry and dissipated energy to minimize splashing into the filter feed tank. When the core wash and blow is complete, the pressure filters will open to discharge the filter cake onto their respective under filter reversible conveyor (3-SP-BT-551A/B/C/D). The under filter conveyors are reversible to transfer the filter cake to one of two takeaway conveyors (3-SP-BT-556A/B) depending on which take away conveyor is operating. The takeaway conveyor will then transfer the filter cake their respective truck load out bin (3-SP-HP-556A/B).

During the filtration cycle, the filtrate will gravity flow to the agitated filtrate tank (3-SP-T-551). A turbidity meter on each filtrate line will determine if the filtrate is clean enough to pump to the clearwell pond. If the filtrate is too dirty likely indicating a torn filter cloth, the filtrate will be diverted to the operating filter feed tank. The filtrate return pumps (3-SP-P-511A/B) pump the filtrate to the clearwell pond to allow the solids to settle before the clean water is recycled to the power plant. The filtrate pumps will also utilize the filtrate during the core wash. During the filter core wash cycle, the filtrate will be redirected back through the filter to flush the core back into the filter feed tank.

At least once per day there will be a high-pressure cloth wash cycle. The wash water tank (3-SP-T-513) will be filled with clean water to be used in the cloth wash cycle. Cloth wash water pumps (3-SP-P-520A/B) pump the clean wash water to the operating filters during this cycle. The water then gravity flows back to a dirty wash water settling tank (3-SP-T-515) where most of the solids will be removed from the stream. The overflow from the settling tank will flow by gravity to the wash water tank. A screen filter before the wash water pumps will removed the remaining solids to protect the high-pressure pumps. A small clean water stream will feed the wash water tank to makeup the water that is lost during the wash cycle. Roughly every two weeks the tank will be emptied completely and refilled with clean water. This is due to an accumulation of dissolved salts in the water that is expected to occur.

Operating and standby sump pumps are located at the truck loadout area and filter area which typically send the sump water to the filter feed tanks. The sump discharge can also be directed to the filtrate tank.

4. SYSTEM DESCRIPTION

4.1 Thickener Underflow Pumps (3-SP-P-530A/B/C/D)

Four heavy duty centrifugal slurry thickener underflow pumps (3-SP-P-530A/B/C/D) (one operating and one standby per PPSM) are installed to feed thickened fly ash to the filter feed tank (3-SP-T-531A/B). Two pumps (one per PPSM) will operate on a continuous basis. The Warman 4/3 pumps are equipped with 10 hp motors and VFDs.

4.2 Filter Feed Tank (3-SP-T-531A/B)

The filter feed tanks (3-SP-T-531A/B) (one operating and one standby) are open-top, flat-bottom cylindrical tanks. The tank has a 16.5 ft diameter, a height of 32.5 ft and a live volume of 28,300 gallons. The tank is equipped with 4 baffles equally spaced.

4.3 Filter Feed Tank Agitator (3-SP-F-531A/B)

Each filter feed tank is equipped with a dual impeller agitator (3-SP-F-531A/B) (one with operating tank and one with standby tank) to maintain particle suspension and minimize settling of the fly ash slurry within the tank.

4.4 Filter Feed Pumps (3-SP-P-540A/B/C)

Three heavy duty centrifugal filter feed pumps (3-SP-P-1005/1006/1007) (one operating per tank and one shared standby) are installed to feed thickened fly ash to the pressure filters (3-SP-F-1001/1002/1003/1004). One pump operates on a continuous basis. Each filter feed tank has one dedicated filter feed pump piped to it with a third standby pump that can draw slurry from either tank via a manual changeover spool. The pump continues running between feeding the operating filters through a filter feed tank recycle loop to ensure that the feed line slurry stays in motion and avoid frequent stop/starts on the pump. The Warman 6/4 pumps are equipped with 250 hp motors and VFDs.

4.5 Pressure Filters (3-SP-FP-501A/B/C/D)

The Aqseptence GHT2000.P7 pressure filters (3-SP-FP-501A/B/C/D) (two operating and two standby) are sequential opening filter presses (vertical plate type) complete with 59 chambers and 78.7 inch x 78.7 inch plates. Each pressure filter has a 4,445.5 ft^2 filtration area and can produce a filter cake with a moisture content of 18% w/w at a maximum tonnage rate (dry) of 97 stph.

4.6 Under Filter Reversible Conveyors (3-SP-BT-551A/B/C/D)

Filter cake from each of the pressure filters discharges onto a dedicated filter cake collector conveyor (3-SP-BT-551A/B/C/D), seven feet in width. The conveyor hopper enclosed the cake on the belt as it drops from the filter. Each under filter conveyor is reversible for the filter cake to be deposited on either of the takeaway conveyors (3-SP-BT-1005/1006).

4.7 Takeaway Conveyor (3-SP-BT-556A/B)

Filter cake from the under filter reversible conveyors (3-SP-BT-551A/B/C/D) will deposit filter cake onto the operating takeaway conveyor (3-SP-BT-556A/B). The takeaway conveyor transfers filter cake to the truck load out bin (3-SP-BIN-1001/1002). The takeaway conveyor is horizontal while under the pressure filter to collect the cake. After the conveyor belt leaves the filtration building it is inclined to reach the top of the truck load out bin.

