Initial Certification Statement Supporting the Discharge of Bottom Ash Transport Water

Arizona Public Service Company

Four Corners Generating Station
NPDES Permit No. NN0000019

Project No. 129532 / FCC016494

Revision 1
June 2024

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Prepared for

Arizona Public Service Company
Four Corners Generating Station
NPDES Permit No. NN0000019

Project No. 129532 / FCC016494
Fruitland, NM

Revision 1
June 2024

Prepared by

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Kansas City, Missouri

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Certification

I hereby certify, as a Professional Engineer in the State of New Mexico, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Arizona Public Service Company or others without specific verification or adaptation by the Engineer. I hereby certify that this initial certification was prepared for the Arizona Public Service Company's Four Corners Generating Station in accordance with standard engineering practices and based on my knowledge, information, and belief, the content of this Certification when developed in June 2024 is true and meets the requirements of 40 CFR § 423.19(c). I hereby certify that I am familiar with the ELG regulation requirements and Arizona Public Service Company's Four Corners Generating Station.

Bryan Hansen Digitally signed by Bryan Hansen Date: 2024.06.28 14:57:38-05'00'

Bryan D. Hansen, P.E.
(New Mexico License No. 23480)

Date: June 28, 2024

Owner’s Certification of Compliance - 40 CFR 122.22

Pursuant to 40 CFR 122.22, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

On behalf of Arizona Public Service Company:

Michael Hancock
(Printed Name)
Manager, Four Corners Power Plant
(Title)
June 28, 2024
(Date)

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
APS	Arizona Public Service Company
BA	Bottom Ash
BASWR	Bottom Ash Sluice Water Recycling
BAT	Best Available Technology Economically Achievable
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
ELG Rule	Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category
EPA	U.S. Environmental Protection Agency
FGD	Flue Gas Desulfurization
Four Corners	Four Corners Generating Station
gpm	gallons per minute
L-SI	Larson-Skold Index
LSI	Langelier Scaling Index
MW	Megawatt
NPDES	National Pollutant Discharge Elimination System
PSI	Puckorius Scaling Index
RSI	Ryznar Scaling Index
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

1.0 INTRODUCTION

On November 3, 2015, the U.S. Environmental Protection Agency (EPA) issued the federal Steam Electric Power Generating Effluent Limit Guidelines and Standards (ELGs); see 80 FR 67838. The 2015 rule addressed discharges from flue gas desulfurization (FGD) wastewater, fly ash transport water, bottom ash (BA) transport water, flue gas mercury control wastewater, gasification wastewater, combustion residual leachate, and non-chemical metal cleaning wastes.

The 2015 ELG Rule was reconsidered by EPA, with updates finalized on October 13, 2020 (see 85 FR 64650), and effective as of December 14, 2020. The 2020 ELG Rule revises limitations and standards for two of the waste streams addressed in the 2015 rule: BA transport water and FGD wastewater. For BA transport water, the final rule establishes Best Available Technology Economically Achievable (BAT) as a high recycle rate system with a site-specific volumetric purge (defined in the final rule as BA purge water) which cannot exceed a 30-day rolling average of 10 percent of the BA transport water system's primary active wetted volume. The purge volume and associated effluent limitations are to be established by the permitting authority. EPA selected a 95th percentile of total system volume as representative of a 30-day rolling average, which results in a limitation of 10 percent of total system volume and requires the National Pollutant Discharge Elimination System (NPDES) permitting authority to develop a site-specific purge percentage that is capped at 10 percent. EPA recognizes that some plants may need to improve their equipment, process controls, and/or operations to consistently meet the limitations included in this final rule; however, this is consistent with the Clean Water Act, which requires that BAT discharge limitations and standards reflect the best available technology economically achievable.

This document serves as a finalized version of the Initial Certification Statement required by 40 CFR § 423.19(c)(1) supporting a permit modification request made in January of 2021 pursuant to the 2020 ELG Rule. On behalf of Arizona Public Service Company (APS), this initial certification supports the discharge of BA transport water pursuant to 40 Code of Federal Regulations (CFR) § 423.13(k)(2)(i) at the Four Corners Generating Station (Four Corners), located in San Juan County, New Mexico in accordance with NPDES Permit NN0000019 (modified on December 1, 2023). As required by the ELG Rule, this plan includes the following:

A. A statement that the professional engineer is a licensed professional engineer.
B. A statement that the professional engineer is familiar with the regulation requirements.
C. A statement that the professional engineer is familiar with the facility.

D. A calculation of the primary active wetted bottom ash system volume as required per 40 CFR § 423.11(aa).

E. Material assumptions, information, and calculations used by the certifying professional engineer to determine the primary active wetted bottom ash system volume.

F. A list of all potential discharges under 40 CFR § 423.13(k)(2)(i)(A)(1) through (4), the expected volume of each discharge, and the expected frequency of each discharge.

G. Material assumptions, information, and calculations used by the certifying professional engineer to determine the expected volume and frequency of each discharge, including a narrative discussion of why such water cannot be managed within the system and must be discharged.

H. A list of all wastewater treatment systems at the facility currently, or otherwise required by a date certain under this section.

I. A narrative discussion of each treatment system including the system type, design capacity, and current or expected operation.

The Four Corners Generating Station is a coal-fired mine-mouth generating plant located on the Navajo Indian Reservation near Fruitland, NM. The plant includes two 770-Megawatt (MW) coal-fired units (Units 4 and 5). Four Corner's original once-thru sluicing system has been replaced with a new BAT high recycle system which utilizes wet sluicing to transport bottom ash through a hydrobin and Bottom Ash Sluice Water Recycling (BASWR) settling tank system to dewater the bottom ash. The system cannot be operated as a closed loop without significant water balance, scaling, corrosion, and maintenance challenges and should be operated as a high recycle rate system with the allowed purge to alleviate these concerns. **APS is requesting to purge up to 10 percent of the total system volume (up to 459,435 gallons per day on a 30-day rolling average basis) to maintain water balance, address system water chemistry, and conduct maintenance as allowed under 40 CFR § 423.13(k)(2)(i)(A) for the initial 6 months of startup activities and up to 2.5 percent of the total system volume (up to 114,859 gallons per day on a 30-day rolling average basis) thereafter.**

2.0 HIGH RECYCLE SYSTEM DESCRIPTION

As required by 40 CFR § 423.19(c)(3)(D) through (I), the following is a description of the bottom ash system at Four Corners, including the assumptions, information, and calculations used by the certifying professional engineer to determine the primary active wetted bottom ash system volume and the expected volume and frequency of each discharge. This section also includes a description of the wastewater treatment systems at Four Corners.

2.1 Bottom Ash System Description

After combustion, ash that accumulates in the bottom of the boiler is captured in the ash hoppers located directly beneath the boiler. Bottom ash is then crushed into small pieces by the clinker grinders and sluiced by jet pumps to a series of unit processes designed to separate the bottom ash from the transport water. The original once-thru sluicing system discharged after treatment to an internal outfall identified in the facility's NPDES permit. Following the conversion to a the high recycle bottom ash system, the bottom ash transport water is treated and recycled for reuse in BA sluicing operations.

The major process equipment in the high recycle bottom ash system at Four Corners consists of the following:

- Two (2) original ash hoppers with multiple compartments, one per unit
- Eight (8) original pyrites tanks per unit, sixteen (16) total
- Four (4) original hydrobins
- Two (2) new hydrobin overflow tanks
- Four (4) new hydrobin overflow tank agitators, two per tank
- Three (3) new hydrobin overflow return pumps
- Three (3) sumps, two new and one existing
- Three (3) new boiler area sump pumps
- Three (3) new hydrobin area sump pumps
- The original BASWR settling tank system consisting of:
    - One (1) primary settling basin
    - Two (2) secondary settling basins
    - One (1) clearwell chamber
- Two (2) new sluice water pumps
- Two (2) new flush water pumps
- One (1) new low volume wastewater settling tank

- Two (2) new bottom ash system makeup pumps
- One (1) original makeup water storage tank

Appendix A contains a schematic overview of the high recycle rate bottom ash sluicing system's major components and interfaces with other plant systems. The hydrobin overflow tanks and two (2) of the sumps are new. In addition to these new process units, plant modifications isolated many of the currently permitted low volume wastewater flows at the facility from the existing BA sluicing system and directed these segregated flows to a new low volume wastewater treatment system prior to discharge through the facility's NPDES permit (see Section 2.4).

The sluiced bottom ash will be initially treated with hydrobins, allowing dewatered bottom ash to be discharged into trucks prior to being hauled to the site Coal Combustion Residuals (CCR) landfill or hauled offsite for beneficial reuse. The four (4) original hydrobins will be operated sequentially with a single hydrobin receiving sluiced ash from both units until it is full. Once a hydrobin is full, the next hydrobin will be placed into service, and the full hydrobin will be allowed to decant for 10-12 hours prior to discharging ash to the trucks. Hydrobins will be continuously cycled to allow for filling to capacity, decanting, and unloading to maintain the system in operation. The two (2) new 111,000-gallon hydrobin overflow tanks (plumbed in parallel) will receive intermittent overflow from the hydrobins during sluicing operations. The new hydrobin overflow tanks represent the only surge capacity within the system other than the freeboard available in the BASWR. The surge capacity in the system provided by the new hydrobin overflow tanks is needed to allow for operational flexibility in responding to system upset conditions, equipment failures, and stormwater inflow without having to discharge sluice water from the system or cause a plant outage.