4.8 Truck Load Out Bin (3-SP-HP-556A/B)

The truck load out bins (3-SP-HP-556A/B) receive the filter cake from the takeaway conveyors. The truck load out bins will have a capacity of 100 tons at 80 lb/ft^3 which will give each bin about one hour of retention time.

4.9 Clamshell Style Gate (3-SP-CG-566A/B)

A clamshell style gate (3-SP-CG-566A/B) is used to control the discharge of cake from the truck load out bins. The gate will open to allow discharge from the bin into the haul trucks. Once the truck is full the gate will then close to allow the bin to refill.

4.10 Filtrate Tank (3-SP-T-551)

The filtrate tank (3-SP-T-551) receives the filtrate from the pressure filters. The tank has a 13.1 ft diameter, a height of 24.0 ft and a live volume of 16,400 gallons. The dirty wash water is pumped to the clearwell pond to allow the solids to settle before recycling the clean water.

4.11 Filtrate Tank Agitator (3-SP-F-551)

The filtrate tank is equipped with a single impeller agitator (3-SP-AG-1003) to maintain suspension of the solids should solids enter the tank.

4.12 Filtrate Return Pump (3-SP-P-511A/B)

The filtrate return pump (3-SP-P-511A/B) (one operating and one standby) sends filtrate from the filtrate tank to the clearwell pond. During the core wash cycle the filtrate return pump sends filtrate to the core of the filter to flush back to the filter feed tank. After the core wash cycle the flow is resumed to the clearwell pond. The Goulds pumps are equipped with 15 hp motors and VFDs.

4.13 Dirty Wash Water Settling Tank (3-SP-T-515)

The dirty wash water is fed by gravity to the dirty wash water settling tank (3-SP-T-1005). This settling tank removes most of the solids in the stream. Most solids will settle to the cone bottom which is emptied intermittently when necessary to the sump. The overflow of the settling tank flows by gravity to the wash water tank (3-SP-T-513).

4.14 Wash Water Tank (3-SP-T-513)

The wash water tank (3-SP-T-513) is filled with clean water to be used in the cloth was cycle. The tank has a 12.3 ft diameter, a height of 21.7 ft and a live volume of 12,700 gallons. A small stream of clean water is fed to the tank to account for water loses during the wash process. Dewatering well water is also piped to this tank to be used as a backup water supply.

4.15 Cloth Wash Pumps (3-SP-P-520A/B)

The cloth wash pumps (3-SP-P-520A/B) (one operating and one standby) provide cloth wash water to pressure filters for the cloth wash cycles. These triplex plunger pumps are high pressure pumps that deliver the cloth wash water at 725 psi equipped with 50 hp motors.

4.16 Wash Water Takeaway Pump (3-SP-P-513)

The wash water takeaway pump (3-SP-P-513) sends the finished wash water to "A Cell Pond". This pump will be utilized about every few weeks to drain and replenish the wash water tank with clean water.

4.17 Air Compressor (3-SP-G-560A/B)

Two air compressors (3-SP-G-560A/B), one operating and one standby provide compressed air for the air blow dry step as well as for instrumentation. Air will be drawn in from atmosphere to the compressor. The compressors supply 1,350 ACFM at 130 psi (derated) and are equipped with 350 hp motors

4.18 Filter Air Receiver (3-SP-TG-560)

A 14,600 gallon air receiver provides air storage for the filter air blow and for cake drying at the filters and supply for instrument air. Two main outlets from the filter air receiver (3-SP-TG-560) supply air directly to the pressure filters and to the instrument air dryer. The receiver is equipped with a vent silencer, pressure relief valve, drain, and pressure gauge.

4.19 Instrument Air Dryer (3-SP-DY-561)

An air dryer (3-SP-DY-561), is used to dry the discharge from the filter air receiver.

4.20 Instrument Air Receiver (3-SP-TG-561)

A 660 gallon air receiver provides air storage for dried instrument air. Similar to the filter air receiver, the instrument air receiver (3-SP-TG-561) is equipped with a vent silencer, pressure relief valve, drain, and pressure gauge.

4.21 Filtration Area Sump Pumps (3-SP-P-570A/B)

Two spillage sumps will collect spillage from the filtration area within the filtration plant. Spillages will be discharged into the operating filter feed tank using the filtrations area sump pumps (3-SP-P-570A/B).

4.22 Filter Cake Loading Area Sump Pump (3-SP-P-571A/B)

Two spillage sumps will collect spillage and wash down water from the filter cake loading area. Spillages will be pumped to the filtration area sump using filter cake loading area sump pumps (3-SP-P-571A/B).

4.23 Filter Feed GSW Pump (3-SP-P-541A/B)

The filter feed GSW pumps (3-SP-P-541A/B) one operating and one standby, will provide high pressure gland seal water to the filter feed pumps.

4.24 Overhead Crane (3-KF-L-518)

The overhead crane (3-KF-L-518)) in the filtration area will be used for the pressure filter installation as well as maintenance.

5. CONTROL PHILOSOPHY

5.1 Control System

The filter plant will be controlled by a central control room in the plant and a distributed control system (DCS) providing an operating interface and automated control structure. The pressure filters and other equipment will not have standalone PLCs.

5.2 Operating Philosophy

5.2.1 Thickener Underflow Pumping System

The PPSM underflow flow and density will be measured by a flow meter and densitometer and the underflow reports to either filter feed tank.

Controlling the thickening process is based upon controlling of solids inventory in the thickener tank. Controlling the PPSM solids inventory requires speed control of the underflow pumps to maintain a steady state mass of solids in the settled bed of the PPSM. If these two conditions can be achieved, the thickener will produce a consistent underflow density, rake torque and overflow clarity while minimizing flocculant consumption.

The PPSM underflow density will be maintained at the desired set point via manipulation of the underflow pump speed. The density target will be 55%m and if this value is surpassed, the flow meter will call for increased pump speed, thus drawing additional material out of the PPSM to reduce the density. Conversely if the density is below set point, the pump speed will decrease until the density rises. The discharge from the underflow pumps report to the filter feed tank.

5.2.2 Filter Feed System

Normally, one of the two filter feed tanks operate at a time. The operator selects the pump and filters to operate. Manual valves on the filter feed manifold direct slurry to the operating filters to reduce dead legs in the feed piping. Automated valves at the filter and recycle lines direct flow to the operating filter during the feed cycle or to recycle back to feed tank when the filters are performing other operations.

The filter feed tanks are equipped with a level sensor of which the High-High alarm is interlocked to the underflow pump system. The filter feed tank is equipped with a level sensor and its level will be maintained at as high a level as possible to provide buffer slurry to the filters as well as suction head for the filter feed pumps.

The filter feed pumps discharge valves are interlocked with the filter cycles to only allow feed to the filters once a filter is appropriately closed.

Feed to a closed filter will continue until the pressure setpoint is reached and held for a specific time at which point the feed valves are closed to stop feed to the filter. When no filter needs feed, the feed pump will slow and the recycle valve will open to direct slurry back to the operating filter feed tank. The filter will enter its air blow and plate opening cycles.

Although not envisioned for typical operations, the feed system is designed so both tanks and feed pumps can operate to feed more than two filters simultaneously if desired.

5.2.3 Pressure Filter System

Nominally, two of four installed filters operate at a time. The pressure filter mechanical and filtration operations are automated and controlled by the central filter plant control room.

Core wash is provided by the filtrate take away pumps. Core wash clears the filter core of slurry during the filters cycle. This is followed by the core blow in which compressed air pushes the core wash out of the filter. The core wash and blow is directed to either cyclone that sits over both filter feed tanks. The cyclone that sits over the currently operating filter feed tank is used for this operation.

A cloth wash is performed up to once per day per filter. This requires taking the filter offline.

5.2.4 Filtrate System

Filtrate flows from each filter by gravity to a turbidity meter (one per filter). If the turbidity meter indicates the filtrate is clear, the filtrate flows by gravity to the filtrate tank. If the filtrate is very dirty, likely caused by a cloth break, the filtrate for the cycle is directed to the filter feed tank and the filter is shut down for maintenance.

From the filtrate tank, the filtrate tank level is controlled by a filtrate takeaway pump. The takeaway pump will modulate to maintain a tank level. When a filter requests core wash, the filtrate will be directed to that filter.

When the pump is providing core wash, the pump will be controlled by a pressure gauge to maintain the correct pressure for core wash.

5.2.5 Compressed Air System

Compressed air is fed from the compressor to the filter air receiver. When the filter air receiver reaches maximum operating pressure, the air compressor is turned off. Although not required for normal operation, the standby compressor can supply air in parallel to the operating air compressor if the air receiver fails to maintain a minimum pressure.

The filter air receiver supplies compressed air to the pressure filters and instrument air receiver.

Before reaching the instrument air receiver, compressed air passes through the instrument air dryer. Dry air is fed to the instrument air receiver. The instrument air receiver supplies air to the filter plant and filter cake load out area.

5.2.6 Cloth Wash Water System

It is vital to keep high salt water and cake solids separate from the cloth wash water system as much as possible. Before a cloth wash begins, filters should be manually sprayed down with a hose to remove any large cake chunks that are left stuck to the filter cloth or drip tray. During this manual wash down, the drip trays will be closed and dirty wash water will be sent directly to the sump.

Cloth wash water is held in the cloth wash water tank. A conductivity meter on the tank will be used to monitor the salt content of the water. Clean water will be used to maintain a tank level.

As a standby, well water can also be used to supply water to the cloth wash water tank. The tank level is monitored using a presser gauge. When the water reaches a salt content that is deemed too salty, the tank is emptied using the centrifugal wash water takeaway pump. The rest is gravity drained into the sump. The tank is then refilled with clean water.

A high pressure cloth wash pump will provide cloth wash when a filter requests it to perform the automated cloth wash cycle

As the filter cloth is being cleaned, the drip trays are closed. Dirty wash water is directed to the settling tank. The overflow of the settling tank flows by gravity to the cloth wash water tank. Periodically, this settling tank much be emptied into the sump.

5.2.7 Conveyor System

The reversible under filter conveyors operate at a slow speed to evenly feed filter cake to either take away conveyor. The takeaway conveyors run at a fixed speed. Only one takeaway conveyor operates at a time. All conveyors are interlocked with belt rip, belt shift and pull cord switches.