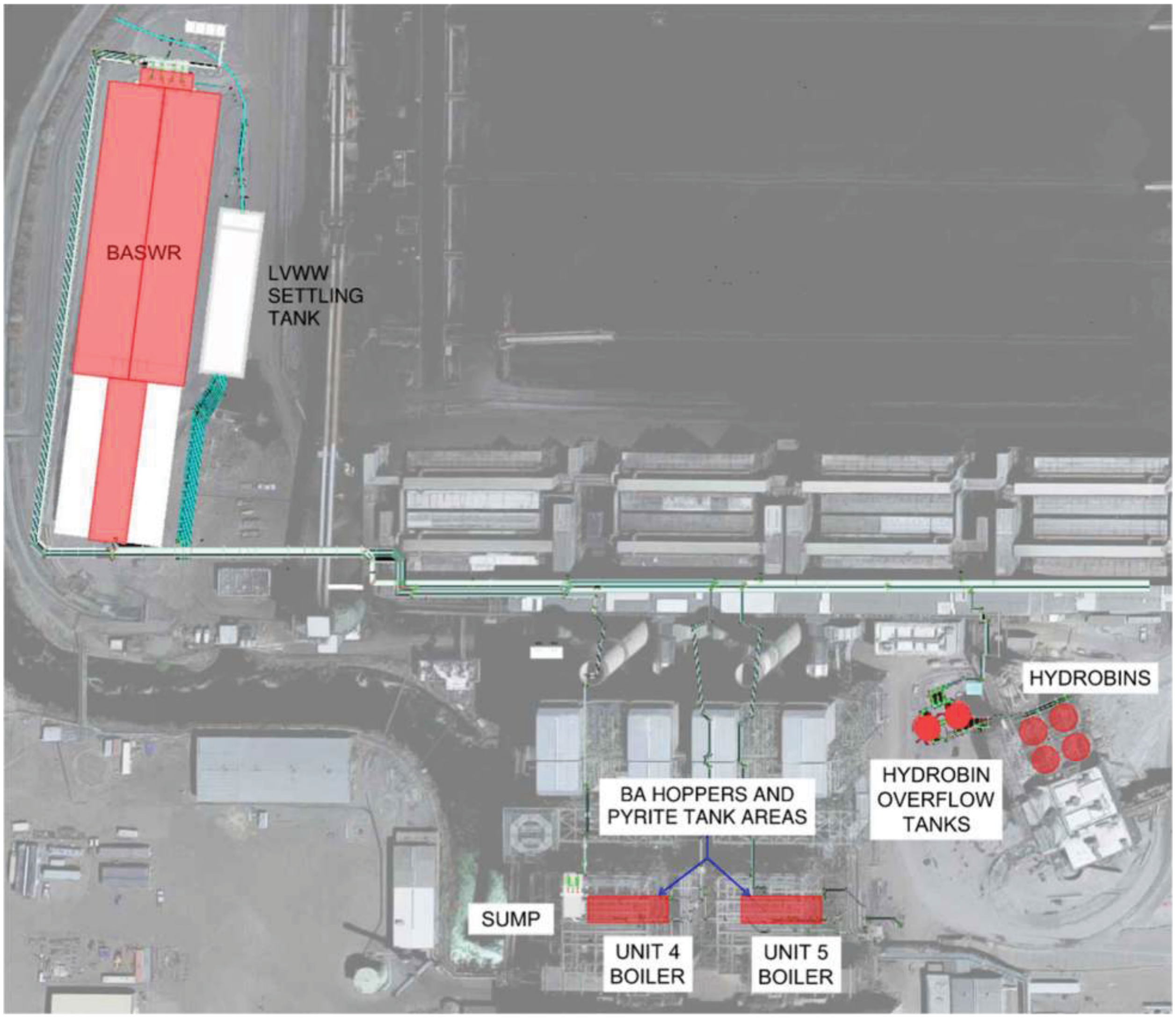
Bottom ash will also be mechanically removed from the BASWR settling tank system, loaded into trucks, and hauled to the site CCR landfill. The BASWR settling tank system is a reinforced concrete (free-standing) structure comprised of a single primary settling basin that discharges into two adjacent secondary settling basins operated in parallel that overflow into a clearwell chamber. The treated transport water that overflows into the clearwell will then be pumped back to the boiler hoppers for re-use.

Due to proximity and level of effort to segregate flows, seal trough water for the bottom ash hoppers will be routed with bottom ash hopper overflow to the bottom ash system even though it is technically not bottom ash transport water. The seal trough water will be sourced from the bottom ash loop water and will not add additional fresh water to the system.

As part of the design of the bottom ash high recycle system, APS identified all non-bottom ash transport flows that were originally combined with bottom ash transport water in the original once-thru sluicing system. The intent of this analysis was to segregate low volume wastewater from the high recycle rate bottom ash system to simplify process operations and promote reliability. In addition to the seal trough water previously discussed, wastewater flows generated during cleaning events in the baghouse enclosure were identified as a waste stream that should not be directed to a low volume wastewater system due the high total suspended solids content and variable nature of flows which could lead to performance issues in the low volume wastewater treatment system. On this basis, the baghouse enclosure sump waste stream was routed to the bottom ash system. Routing of this wastewater into the bottom ash system with treatment in the BASWR tank system allows for efficient removal of these suspended solids. Washdown of the baghouse area is an infrequent operation, so it does not substantially contribute to the solids loading in the BASWR tank system.

The site plan below and in Appendix E includes a general overview of the major equipment included in the high-recycle bottom ash system design.

Figure 2-1: Site Plan Showing Major System Components



To determine the Four Corners primary active wetted system volume, calculations were performed based on the major equipment and piping systems. A summary of the system volume calculations is provided in Table 2-1. The volumes of the original ash hoppers and pyrites tanks were derived from plant drawings. The volumes of the original hydrobins, system sumps, and individual BASWR tank cells were calculated from dimensions (summarized below in Table 2-1) derived either from field measurements and/or plant drawings. For the BASWR tank system, both secondary cells were included in the calculations because one secondary cell per electric generating unit is required to be in operation per the original design basis of the BASWR tank system to achieve the target effluent solids concentration. Finally, the volume of interconnecting piping was calculated for the major piping in the system as shown in Table 2-1. Piping sizes and overall estimated lengths of each run are also shown in Table 2-1. Overall piping lengths were estimated based on the final equipment layout as shown above. The overall system volume was calculated as the summation of the volumes from the major components in the system including interconnecting piping.

A water balance analysis used to size new equipment and evaluate operations with the high recycle rate bottom ash system is discussed in Section 2.2 and presented in Appendix A.

Table 2-1: Four Corner's Primary Active Wetted Volume Summary

Ash Hoppers		
	Volume (cubic ft)	Volume (gals)
Unit 4 Hopper	10,000	74,800
Unit 5 Hopper	10,000	74,800
Total	20,000	149,600

Pyrites Tanks		
	Volume (cubic ft)	Volume (gals)
Unit 4 (8 total)	144	1,077
Unit 5 (8 total)	144	1,077
Total	288	2,154

Hydrobins					
	Diameter (ft)	Height of Cylinder (ft)	Height of Cone (ft)	Volume (cubic ft)	Volume (gals)
Tank 1	35	13.25	27.75	21,648	161,924
Tank 2	35	13.25	27.75	21,648	161,924
Tank 3	35	13.25	27.75	21,648	161,924
Tank 4	35	13.25	27.75	21,648	161,924
			Total	86,590	647,694

Sumps					
	Width/Diameter (ft)	Length (ft)	Depth (ft)	Volume (cubic ft)	Volume (gals)
Unit 4 Ash Pit	6		10	283	2,115
Unit 4 Bottom Ash Area Sump	18	35	13	8,190	61,261
Hydrobin Area Sump	15	10	10	1,500	11,220
			Total	9,973	74,596

Hydrobin Overflow Tanks				
	Diameter (ft)	Height (ft)	Volume (cubic ft)	Volume (gals)
Tank 1	32.5	18	14,932	111,694
Tank 2	32.5	18	14,932	111,694
		Total	29,865	223,388

BASWR (Settling) Tank System					
	Width (ft)	Length (ft)	Depth (ft)	Volume (cubic ft)	Volume (gals)
Primary	40	200	8.5	68000	508,640
Secondary 1	66	356	8.2	190,915	1,428,043
Secondary 2	66	356	8.2	190,915	1,428,043
Clearwell	60	20	7.8	9,400	70,312
			Total	459,230	3,435,039

Piping				
	Diameter (in)	Length (ft)	Volume (cubic ft)	Volume (gals)
Sluice Piping 1	12	1,800	1,414	10,575
Sluice Piping 2	12	1,800	1,414	10,575
Flush Piping 1	12	1,800	1,414	10,575
Flush Piping 2	12	1,800	1,414	10,575
U4 Sump Return 1	10	1,100	600	4,488
U4 Sump Return 2	10	1,100	600	4,488
Hydrobin Overflow Return 1	10	1,300	709	5,304
Hydrobin Overflow Return 2	10	1,300	709	5,304
		Total	8,273	61,881

Total System Wetted Volume (gal) =	149,600 + 2,154 + 647,694 + 74,596 + 223,388 + 3,435,039 + 61,881 = 4,594,352
10% gal/day	459,435
10% gal/hr	19,143
10% gpm	319
2.5% gal/day	114,859
2.5% gal/hr	4,786
2.5% gpm	80

2.2 Water Balance Description

Three water balance cases were created to evaluate planned operations and are included in Appendix A. The flows used in the water balance analyses represent best estimates for operation based on engineering judgement and flow measurements (where feasible) conducted during existing operations. All water balances included daily average/max process flows while water balance cases WMB-01 and WMB-03 include 10-year and 100-year design storm events averaged over a 24-hour period, respectively. Water balance calculations are based on average flows, but maximum flows are also shown in the water balance figures to demonstrate the magnitude of variability that must be accounted for in routine flow balancing operations.

2.2.1 Process Flows

As shown on the water balances, the main process flow in the bottom ash sluice system is intermittent and comes from the sluicing of bottom ash to the hydrobins. Each units' hoppers are sluiced via jet pumps on a scheduled basis to the hydrobins, at an average rate of 2,629 gpm, where bottom ash, 966 tons/day including 35 gpm of entrained water, is removed via trucks. The overflow from the hydrobins, at an average rate of 2,610 gpm, will be captured and sent to the BASWR settling tank system for further treatment prior to reuse or purge.

The other main flow in the bottom ash system is from seal trough and hopper overflows. The seal trough consistently overflows to maintain level within the hopper seal trough while the hopper overflows discharge during/after sluice events. As indicated previously, seal trough overflow is typically not considered a bottom ash transport stream, but in this case, it will be fed off the high recycle return water system based on the magnitude and proximity of these flows. Seal trough and hopper overflows will continue to gravity discharge to an existing drainage trench that was rerouted to a new sump prior to being forwarded to the BASWR settling tank for solids settling. The seal trough overflow and hopper overflow average rates are 1,400 gpm and 1,197 gpm, respectively. The remainder of the flows within the system are due to miscellaneous water users.

A new low volume wastewater settling tank is also shown on the water balance figures. Various sumps were evaluated at Four Corners for flow and quality prior to determining adequate treatment for the low volume waste streams to meet NPDES permitted outfall limits. Typical discharges to the low volume wastewater tank include reverse osmosis reject and backwash discharges, at an average rate of 200 gpm, and miscellaneous service water users, at an average rate of 230 gpm. A majority of the plant stormwater runoff will also be directed to the low volume wastewater settling tank for solids settling prior to discharge. WMB-01 includes a 10-year, 24-hour storm event which is the required system stormwater design basis per regulation and was used as the design basis for the stormwater calculations. WMB-03 includes a 100-year, 24-hour event for reference purposes.

2.2.2 Operational Scenarios

Existing flow rates for the bottom ash sluice and low volume wastewater systems were measured to evaluate potential discharges from the high recycle rate system. Daily average flows were established for the major system components based on the expected flow rates once the system operates as a high recycle rate system. WMB-01 and WMB-03 include design storm events for a 10-year, 24-hour and 100-year, 24-hour storm respectively. Estimated purge flows required from the water balance scenarios evaluated are listed in Table 2-2 below.

Table 2-2: Purge Rates for Water Balance Considerations

Water Balance Number/Condition	Purge Rate Directed to a NPDES Outfall (gpm)	Purge Rate Directed to Other Systems for Plant Reuse (gpm)
WMB-01 Process and 10-year, 24-hour storm	0	156
WMB-02 Process Only	0	79
WMB-03 Process and 100-year, 24-hour storm	32	156

Based on the water balance analyses, routine operations will require a constant purge to the FGD system once high-recycle operations are initiated. Given the complexity of this system, all purges to the FGD system will have to be carefully managed. Short duration increases in the purge rate to accommodate storm surges was incorporated into the design; however routine discharges exceeding 79 gpm could pose water management issues in the FGD system and impact plant reliability.

2.3 List of All Potential Discharges under 40 CFR § 423.13(k)(2)(i)(A)(1) – (4)

APS has designed the high-recycle bottom ash transport system to routinely operate without purging via the new low volume wastewater treatment to the NPDES outfall (water balance case WMB-02 in Appendix A). However, as 40 CFR §423(k)(2)(i)(A) anticipates, there will be circumstances that could affect the reliability of plant operations if the high-recycle bottom ash transport system is overwhelmed. In those instances, discharges directed to the NPDES outfall would be required and permitted under existing regulation under four categories of conditions. To inform a case-by-case analysis of the allowable purge rate for the high-recycle bottom ash system at Four Corners, Table 2-3 presents the best available estimate of discharges that could be directed to a NPDES outfall under the four categories of conditions allowed in regulation:

Table 2-3: Four Corner's Purge Discharges

Discharge Stream	Estimated Flow/Volume	Description	Estimated Frequency
(A)(1) Water Balance – Stormwater	Stormwater flows in excess of 111,000 gallons	Precipitation-related inflows generated from storm events exceeding a 10-year storm event of 24-hour or longer duration (e.g., 30-day storm event) and cannot be managed by installed spares, redundancies, maintenance tanks, and other secondary bottom ash system equipment	Following storm events that exceed the design storm (i.e., a storm event with a return period greater than 10 years and intensity of 24 hours which is equivalent to 1.54 inches of rainfall, or 111,000 gallons). This design storm would be stored within the freeboard of the BASWR settling tank system prior to being reused within the FGD system. Anything surpassing this storm event would be purged via the low volume wastewater treatment system to the NPDES outfall. A 100-year/24-hour storm event would contain an estimated additional 70,000 gallons of water that would need to be purged from the system to maintain water balance and avoid overtopping of the BASWR settling tank system.
(A)(2) Water Balance – Other Waste Streams	400 gpm peak (20 gpm average)	Regular inflows from waste streams other than bottom ash transport water that exceed the ability of the bottom ash system to accept recycled water	Intermittent flows from sumps that discharge into the bottom ash system because they have a high solids content and/or contribute area washdown volumes on an irregular basis have the potential to create water balance issues if spare/surge capacity is unavailable. For the purpose of estimating a potential 'other waste stream' flow, the intermittent flow from baghouse enclosure sumps, which discharge high solids content wastewater, serves as the basis for the estimated other inflow rates.

Discharge Stream	Estimated Flow/Volume	Description	Estimated Frequency
(A)(3) Water Chemistry	80 gpm	To maintain system water chemistry where installed equipment at the facility is unable to manage pH, corrosive substances, substances or conditions causing scaling, or fine particulates to below levels which impact system operation or maintenance	Water within the bottom ash system will have scaling potential based on the cycled up constituents and elevated pH from contact with bottom ash. A continuous purge of up to 2.5% of the total system wetted volume (80 gpm) and an acid feed for pH control will be required to prevent scale formation in the bottom ash system.
(A)(4) Maintenance	1,428,043 gallons	To conduct maintenance not otherwise included in (A) (1), (2), or (3) of this table and not exempted from the definition of transport water in § 423.11(p), and when water volumes cannot be managed by installed spares, redundancies, maintenance tanks, and other secondary bottom ash system equipment	Although it is difficult to predict the volumes/discharge frequencies required for maintenance of the new high recycle rate bottom ash system, there will be times when one secondary BASWR cell will need to be dewatered for cleaning purposes. This could occur as frequently as once a year and is the basis for the estimate of volume required for maintenance of the BA system. Maintenance of smaller vessels at a similar frequency is anticipated.

2.3.1 Water Balance – Stormwater

Although APS has taken measures in the design of the bottom ash transport system to limit the inflow of as much stormwater as possible, there will be purges required for storm events that exceed the design storm noted in regulation. Calculation of the threshold stormwater volume of 111,000 gallons as well as the 100-year, 24-hour reference storm is detailed in Appendix B and summarized below:

- Stormwater calculations are based on the methodology outlined in the New Mexico Department of Transportation Drainage Design Manual and the 'Civil Engineering Reference Manual for the PE Exam,' (Lindeburg, M, 2008). Rainfall data for the 1-year, 10-year, and 100-year 24-hour storm were obtained from the National Oceanic and Atmospheric Administration Atlas 14, Volume 8, Version 2. The assumed design storm is the 10-year, 24-hour storm as identified by regulation.

- The stormwater contribution method begins with estimating the drainage areas and determining the type of cover for each area which was done from site arrangement drawings. From there we calculated the total weighted curve number, soil water storage capacity, and initial abstraction values as inputs to the curve number method runoff equation. This provides the estimated runoff for each area which in turn is used to calculate the total volume input per area for each storm event.

- The total volume of stormwater that enters the bottom ash handling system is comprised of three areas: the U4 Bottom Ash Area Sump, the Hydrobin Overflow Sump, and the open top BASWR settling tank system. For the 10-year, 24-hour storm, these volumes are 35,900 gallons, 14,400 gallons, and 61,000 gallons respectively. This equates to the 111,000 gallons noted above in Table 2-2.