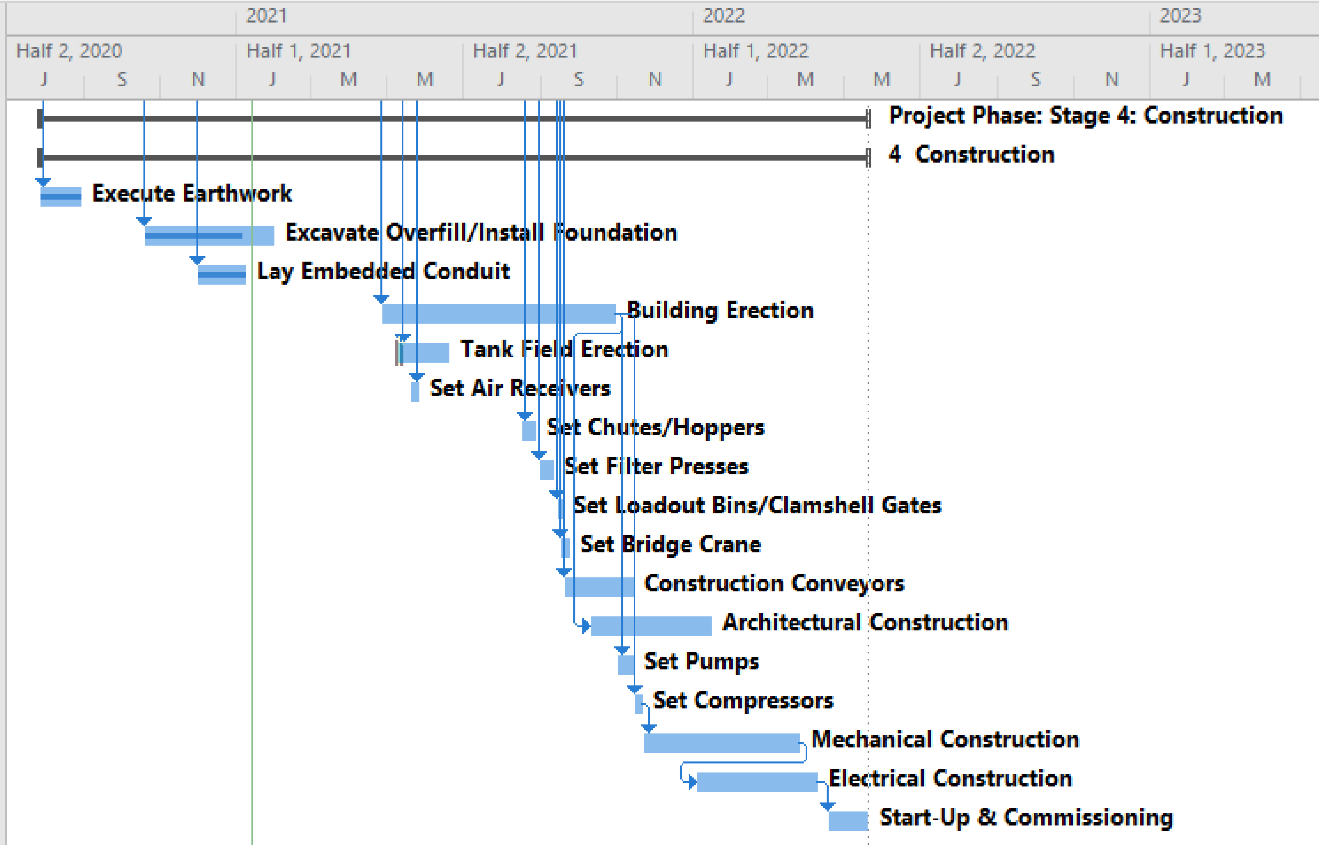
5.2.8 Cake Loadout System

Each loadout bin has a dedicated takeaway conveyor. The conveyor continues to run and fill the bin unless the high level limit from the bin level indicator is reached. The truck operator controls the clam shell gate to open and fill the truck and close to stop filling.

James Keat	**Jason Hamelehle**	**Casey Schmitt**
Graduate Engineer	Process Engineer	Senior Engineer

PRELIMINARY CONSTRUCTION SCHEDULE 1/14/21

Task Name	Duration	Start	Finish	% Complete
Project Phase: Stage 4: Construction	**475d**	**Mon 7/27/20**	**Fri 5/20/22**	**17%**
4 Construction	**475d**	**Mon 7/27/20**	**Fri 5/20/22**	**17%**
Execute Earthwork	**25 days**	**Mon 7/27/20**	**Fri 8/28/20**	**100%**
Excavate Overfill/Install Foundation	75 days	Mon 10/19/20	Fri 1/29/21	75%
Lay Embedded Conduit	**29 days**	**Mon 11/30/20**	**Thu 1/7/21**	**100%**
Building Erection	135 days	Mon 4/26/21	Fri 10/29/21	0%
Tank Field Erection	30 days	Mon 5/10/21	Fri 6/18/21	0%
Set Air Receivers	5 days	Wed 5/19/21	Tue 5/25/21	0%
Set Chutes/Hoppers	10 days	Mon 8/16/21	Fri 8/27/21	0%
Set Filter Presses	10 days	Mon 8/30/21	Fri 9/10/21	0%
Set Loadout Bins/Clamshell Gates	5 days	Mon 9/13/21	Fri 9/17/21	0%
Set Bridge Crane	5 days	Thu 9/16/21	Wed 9/22/21	0%
Construction Conveyors	40 days	Mon 9/20/21	Fri 11/12/21	0%
Architectural Construction	70 days	Mon 10/11/21	Fri 1/14/22	0%
Set Pumps	10 days	Mon 11/1/21	Fri 11/12/21	0%
Set Compressors	5 days	Mon 11/15/21	Fri 11/19/21	0%
Mechanical Construction	90 days	Mon 11/22/21	Fri 3/25/22	0%
Electrical Construction	70 days	Mon 1/3/22	Fri 4/8/22	0%
Start-Up & Commissioning	25 days	Mon 4/18/22	Fri 5/20/22	0%