- For the 100-year, 24-hour storm, the corresponding stormwater volumes are 57,900 gallons, 23,200 gallons, and 98,400 gallons respectively. This equates to a total of 179,500 gallons or the difference of about 70,000 gallons (179,500 – 111,300 = 68,200 gallons) as noted above in Table 2-2.

2.3.2 Water Balance – Other Waste Streams

As noted in Table 2-3 above, there could be other waste streams from intermittent sources that have the potential to impact the water balance of the bottom ash transport system, especially in the aftermath of a significant storm when the spare/surge capacity in the system would be full. One example waste stream is the intermittent discharge of wastewater from the baghouse enclosure sump into the bottom ash system. The baghouse enclosure sump pumps are rated for 400 gpm which could over short periods cause water balance issues if the spare/surge capacity of the system is limited. Although this flowrate is not significant relative to the full process flow of the bottom ash transport recirculation flow, balancing short duration, high intensity flows could overwhelm an already overwhelmed system.

2.3.3 High Recycle Rate Bottom Ash Chemistry Considerations

In the original once through (i.e., open loop) bottom ash sluicing system, ash was sluiced to the hydrobins which acted as the primary ash separation devices. Overflow and decant sluice water was pumped to the BASWR settling tank system, where most of the remaining ash settled out to be dewatered and removed. Overflow from the BASWR settling tank system was discharged through the permitted NPDES outfall and fresh makeup water was used for subsequent sluice cycles.

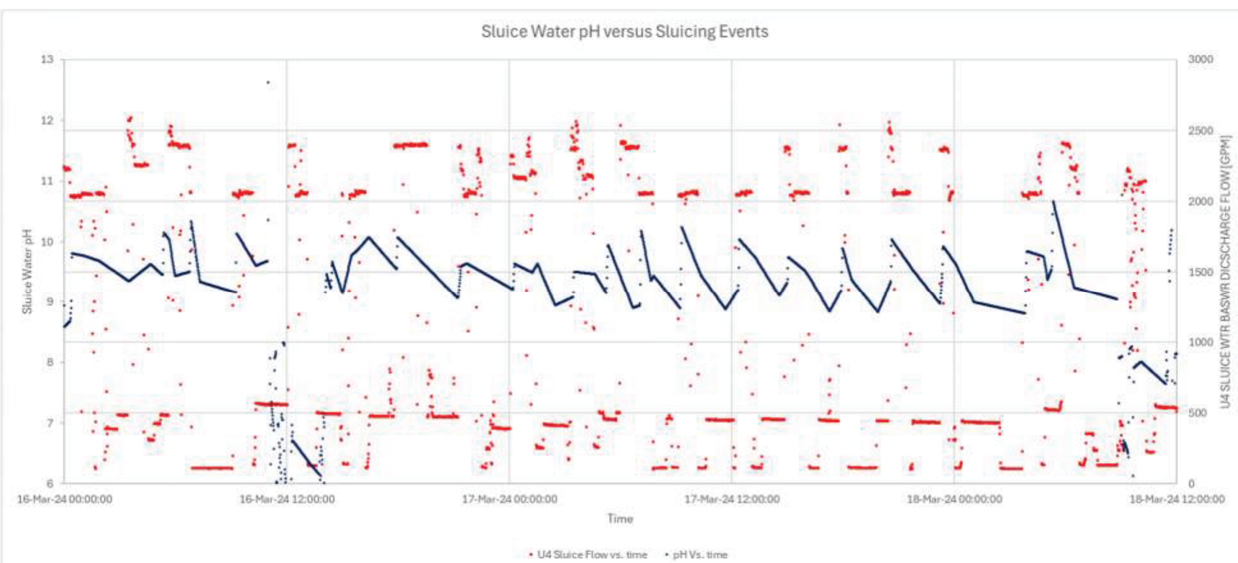
After the conversion to a high recycle rate system, the closed-loop water quality cycled up to a new equilibrium concentration, where the additional mass of constituents introduced per sluice cycle is equal to the mass exiting the closed-loop system through purge flows and the reuse of treated sluice water in the

FGD system. There has been an observed increase in total dissolved solids (TDS), conductivity, and most constituents from contact with the bottom ash and due to evaporation of water in the system.

Some constituents had higher observed concentrations than what could be predicted from cycling up in the wastewater alone. These are mostly attributed to dissolution of these constituents into the wastewater from the bottom ash. These constituents included calcium, silica, nitrogen, and boron. Other constituents had lower observed concentrations than what could be predicted from cycling up in the wastewater alone. These constituents include alkalinity, aluminum, copper, iron, magnesium, manganese, and zinc. It is believed that metal hydroxides were forming in the bottom ash hopper as the pH in the hopper increased causing the metal hydroxides to precipitate and be removed with the bottom ash solids.

Figure 2-2 below shows the sluice flows versus sluice water pH during a few days of operation. What is observed is a noticeable spike in sluice water pH at the beginning of the sluice cycle which then decays over time. This is indicative of an increase in alkalinity as ash accumulates in the bottom ash hopper which pushes the pH in the hoppers higher. As the pH and alkalinity increase in the bottom ash hopper, we begin to precipitate out various metal hydroxides which are removed from the system with the bottom ash. As the metal hydroxides precipitate, this also acts to lower the alkalinity in the sluice water.

Figure 2-2: Sluice Flow Rate versus Sluice pH



Once the sluice water enters the hydrobins, the elevated pH begins to neutralize as it is mixed with the bulk of the water in the bottom ash sluice system. Over time, the pH in the bottom ash system will increase which will require the addition of acid to control the scaling tendencies of the bottom ash sluice water.

Several scaling indices can be used to model the scaling and corrosive properties of the water. These are the Puckorius Scaling Index (PSI), The Ryznar Scaling Index (RSI), the Langelier Scaling Index (LSI), and the Larson-Skold Index (L-SI). The PSI, RSI, and LSI all use alkalinity, hardness, temperature, and pH to estimate calcium scale and corrosivity, comparing the pH of the system to the equilibrium pH and the pH of saturation. The L-SI looks at the concentrations of carbonate, bicarbonate, sulfate, and chloride to estimate the tendency for sulfate and chloride to interfere with scale formation and to support corrosion due to sulfate and chloride chemistry. The target ranges for these indices are shown in Table 2-4.

Table 2-4: Key to Scaling Indexes (pH of the system)

	PSI	RSI	LSI	L-SI
Extreme Corrosion	>9.0	>9.0	<-2	>4.0
Moderate Corrosion	>7.5 - 9.0	>7.5 - 9.0	-2.0 - -0.5	1.2 - 4.0
Slight Corrosion	>7.0 - 7.5	>7.0 - 7.5	>-0.5 - 0.0	0.8 - <1.2
In range	>6.0 - 7.0	>6.0 - 7.0	>0.0 - 0.5	<0.8
Slight Scaling	5.0 - 6.0	5.0 - 6.0	>0.5 - 2.0	
Heavy Scaling	<5.0	<5.0	>2.0	

Samples have been collected regularly at various locations in the bottom ash handling system and analyzed for a variety of constituents (see analytes and results in Appendix C).

Appendix D shows the calculated scaling and corrosion indices values for various conditions. Key input parameters and assumptions include:

- Total system volume: 4,594,352 gallons (see Table 2-1 above)
- System evaporation: Total evaluation rate was calculated at approximately 102 gpm (146,949 gallons/day) from the observed cycles of concentration and blowdown rates.
- Bottom ash drag out rate (amount of bottom ash removed from system) was calculated as follows: 21.2 tons/hour average bottom production rate per unit * 2 units * 20% assumed moisture content, 21.2 * 2000 * 2 * 0.2 / 500.4 = 33.9 gpm (48,805.8 gallons/day) water in bottom ash drag out waste stream. This provided a good correlation to the measured average value of 35 gpm from the

hydrobins as shown on the water balances. Water entrained with the bottom ash removed from the system was assumed to be the average 35-gpm number based on existing flow measurement data.

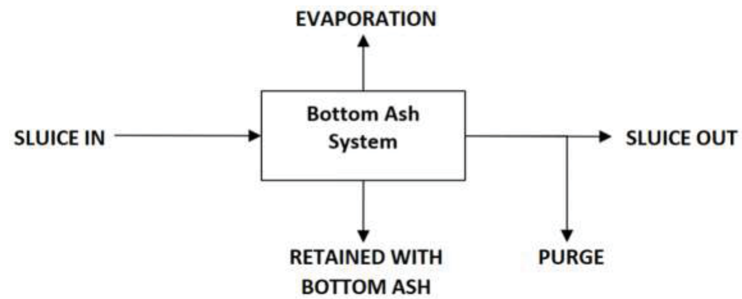
- Total purge rate was estimated to be 80 gpm (114,859 gallons/day)
- Total makeup rate: evaporation + drag out + purge rates = 102 + 35.0 + 80 = 217 gpm (312,208 gallons/day)
- The hydraulic residence time of the system is calculated as the total system volume divided by the makeup rate, or 4,594,353 gallons / 312,208 gallons / day = 14.7 days.
- Selected water quality data was collected from various locations in the system as shown with blue boxes on the water balance diagrams. A summary of the sampling results is contained in Appendix C.

What we can conclude from the calculated scaling and corrosion indices in Appendix D, is as follows:

- Lake water (makeup water) is slightly corrosive
- With a 2.5% purge flow, sluice water at the hydrobins and BASWR will be in a slight to heavy scale forming region at the elevated pH conditions observed. The addition of acid will be required to control pH and consequently scale within the system.
- Without a purge stream and pH control with acid feed, the sluice water will be in a heavy scale forming region as the constituent concentrations cycle up in the system. pH control with acid feed will be required.
- With a 10% purge flow, the bottom ash sluice water will be more like lake water and slightly corrosive.

Evaporation in the bottom ash system (including hoppers, hydrobins, overflow tanks and BASWR) has a net result of increasing the constituent concentrations in the water. The water retained in the bottom ash that is removed does not change the concentrations of the remaining constituents in the system but does remove some mass from the system. Contact of the bottom ash material with the water results in some dissolution of constituents from the bottom ash into the water. The combination of evaporation and contact of bottom ash with the sluice water results in a change in some of the constituent concentrations.

Figure 2-3: Mass Balance Around Bottom Ash System



Provisions for a purge rate of 2.5% plus the maximum possible purge to the WFGD system (peak purge rate of 79 gpm) and installation of some form of chemical feed adjustment is required to maintain system chemistry in the bottom ash system. The provisions for a system purge and an acid feed chemical feed addition will produce a sluice water quality that has less scaling potential and comparable corrosion potential to the existing open-loop bottom ash system configuration. The ability to feed acid has been incorporated into the design of the high recycle rate, closed-loop bottom ash system prior to the BASWR settling tank system.

2.3.4 Maintenance

Estimates of potential purge volumes required for future maintenance are difficult to predict, especially for a system that has just been put into service. It is anticipated, however, that there will be scenarios where large volumes of water will need to be drained from the bottom ash transport system for maintenance. To provide an example maintenance purge volume that would be difficult to retain onsite given the magnitude of the system, a scenario involving clean out of one of the secondary settling cells of the BASWR tank was selected.

The existing BASWR system consists of a primary settling cell, two secondary settling cells, and one clearwell. As noted in Table 2-2 above, there will be times when one 1,428,043-gallon secondary BASWR cell will need to be dewatered for cleaning purposes which may happen as frequently as once per year. Under normal operating circumstances, every effort will be made to process drainage of the secondary settling cell within routine system purges to the FGD system. However, due to the magnitude of volume in each of the secondary cells, as well as plant operational requirements, a purge through the NPDES outfall will likely be required.

The BASWR system design requires one secondary settling cell to be in service per unit in operation to achieve the target TSS removal rates. As noted in Table 2-2 above, there will be times when one secondary BASWR cell will need to be dewatered for cleaning purposes which may happen as frequently as once per year. This means that the BASWR tank system is undersized for proper treatment of full flow from both units and secondary settling cell cleanouts will have to occur during either a scheduled single or dual unit outage. In the lead up to the scheduled outage, a single secondary settling cell will require over 12 days of continuous draining to dewater the cell at the FGD bottom ash transport system purge rate identified for routine operations (79 gpm; see water balance case WMB-02 in Appendix A). This operation could take longer if there are issues in FGD operations. Further, there may be times when it will be necessary to dewater a cell very quickly, such as when an equipment failure could lead to a forced unit outage. In either instance, maintenance would require a significant purge volume equal to the volume of the cell to be actively managed with the needs of plant operational requirements. The addition of a third (spare) secondary settling cell was considered for this scenario; however, the cost to incorporate a third settling cell for a once/year maintenance event does not have a good cost to benefit ratio and physical space for such an addition was limited.

2.4 Wastewater Treatment Systems at Four Corners

Table 2-5 summarizes the water treatment systems that process water that will have the potential to be discharged in accordance with the NPDES permit at Four Corners (i.e., non-bottom ash transport systems). Design assumptions and design basis information are discussed in the following sections.

Table 2-5: Four Corners Wastewater Treatment Systems

System Name	Design Capacity	Current Operation	Expected Operation
Low Volume Wastewater Treatment System	440 gpm daily average. 1,213 gpm daily max including stormwater flows based on a 10-year, 24-hour storm.	Settling via BASWR prior to discharge through the permitted NPDES outfall.	Low volume wastewater will be segregated from bottom ash sluice system flows and re-routed to a new settling tank prior to discharge through the permitted NPDES outfall.

System Name	Design Capacity	Current Operation	Expected Operation
High Recycle Bottom Ash System	Hydrobins – 2,610 gpm daily average BASWR – 5,642 gpm daily average	Ash removed via Hydrobins prior to final settling via BASWR with polymer addition prior to discharge through the permitted NPDES outfall.	Ash removed via Hydrobins with newly installed polymer injection. Chemical feeds prior to BASWR for pH adjustment. Final settling via BASWR with polymer prior to reuse within existing FGD system or purge to LVWTS and ultimately through the permitted NPDES outfall.

2.4.1 Low Volume Wastewater Treatment System

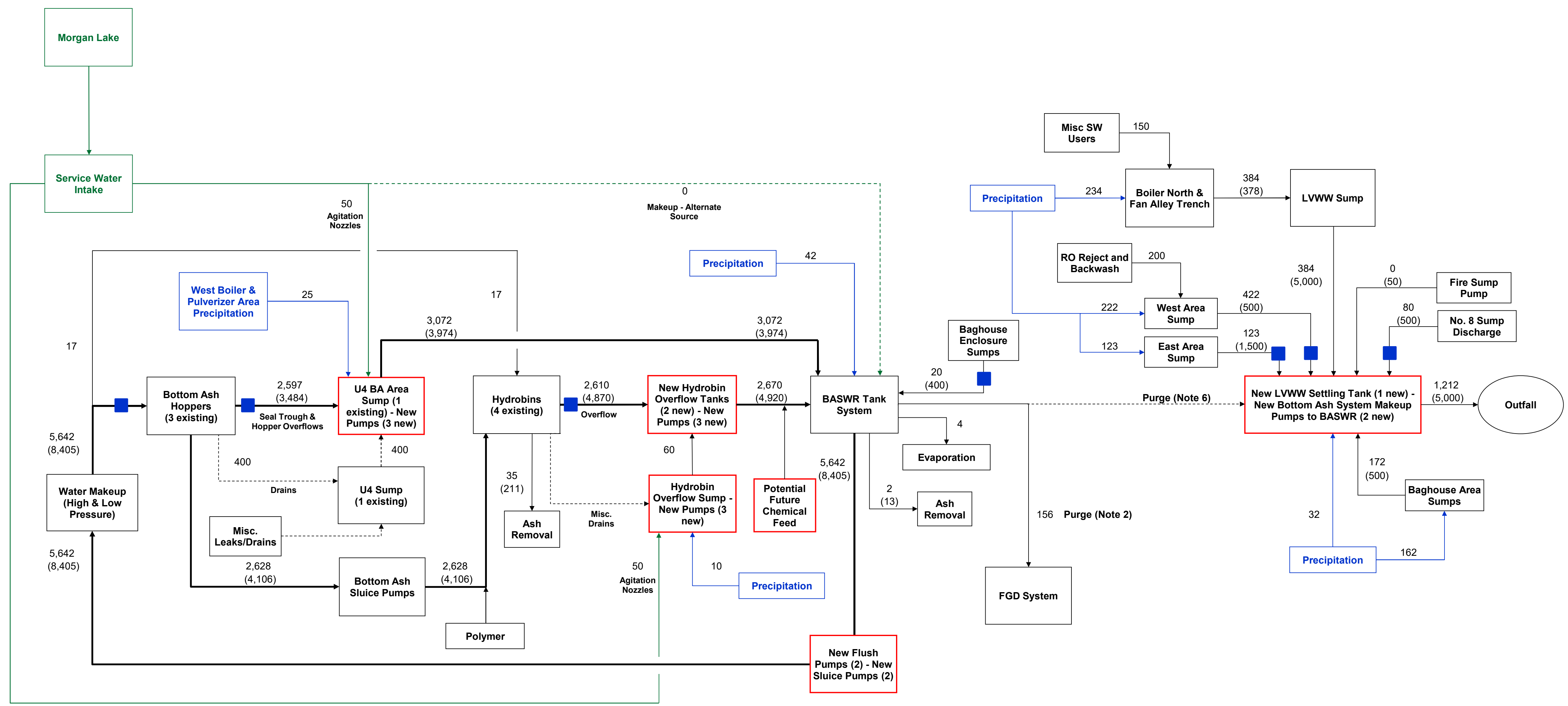
Low volume wastewater flows were evaluated based on existing plant data and flowmeter analysis. Stormwater areas were established to determine runoff volumes that contribute to each low volume wastewater area. Average/max daily flows were established at each low volume source along with expected flows from a 10-year, 24-hour storm to establish sizing required for a low volume wastewater treatment system capable of meeting the NPDES permitted outfall.