Major Equipment Contracts In Place Payment Schedules 1/14/21

Filter Presses - [redacted] - Aqseptence			
15%	[redacted]	Contract Award	Jul. '20
20%		Receipt of Major Materials	Dec. '20
50%		Notice to Ship	Mar. '21
15%		Start-Up	Apr. '22

Bridge Crane - $[redacted] – Anderson Service			
30%	[redacted]	Contract Award	Nov. '20
30%		January 2021	Jan. '21
30%		Shipment to Site	May '21
10%		Final Acceptance	Oct. '21

Tanks - [redacted] - Affco			
50%	[redacted]	Contract Award	Dec. '20
20%		Drawing Approval	Feb. '21
20%		Shipment to Site	Apr. '21
10%		Final Acceptance	Jun. '21

Compressors - [redacted] Rogers Machinery			
30%	[redacted]	Contract Award	Dec. '20
20%		Approval of Submittals	Mar. '21
50%		Shipment to Site	Jul '21

Air Receiver - [redacted] – Arrow			
50%	[redacted]	Contract Award	Dec. '20
50%		Shipment to Site	May '21

REDACTED VERSION

Major Equipment Vendors Selected Proposed Payment Schedules 1/14/21

Conveyors - [redacted] - Masaba			
25%	[redacted]	Contract Award	Jan. '21
25%	$412,650	Approval of Drawings	Apr. '21
40%	$660,240	Notice to Ship	Aug. '21
10%	$165,060	Shipment to Site	Sept. '21

Slurry Pumps - $[redacted] - Schurco			
15%	[redacted]	Approval of Drawings	Mar. '21
25%		60 Days ARAD	Jul. '21
25%		120 Days ARAD	Sept. '21
35%		Shipment to Site	Oct. '21

Agitators - [redacted] - NOV
Payment Schedule To Be Determined

Filtrate Pumps - $85,000 – IME Solutions
Payment Schedule To Be Determined

Wash Water Takeaway Pump - $15,900 – Power Service
Payment Schedule To Be Determined

REDACTED VERSION

TALEN ENERGY

Worley
energy | chemicals | resources

Colstrip 3&4
Dry Disposal Project

PROJECT COST UPDATE

JANUARY 14, 2021

Preliminary Project Cost Estimate Summary 1/14/21

Project Cost Estimate Summary	
Project Total Without Contingency ($)	[redacted]
Contingency ($)	
Project Total With Contingency ($)	
Total Committed ($)	
Actuals to Date ($)	

REDACTED VERSION

Cost Estimate Status Summary – 1/14/21

- Budgetary Cost Information Received (~55% of total project estimated costs) - ~[redacted]
  - Dirt Work – Major Activities Complete
  - Foundation – Contract in Place
  - Building Material & Erection – Bid Received, Vendor Selected
  - Pumps – Bids Received on Major Pumps
  - Tanks/Agitators – Contracts in Place
  - Filter Press System – Contract in Place
  - Compressors – Contract in Place
  - Air Receiver – Contract in Place
  - Conveyor System – Bid Received, Vendor Selected
  - Bridge Crane – Contract in Place
  - Separators – Bids Received
  - Paste Plant Modifications – Contract in Place
  - FEED Engineering – Contracts in Place
- Estimated Costs (~45% of total project estimated costs) - ~[redacted]
  - Utility Power Upgrade (NWE) – Design Report and Cost Estimate Expected Jan. 2021
  - Building OH/Rollup/Hinged Doors – Bids Expected by end of Feb. 2021
  - Freight for Filter Presses – Budgetary Quotes Expected Feb. 2021
  - HVAC Equipment – Budgetary Quotes Expected Jan. 2021
  - Piping/Valves, Instrumentation, Electrical Materials – Budgetary Quotes Expected end of Feb. 2021
  - ME & EL Construction – Budgetary Quotes Expected end of Feb. 2021
  - Detail Engineering – Proposals Expected Feb. 2021

Summary of Costs – Committed/Actuals 1/14/21

REDACTED VERSION

Cost Line Item	Estimate ($)	Committed ($)	Actuals ($)	Comments
Earthwork	[redacted]	[redacted]	[redacted]	70% Complete – Dirt Work for Piping & Layout Down Area Remaining
Foundation	[redacted]	[redacted]	[redacted]	Contract in Place - 75% Complete
Utility Power Upgrade	[redacted]	[redacted]	[redacted]	Estimate Expected by End of January '21
Pumps	[redacted]	[redacted]	[redacted]	75% of Bids in Place
Tanks/Agitators	[redacted]	[redacted]	[redacted]	Contracts in Place
Building Material & Erection	[redacted]	[redacted]	[redacted]	Vendor Selected. Waiting on Contract
Building OH Doors/Install	[redacted]	[redacted]	[redacted]	Developing Bid Spec.
Filter Press System	[redacted]	[redacted]	[redacted]	Contract in Place
Compressors	[redacted]	[redacted]	[redacted]	Contract in Place
Air Receiver	[redacted]	[redacted]	[redacted]	Contract in Place
Conveyors/Chutes/Hoppers/Bins	[redacted]	[redacted]	[redacted]	Vendor Selected. Waiting on Contract
Bridge Crane	[redacted]	[redacted]	[redacted]	Contract in Place
Cyclone Separators	[redacted]	[redacted]	[redacted]	Evaluating Bids
HVAC Equipment	[redacted]	[redacted]	[redacted]	Design in Progress. Collecting Budgetary Quotes.
Misc. Equipment	[redacted]	[redacted]	[redacted]	Misc. Facility Equipment/Tools, HSE, Septic, Cistern, Wash Stations
Piping/Valves	[redacted]	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Instrumentation	[redacted]	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Electrical	[redacted]	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Paste Plant Modifications	[redacted]	[redacted]	[redacted]	Contract in Place
Engineering/Const. Management	[redacted]	[redacted]	[redacted]	55% Complete – Detail Eng. and Const. Mgmt. Support Remaining
Construction-Mechanical	[redacted]	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Construction-Electrical	[redacted]	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Freight	[redacted]	[redacted]	[redacted]	Shipment of Filter Presses– Budgetary Quotes Expected Feb. '21
Owner's Cost	[redacted]	[redacted]	[redacted]	Equipment Install Support Services, Misc. Support Tasks
Total	[redacted]	[redacted]	[redacted]	
Contingency	[redacted]			
Total With Contingency	[redacted]			

Shaded information is designated as CONFIDENTIAL per WAC 480-07-160

Summary of Costs w/Contingencies 1/14/21

REDACTED VERSION

Cost Line Item	Category	Estimate ($)	Contingency ($)	Comments
Earthwork	Labor	[redacted]	[redacted]	70% Complete – Dirt Work for Piping & Layout Down Area Remaining
Foundation	Material & Labor	[redacted]	[redacted]	Contract in Place - 75% Complete
Utility Power Upgrade	Material & Labor	[redacted]	[redacted]	Estimate Expected by End of January '21
Pumps	Equipment	[redacted]	[redacted]	75% of Bids in Place
Tanks/Agitators	Equipment	[redacted]	[redacted]	Contracts in Place
Building Material & Erection	Material & Labor	[redacted]	[redacted]	Vendor Selected. Waiting on Contract
Building OH Doors/Install	Material & Labor	[redacted]	[redacted]	Developing Bid Spec.
Filter Press System	Equipment	[redacted]	[redacted]	Contract in Place
Compressors	Equipment	[redacted]	[redacted]	Contract in Place
Air Receiver	Equipment	[redacted]	[redacted]	Contract in Place
Conveyors/Chutes/Hoppers/Bins	Equipment	[redacted]	[redacted]	Vendor Selected. Waiting on Contract
Bridge Crane	Equipment	[redacted]	[redacted]	Contract in Place
Cyclone Separators	Equipment	[redacted]	[redacted]	Evaluating Bids
HVAC Equipment	Equipment	[redacted]	[redacted]	Design in Progress. Collecting Budgetary Quotes.
Misc. Equipment	Equipment	[redacted]	[redacted]	Misc. Facility Equipment/Tools, HSE, Septic, Cistern, Wash Stations
Piping/Valves	Material	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Instrumentation	Material	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Electrical	Material	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Paste Plant Modifications	Material & Labor	[redacted]	[redacted]	Contract in Place
Engineering/Const. Management	Engineering	[redacted]	[redacted]	55% Complete – Detail Eng. and Const. Mgmt. Support Remaining
Construction-Mechanical	Labor	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Construction-Electrical	Labor	[redacted]	[redacted]	Budgetary Quotes Expected End of February '21
Freight	Freight	[redacted]	[redacted]	Shipment of Filter Presses– Budgetary Quotes Expected Feb. '21
Owner's Cost	Owner's Cost	[redacted]	[redacted]	Equipment Install Support Services, Misc. Support Tasks
Total		[redacted]	[redacted]	
Contingency		[redacted]		
Total With Contingency		[redacted]		

Shaded information is designated as CONFIDENTIAL per WAC 480-07-160

TECHNICAL NOTE			
To:	Talen Energy	From:	Jason Hamelehle
Att.:	Rick Borsheim	Tel No:	+1 303 800 6281
E-mail:	Richard.Borsheim@talenenergy.com	E-mail:	Jason.Hamelehle@PatersonCooke.com
Date:	November 13, 2019	Page:	Page 1 of 9
Proj. No:	TEC-31-1079	Doc No:	31-1079-00-PR-TEC-0002 Rev A

TALEN COLSTRIP FLY ASH DEWATERING: DEWATERING TRADE-OFF

1. INTRODUCTION

1.1 Background

Fly ash from power generation Units 3 and 4 of Talen Energy's (Talen) Colstrip Power Plant is currently thickened and deposited in cells adjacent to the paste thickener plant for disposal. Talen has committed to transitioning to dry disposal of fly ash by 2022. Meeting the new dry disposal standard will require modification to their current dewatering infrastructure and addition filtration and bulk handling equipment.