2.4.2 High Recycle Bottom Ash System

High-recycle bottom ash system flow rates, based on existing system flow rates averaged over a 24-hour period, were utilized to establish daily averages. Hydrobins are the primary ash separation step while the BASWR settling tank system settles fines carryover from the Hydrobins along with seal trough and hopper overflow. Two sumps are included in the high recycle bottom ash system to capture various closed-loop waters along with any stormwater in the bottom ash areas. Polymer injection is expected to be utilized upstream of the Hydrobins and BASWR settling tank system to enhance fines settling while acid will be used for pH adjustment. Purge flow to the FGD system or LVWW treatment system (to the NPDES outfall) would be discharged after the treatment of the closed-loop water by the Hydrobins and BASWR settling tank system along with any required chemical feed. Purge flow for reuse or outfall discharge is dependent on considerations listed in Section 2.3.

Wastewater streams generated at the plant that do not discharge through NPDES permitted outfalls include blowdown from the wet FGD scrubber, sanitary wastewater, and various boiler cleaning solutions. Blowdown and associated slurries from the wet FGD scrubber are blended with ash and landfilled in an onsite CCR landfill. Sanitary wastewater and boiler cleaning solutions are discharged to an on-site CCR surface impoundment where they evaporate or are reused in non-bottom ash sluice water plant operations.

APPENDIX A – WATER BALANCE DRAWINGS



no.	date	by	ckd	description
A	7/30/21	DKE		PRELIMINARY
B	1/13/22	BDH		UPDATES
C	1/24/22	BDH		EPA LETTER UPDATES
D	2/16/22	BDH	DKE	EPA LETTER UPDATES
E	3/3/22	BDH	DKE	EPA LETTER UPDATES

☑ Precipitation Included

NOTES:
1. Precipitation values based on 10 year, 24 hour storm averaged over 24 hour period.
2. Purge based on water balance requirements for the closed-loop system.
3. All flows shown in gallons per minute (GPM).
4. Max flows for normal operation are in parentheses and may not balance.
5. Water leaving with ash assumed to be 20% moisture. Hydrobin ash expected to be removed for 4 hour duration per day. BASWR ash removal expected 3 times per week and estimated to be removed within 8 hour duration.
6. Purge to maintain system water chemistry up to 319 gpm or 10% of the bottom ash system flow.
7. Maintenance purge to drain one secondary cell of the BASWR to the LVWW settling tank is not shown.
8. Dashed lines represent intermittent flows.

■ Sampling Location

PRELIMINARY

BURNS McDONNELL

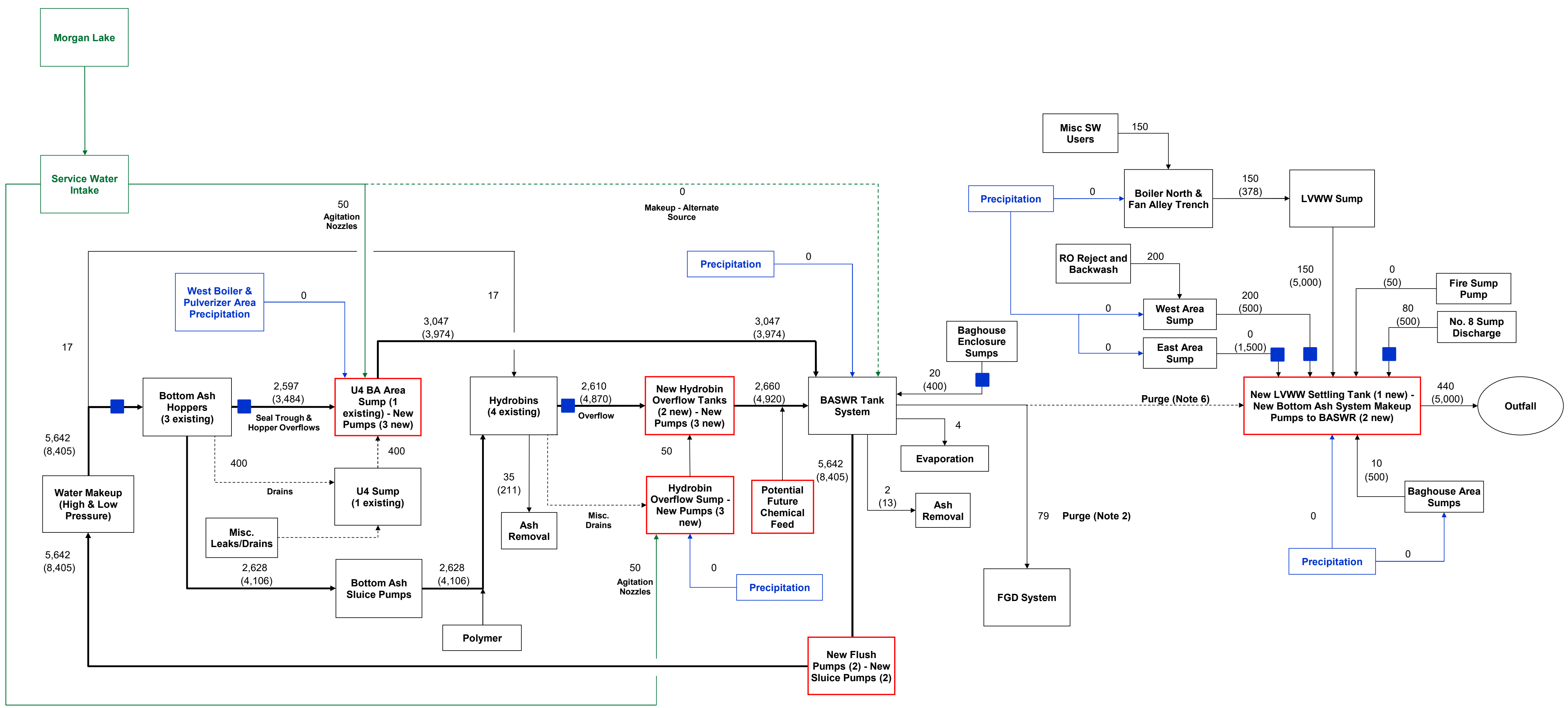
date 7/30/2021 | detailed D. Elliott
designed D. Elliott | checked B. Hansen

aps

APS Four Corners
Future Conditions
Process & 10yr Stormwater Flows

project 129532 | contract
drawing WMB-01 | --- | rev. E
sheet 1 of 1 sheets
file

no.	date	by	ckd	description
A	7/30/21	DKE		PRELIMINARY
B	1/13/22	BDH		UPDATES
C	1/24/22	BDH		EPA LETTER UPDATES
D	2/16/22	BDH	DKE	EPA LETTER UPDATES
E	3/3/22	BDH	DKE	EPA LETTER UPDATES



◻	Precipitation Included

NOTES:

1. Precipitation values based on 10 year, 24 hour storm averaged over 24 hour period.
2. Purge based on water balance requirements for the closed-loop system.
3. All flows shown in gallons per minute (GPM).
4. Max flows for normal operation are in parentheses and may not balance.
5. Water leaving with ash assumed to be 20% moisture. Hydrobin ash expected to be removed for 4 hour duration per day. BASWR ash removal expected 3 times per week and estimated to be removed within 8 hour duration.
6. Purge to maintain system water chemistry up to 319 gpm or 10% of the bottom ash system flow.
7. Maintenance purge to drain one secondary cell of the BASWR to the LVWW settling tank is not shown.
8. Dashed lines represent intermittent flows.

■	Sampling Location

PRELIMINARY

BURNS McDONNELL

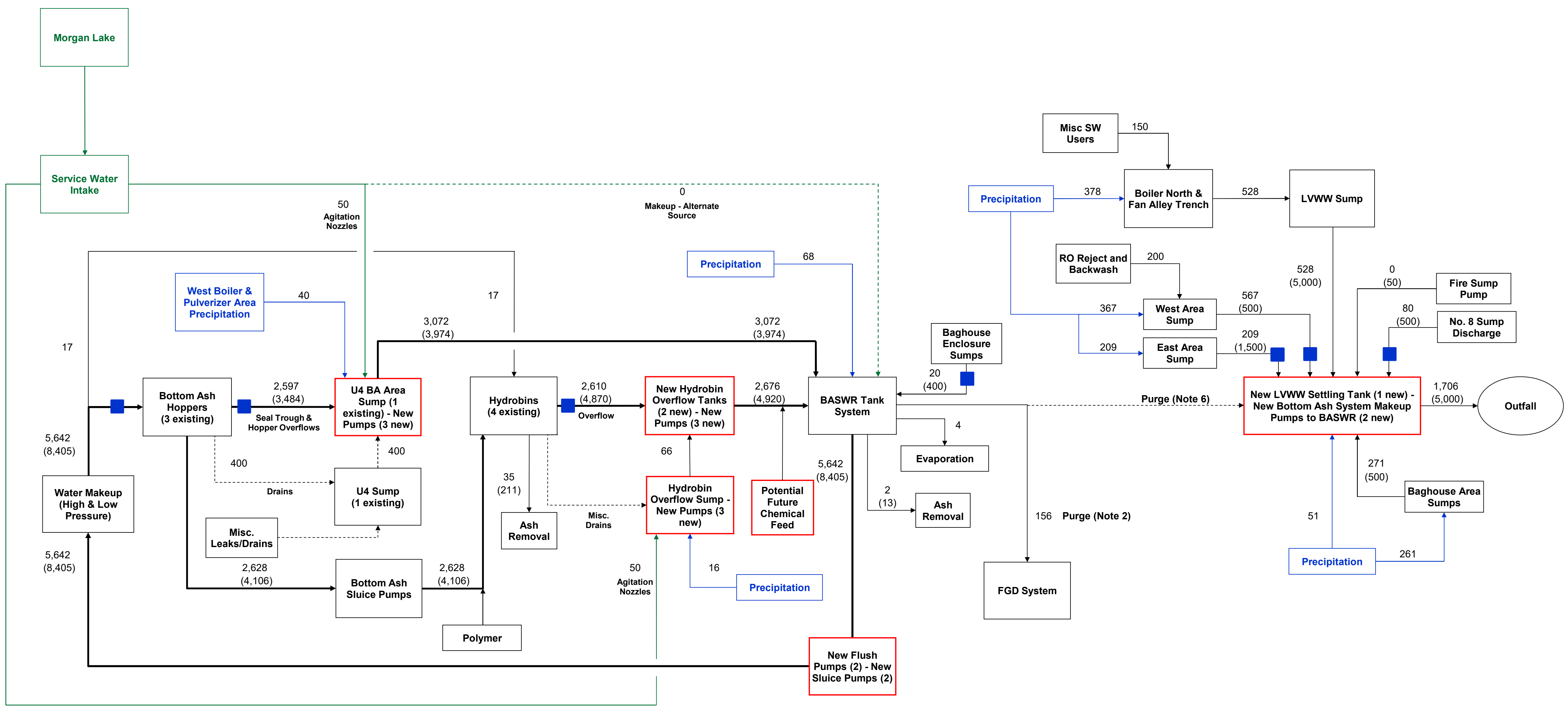
date 7/30/2021	detailed D. Elliott
designed D. Elliott	checked B. Hansen