Talen has engaged Paterson & Cooke USA Ltd. (P&C) to perform test work and develop the process design for the fly ash dewatering system.

1.2 This Document

This document presents the results of a high-level tradeoff study evaluating three conceptual process options for fly ash disposal. One considers filtration with disposal as a dry cake. The other two feature a combination of thickening and filtration with disposal as a paste.

1.3 Document Revision History

A	Nov 13, 2019	Issued for client	JMH/CTS	JDW/RC	
Rev No.	**Date**	**Description**	**Prepared**	**Reviewed**	**Reviewed**
			Originator		**Client**

1.4 Reference Documents

The following documents are referenced in this report.

Title	Abbreviation
P&C Design Basis Document 31-1079-00-PR-DCB-001 Rev B, Oct 21, 2019.	P&C-01
P&C Technical Note 31-1079-00-PR-TEC-0002 Rev A, Talen Colstrip Fly Ash Dewatering: Interim Test Work Results, Nov 12, 2019	P&C-02

1.5 Units and Abbreviations

Metric units are used throughout the report.

The following definitions and abbreviations are used:

%m percentage by mass (solids concentration)

moisture It is important to note that different definitions for moisture content exist:

$$\theta_d = \left(\frac{\text{water mass}}{\text{solids mass}}\right) * 100$$

The process moisture content is calculated using:

$$\theta_w = \left(\frac{\text{water mass + salt mass}}{\text{water mass + solids mass + salt mass}}\right) * 100$$

The relationship between process and geotechnical moisture content is as

$$\theta_w = \frac{\theta_d}{100 + \theta_d}$$

Throughout this report only the process definition is used.

stph short ton per hour

stpd short ton per day

P&C Paterson & Cooke

Talen Talen Energy

TML transportable moisture limit

1.6 Design Basis

The full design basis is presented in the P&C Design Basis Document (P&C-01). Table I summarizes key elements relevant to the current trade off study.

Table I: Design Basis Summary

Item	Value / Description	Source / Comments
Slurry description	Fly ash filter cake	P&C-01
Solids throughput	Minimum value: 86 stph (max flow, min %m) Nominal value: 89 stph (nom flow nom %m) Maximum value: 97 stph (min flow, max %m)	P&C-01
Availability	95%	P&C-01
Design factor	15%	P&C design
Throughput	Maximum value = 97 stph / 95% availability = 102 stph Design value = 102 stph × 15% design factor = 117 stph	Calculation
Filter cake transportable moisture limit	18.4%m moisture	P&C-02
Paint filter test concentration	24.5%m moisture	P&C-02

1.7 Battery Limits

Table II lists the battery limits for the trade off study.

Table II: Battery Limits

Item	Battery Limits
Fly Ash	From the discharge to the filter feed tank to the discharge point for transport to tailings facility.
Process water	Process water will be drawn from a point on the plant distribution system / ring main (Process water may be required for flushing or control aspects, such as dilution).
Good quality water	Good quality water for pump seals and/or cooling systems water will be drawn from a point on the plant distribution system / ring main.

2. OPTION DESCRIPTIONS

P&C performed exploratory filtration test work conducted on a fly ash sample from the Colstrip Power Plant. (P&C-02). Two moisture content targets for the dewatered fly ash were developed from this work:

(1) 24.5%m – Paint filter test (minimum regulatory requirement)

(2) 18.4%m – Transportable moisture limit (TML)

At 18.4%m and below, the material behaves as a solid and will not liquify during transport and placement. However, at 24.5%m the fly ash is a paste consistency with an approximate yield stress 125 Pa and is transportable by pump and pipeline. In this case it may be possible to filter and recombine a fraction of the total fly ash stream to produce a paste for disposal.

Results from exploratory test work also showed that pressure filtration with an air blow sequence incorporated into the overall cycle was required to achieve moisture levels below the TML. Pressure filters are required for any option including trucking or conveying in the disposal process. This is considered the baseline option.

With no air blow step, pressure filtration achieved moisture levels below the paint filter test minimum. Vacuum filtration produced similar results. These methods cannot be used for options with trucking but could be used in paste applications. Two options were developed based on this consideration.

2.1 Option 1: Pressure Filtration and Trucking (Baseline)

Thickener underflow from the existing paste production storage mechanism (PPSM) units is pumped to the filter feed tanks using new centrifugal pumps. The fly ash slurry is then filtered in two pressure filters with each incorporating an air blow step to achieve moisture levels at or below the TML. The cakes are taken away via conveyor to a truck load out bin.

2.2 Option 2A: Pressure Filtration and Paste Pumping

Thickener underflow from the existing paste production storage mechanism (PPSM) units is pumped to the filter feed tanks using new centrifugal pumps. The fly ash slurry is then filtered in two pressure filters. Air blow steps are not incorporated in the overall filter process and the resulting cakes moisture levels are above the TML. The filter cakes are transferred via conveyor to a continuous paste mixer where they are diluted to a paste consistency using unfiltered fly ash slurry. The resulting paste is pumped to the TSF using the paste pumps relocated from the thickener underflow.