aps

APS Four Corners
Future Conditions
Process Only Flows

project 129532	contract		
drawing WMB-02	---	rev. E	
sheet 1	of	1	sheets
file			

no.	date	by	ckd	description
A	7/30/21	DKE		PRELIMINARY
B	1/13/22	BDH		UPDATES
C	1/24/22	BDH		EPA LETTER UPDATES
D	2/16/22	BDH	DKE	EPA LETTER UPDATES
E	3/3/22	BDH	DKE	EPA LETTER UPDATES



Precipitation Included

NOTES:

1. Precipitation values based on 100 year, 24 hour storm averaged over 24 hour period.
2. Purge based on water balance requirements for the closed-loop system. Purge to LVWW based on flow exceeding 10 year storm.
3. All flows shown in gallons per minute (GPM)
4. Max flows for normal operation are in parentheses and may not balance.
5. Water leaving with ash assumed to be 22% moisture. Hydrobin ash expected to be removed for 4 hour duration per day. BASWR ash removal expected 3 times per week and estimated to be removed within 8 hour duration.
6. Purge to maintain system water chemistry up to 319 gpm or 10% of the bottom ash system flow.
7. Maintenance purge to drain one secondary cell of the BASWR to the LVWW settling tank is not shown.
8. Dashed lines represent intermittent flows.

Sampling Location

PRELIMINARY

BURNS McDONNELL

date	detailed
7/30/2021	D. Elliott
designed	**checked**
D. Elliott	B. Hansen

aps

APS Four Corners
Future Conditions
Process & 100yr Stormwater Flows

project	contract
129532	

drawing: WMB-03 --- rev. E

sheet 1 of 1 sheets

file

APPENDIX B – STORMWATER RUNOFF CALCULATIONS

BURNS McDONNELL

WORKSHEET TITLE:	APS 4C Runoff Calcs	**CALCULATION NO.:**	
CREATED:	4/26/2021	**REVISION:**	A
PERFORMED BY:	D. ELLIOTT	**REVIEWED BY:**	
OBJECTIVE:	Determine Runoff Volumes		

REFERENCES:

1 Lindeburg, M. (2008). Civil engineering reference manual for the PE exam. Belmont, CA: Professional Publications, Inc.

2 Drainange Design Manual - NMDOT
https://dot.state.nm.us/content/dam/nmdot/Infrastructure/Drain_Design_Manual.pdf

3 National Oceanic and Atmospheric Administration. (2015). NOAA Atlas 14, Volume 8, Version 2. [Point precipitation frequency estimates for Farmington, NM, US]. Retrieved from http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo

4 United States. Department of Agriculture. Natural Resources Conservation Service. National Engineering Handbook: Part 630 Hydrology, Chapter 15 Time of Concentration. N.p., n.d. Web. 9 Feb. 2016.

DESIGN INPUTS:

1 Design storm duration is 24 hours.

2 Max intensity duration is 5 minutes

3 Based on Custom Soils Resource Report, soils in the vicinity of the watershed areas are generally sandy loam Hydrologic Soil Group C. Reference 3

EQUATIONS:

1 SCS Curve Number Method Runoff Equation
$Q = (P-I_a)^2/(P-I_a+S)$ Reference 1, p. 20-19, eq. 20.44

2 Soil Water Storage Capacity
$S = (1000/CN) - 10$ Reference 1, p. 20-19, eq. 20.43

3 Initial Abstraction
$I_a = 0.2*S$ Reference 1, p. 20-15, eq. 20.38

4 Weighted Curve Number
$CN_W = (CN_i*A_i)/A_T$

5 Volume of Runoff
$V = Q*A_i$

VARIABLES:

1	Q	runoff, in
2	A_d	total drainage area, ac or mi^2
3	S	soil water storage capacity, in
4	CN	curve number, unitless
5	I_a	initial abstraction, in
6	CN_W	weighted curve number, unitless
7	A_T	total area, ac
8	CN_{WT}	total weighted curve number, unitless

CALCULATIONS:

1 Establish drainage area

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	As shown on the area map figure, see below
	West Sump	East Sump	LVWW Sump	Baghouse Area	U4 BA Area	BASWR	Hydrobin Area	
A_d (ac)	9.61	5.75	9.40	6.50	1.00	1.70	0.40	
A_d (mi^2)	0.015	0.009	0.015	0.010	0.002	0.003	0.001	Conversion from ac to mi^2

2 Establish rainfall data

SCS Storm	Depth (in)	
1yr, 24hr	0.83	Reference 3
10yr, 24hr	1.54	Reference 3
100yr, 24hr	2.36	Reference 3

3 Establish CN, Percent Impervious Cover, and Initial Abstraction

	West Sump			East Sump			LVWW Sump			Baghouse Area			U4 BA Area			BASWR			Hydrobin Area			
Land Description	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	CN_i*	A_i** (ac)	CN_W	
Open space, fair condition	79		0.0	79		0.0	79		0.0	79		0.0	79		0.0	79		0.0	79		0.0	Equation 4
Gravel	96	7.21	72.0	96	5.18	86.4	96		0.0	96		0.0	96		0.0	96		0.0	96		0.0	Equation 4
Pond	100		0.0	100		0.0	100		0.0	100		0.0	100		0.0	100	1.62	95.0	100		0.0	Equation 4
Pavement	98	2.40	24.5	98	0.58	9.8	98	9.40	98.0	98	6.50	98.0	98	9.40	98.0	98	0.09	4.9	98	0.40	98.0	Equation 4
Coal Pile	60		0.0	60		0.0	60		0.0	60		0.0	60		0.0	60		0.0	60		0.0	Equation 4
A_T (ac)		9.61			5.75			9.40			6.50			9.40			1.70			0.40		Sum
CN_{WT}			97			96			98			98			98			100			98	Sum
S			0.31			0.42			0.20			0.20			0.20			0.00			0.20	Equation 2
I_a			0.06			0.08			0.04			0.04			0.04			0.00			0.04	Equation 3

*Reference 1, Table 20.4, p. 20-17 and Design Input 3

**Measured in Microstation

4 Establish Runoff Volume based on SCS Curve Number Method

		West Sump	East Sump	LVWW Sump	Baghouse Area	U4 BA Area	BASWR	Hydrobin Area	
1-yr Storm	P (in)	0.83	0.83	0.83	0.834	0.834	0.834	0.834	Reference 3
	Q (in)	0.55	0.48	0.63	0.63	0.63	0.63	0.63	Equation 1
	V (gal)	143,900	75,400	161,100	111,400	17,200	29,200	6,900	Equation 5
	Flow (gpm)	100	52	112	77	12	20	5	
10-yr Storm	P (in)	1.54	1.54	1.54	1.54	1.54	1.54	1.54	Reference 3
	Q (in)	1.22	1.13	1.32	1.32	1.32	1.32	1.32	Equation 1
	V (gal)	319,000	176,900	336,800	232,900	35,900	61,000	14,400	Equation 5
	Flow (gpm)	222	123	234	162	25	42	10	
100-yr Storm	P (in)	2.36	2.36	2.36	2.36	2.36	2.36	2.36	Reference 3
	Q (in)	2.03	1.92	2.13	2.13	2.13	2.13	2.13	Equation 1
	V (gal)	528,600	300,500	544,100	376,300	57,900	98,400	23,200	Equation 5
	Flow (gpm)	367	209	378	261	40	68	16	

5 Evaporation Calcs

68,200

	Area (acres)	Pan Evap Rate (in/yr)	Total Evap (gal/yr)	Average Evap (gpm)
BASWR	1.40	55.00	2,090,877	3.98
LVWW Settling Basin	1.00	55.00	1,493,484	2.84