2.3 Option 2B: Vacuum Belt Filtration and Paste Pumping

Thickener underflow from the existing paste production storage mechanism (PPSM) units is pumped to the filter feed tanks using new centrifugal pumps. The fly ash slurry is then filtered in using two vacuum belt filters. The resulting cakes moisture levels are above the TML. The filter cakes are transferred via conveyor to a continuous paste mixer where they are diluted to a paste consistency using unfiltered fly ash slurry. The resulting paste is pumped to the TSF using the paste pumps relocated from the thickener underflow.

3. PRELIMINARY MAJOR EQUIPMENT COST ESTIMATES

Preliminary cost estimates for equipment requirements were developed to compare the options. The cost estimates are based on preliminary test work and estimates using past projects and are at a conceptual level suitable for comparison. Costs for thickener upgrades and minor equipment are normally common to all options and were not considered in the estimates. Additionally, costs for haul trucks were not considered. Table III to Table V present the cost estimates for each option and Table VI summarizes the overall totals.

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Table III: Option 1 Preliminary Equipment Cost Estimate Details

Equipment Name	**Equipment Description**	**Unit Cost**	**Number Installed**	**Total Equipment Cost (USD)**
Underflow pump	93 m^3/hr, 12 m head	[redacted]	2	[redacted]
Filter feed tank and agitator	60 min retention time	[redacted]	1	[redacted]
Recessed chamber pressure filters	325 m^2 recessed chamber pressure filter	[redacted]	2	[redacted]
Air compressors	Atlas Copco GA 315	[redacted]	2	[redacted]
Air receivers	94 m^3, 1030 kPa	[redacted]	2	[redacted]
Filter feed pumps	Up to 318 m^3/hr, up to 90 m head	[redacted]	2	[redacted]
Cake receiving conveyors	1200 mm wide, 20 m long	[redacted]	2	[redacted]
Take away conveyor	750 mm wide, 50 m long	[redacted]	1	[redacted]
Loadout bin and feeder	1 hr retention time, feeder will depend on truck size and quantity	[redacted]	1	[redacted]

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Table IV: Option 2A Preliminary Equipment Cost Estimate Details

Equipment Name	**Equipment Description**	**Unit Cost**	**Number Installed**	**Total Equipment Cost (USD)**
Underflow pump	93 m^3/hr, 12 m head	[redacted]	2	[redacted]
Filter feed tank and agitator	60 min retention time	[redacted]	1	[redacted]
Recessed chamber pressure filters	200 m^2 recessed chamber pressure filter	[redacted]	2	[redacted]
Filter feed pumps	Up to 318 m^3/hr, up to 40 m head	[redacted]	2	[redacted]
Cake receiving conveyors	1200 mm, 14 m long	[redacted]	2	[redacted]
Cake lump breaker	Breaks up filter cake before paste mixing	[redacted]	2	[redacted]
Take away conveyor	1000 mm wide, 10 m long, with weigh scale	[redacted]	1	[redacted]
Paste dilution pump	Slurry pump	[redacted]	2	[redacted]
Paste mixer	Continuous, 2.5 min retention time	[redacted]	1	[redacted]

Table V: Option 2B Preliminary Equipment Cost Estimate Details

Equipment Name	Equipment Description	Unit Cost	Number Installed	Total Equipment Cost (USD)
Underflow pump	93 m^3/hr, 12 m head	[redacted]	2	[redacted]
Filter feed tank and agitator	60 min retention time	[redacted]	1	[redacted]
Vacuum belt filter	110 m^2 vacuum belt filter	[redacted]	2	[redacted]
Vacuum pump	300 kW vacuum pump	[redacted]	2	[redacted]
Air receivers	For water and air separation	[redacted]	2	[redacted]
Filter feed pumps	47 m^3/hr, up to 15 m head	[redacted]	2	[redacted]
Take away conveyor	1000 mm wide, 10 m long, with weigh scale	[redacted]	1	[redacted]
Paste mixer	Continuous, 2.5 min retention time	[redacted]	1	[redacted]

Table VI: Preliminary Major Equipment Cost Estimates

Item	Cost Estimate (USD)
Option 1: Pressure Filtration and Cake Trucking	[redacted]
Option 2A: Pressure Filtration and Paste Pumping,	[redacted]
Option 2B: Vacuum Belt Filtration and Paste Pumping,	[redacted]

4. SUMMARY

Pressure filters are required for any option including trucking or conveying in the disposal process. This is considered the baseline option. Inspection of Table VI shows that costs for vacuum filtration and paste pumping option are considerably higher than the baseline. This is driven primarily by the size of filters required to achieve moisture levels below the paint filter target. A paste option using pressure filters is technically viable and could result in capital and operating cost savings based on high-level comparisons.

P&C will review the presented alternatives with Talen and Worley to select a preferred option and continue with detailed pressure filtration test work to determine the optimal chamber size and sequence times to support equipment selection and preliminary design.

Jason Hamelehle
Process Engineer

Casey Schmitt
Senior Engineer