Drawing showing relative areas (APS 4C - Google Earth.pdf):

APPENDIX C – SAMPLING ANALYTICAL RESULTS

Water Quality data from 'Four Corners Analytical Summary Original' spreadsheet

Lake Water Quality	pH	Total Alkalinity	Conductivity	Total Hardness	Calcium Hardness	Chlorides	Phosphate	Silicon	Sulfate	Nitrate	Aluminum	Boron	Calcium	Copper	Iron	Potassium	Magnesium	Manganese	Molybdenum	Sodium	Phosphorus	Sulfur	Silicon	Zinc
min	6.79	46.00	630.00	-	-	22.00	0.41	-	-	0.20	0.12	0.15	51.27	0.01	0.01	4.63	21.26	0.00	0.04	70.92	0.13	77.77	0.29	0.01
5th percentile	7.04	84.00	1,044.10	266.85	167.38	25.15	0.48	1.55	335.88	0.45	0.14	0.29	67.75	0.02	0.02	6.33	26.28	0.01	0.04	95.73	0.16	113.32	0.74	0.02
average	7.77	109.73	1,179.84	327.79	207.08	48.21	1.24	8.43	398.86	1.99	0.58	0.59	82.96	0.13	0.08	7.60	30.40	0.02	0.05	111.34	0.40	134.49	3.84	0.08
95th percentile	8.35	141.70	1,309.70	381.10	242.02	62.00	1.97	16.79	465.62	4.00	1.10	1.08	96.49	0.27	0.25	9.11	33.88	0.04	0.06	131.10	0.65	155.08	7.66	0.25
max	8.48	186.00	1,484.00	516.20	372.30	104.00	2.09	20.70	551.90	6.20	5.54	1.12	149.10	0.48	0.46	18.70	41.67	0.15	0.06	173.60	0.68	184.20	9.70	0.52

BASWR Clear Well Quality	pH	Total Alkalinity	Conductivity	Total Hardness	Calcium Hardness	Chlorides	Phosphorus	Silicon	Sulfate	Nitrogen	Aluminum	Boron	Calcium	Copper	Iron	Potassium	Magnesium	Manganese	Molybdenum	Sodium	Phosphorus	Sulfur	Silicon	Zinc
min	7.80	60.00	1,648.00	485.60	363.10	78.00	ND	14.68	626.30	2.90	0.31	0.75	145.40	0.05	0.04	8.66	22.78	0.03	ND	126.80	ND	209.00	6.86	0.05
5th percentile	7.90	60.00	1,656.80	522.08	394.30	79.60	ND	15.42	684.14	3.08	0.37	0.78	157.88	0.07	0.12	9.76	24.84	0.03	ND	141.28	ND	228.36	7.21	0.05
average	8.45	70.82	1,783.94	587.63	468.31	85.35	ND	18.75	759.81	4.72	0.69	1.29	187.34	0.15	0.54	11.07	29.10	0.04	ND	160.79	ND	253.62	8.77	0.05
95th percentile	9.23	80.00	1,907.20	627.48	530.32	96.20	ND	22.62	836.84	6.07	0.96	1.58	212.36	0.27	1.08	12.73	36.49	0.06	ND	175.24	ND	279.30	10.58	0.05
max	9.41	80.00	1,928.00	643.40	532.80	97.00	ND	23.64	857.00	6.75	0.96	1.69	213.40	0.29	1.73	13.39	36.78	0.07	ND	189.40	ND	286.10	11.05	0.05

Hydrobin Effluent Quality	pH	Total Alkalinity	Conductivity	Total Hardness	Calcium Hardness	Chlorides	Phosphorus	Silicon	Sulfate	Nitrogen	Aluminum	Boron	Calcium	Copper	Iron	Potassium	Magnesium	Manganese	Molybdenum	Sodium	Phosphorus	Sulfur	Silicon	Zinc
min	7.96	28.00	1,570.00	468.70	355.80	80.00	ND	12.76	644.30	3.05	0.39	0.86	142.50	0.08	0.01	8.73	2.25	0.01	ND	134.00	ND	215.10	5.96	0.04
5th percentile	8.26	34.40	1,598.80	473.26	377.48	81.60	ND	15.08	669.98	3.18	0.39	0.99	151.14	0.09	0.02	9.95	2.51	0.01	ND	142.08	ND	223.66	7.05	0.04
average	9.82	59.53	1,771.71	563.55	496.15	87.94	ND	20.69	752.80	5.08	0.45	1.42	198.70	0.19	0.03	11.36	16.37	0.01	ND	161.91	ND	251.29	9.67	0.04
95th percentile	11.03	100.80	1,964.40	640.52	622.94	96.80	ND	28.90	833.74	6.37	0.50	1.89	249.50	0.36	0.04	12.86	31.20	0.01	ND	174.44	ND	278.32	13.51	0.04
max	11.10	104.00	2,082.00	661.40	645.90	100.00	ND	30.21	880.70	7.08	0.51	1.94	258.70	0.38	0.04	13.15	34.18	0.01	ND	183.00	ND	294.00	14.12	0.05

Observed cycling up in high recycle rate bottom ash system:

Hydrobin vs Lake	1.26	0.54	1.50	1.72	2.40	1.82	N/A	2.46	1.89	2.55	0.78	2.40	2.40	1.47	0.35	1.50	0.54	0.61	N/A	1.45	N/A	1.87	2.52	0.49
BASWR vs Lake	1.09	0.65	1.51	1.79	2.26	1.77	N/A	2.22	1.90	2.37	1.20	2.18	2.26	1.19	6.60	1.46	0.96	2.05	N/A	1.44	N/A	1.89	2.29	0.56

ND = Non-detect
N/A = Not Applicable

APPENDIX D – CHEMISTRY CALCULATIONS

Closed Loop Bottom Ash System

USER INPUT VALUES

Entire system volume	**4,594,353**	gallons	3,190.52	gpm		
Bottom ash hopper volume, total	**149,600**	gallons	566,297.34	Liters		
Bottom ash hydrobins, total	**647,694**	gallons				
Dragout (losses with BA removed)	50,400	gpd	**35.00**	gpm, from Ash design basis		
System Evaporation	146,949	gpd	102.05	gpm, BASWR evaporation plus bottom ash hopper evaporation		
Evaporation + Dragout	197,349	gpd	137.05	gpm		
System Purge Rate, %	**2.5%**					
System Purge Rate, %	114,859	gpd	79.76	gpm	4,786	gal/hr
Total Makeup (GPD)	312,208	gpd	216.81	gpm		
Cycles of Concentration	1.82	currently observed COC in closed loop operation				
Hydraulic Residence Time (HRT), day	14.72					
Seal trough overflow / agitation nozzles	**3,047**	gpm	4,387,680	gal/day - assumes seal trough flow is continuous		
Sluice rate	**2,628**	gpm	1,261,440	gal/day - sluicing at 1hr per unit sequentially, followed by 1hr of no sluicing, then repeating all day		

Water quality data	Cond, uS/cm	TDS, ppm	Cl, ppm	SO4, ppm	Mg, ppm	Ca, ppm	alk/HCO3, ppm	alk/CO3, ppm	pH, SU	Temp, F	PSI = 2(pHs)-pHeq	RSI =2(pHs) - pHmeasured	LSI = pHmeasured - pHs	LS-I
Lake water (makeup)	**1,179.84**	**790.49**	**48.21**	**398.86**	**30.40**	**82.96**	**109.73**		**7.77**	**70.00**	8.07	7.82	-0.03	5.37
Hydrobin Overflow with 2.5% purge	**1,771.71**	**1,187.04**	**87.94**	**752.80**	**16.37**	**198.70**	**59.53**		**9.82**	**80.00**	8.05	5.37	2.23	18.61
BASWR at Clearwell with 2.5% purge	**1,783.94**	**1,195.24**	**85.35**	**759.81**	**29.10**	**187.34**	**70.82**		**8.45**	**70.00**	8.05	6.86	0.80	15.70
BASWR at Clearwell without purge	**3,675.68**	**2,462.71**	**182.45**	**1,561.80**	**33.97**	**412.23**	**123.50**		**10.00**	**70.00**	6.59	4.20	2.90	18.61
BASWR at Clearwell with 10% purge	**1,209.28**	**810.22**	**60.02**	**513.82**	**11.18**	**135.62**	**40.63**		**8.45**	**70.00**	9.14	7.59	0.43	18.61

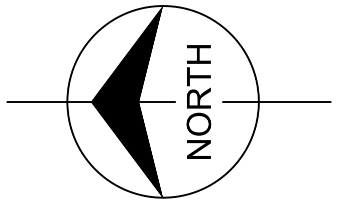
Current Cycles Observed	1.5016	1.5016	1.8241	1.8874	0.5386	2.3953	0.5425
Change in system concentration	591.86	396.55	39.73	353.94	(14.03)	115.74	(50.20)
Excess concentration at reported HRT, ppm/day		26.95	2.70	24.05	(0.95)	7.87	(3.41)
Concentration change from evaporation (increase)		178.62	10.89	90.12	6.87	18.74	24.79
Concentration input from contact with bottom ash		217.93	28.84	263.81	(20.90)	97.00	(75.00)

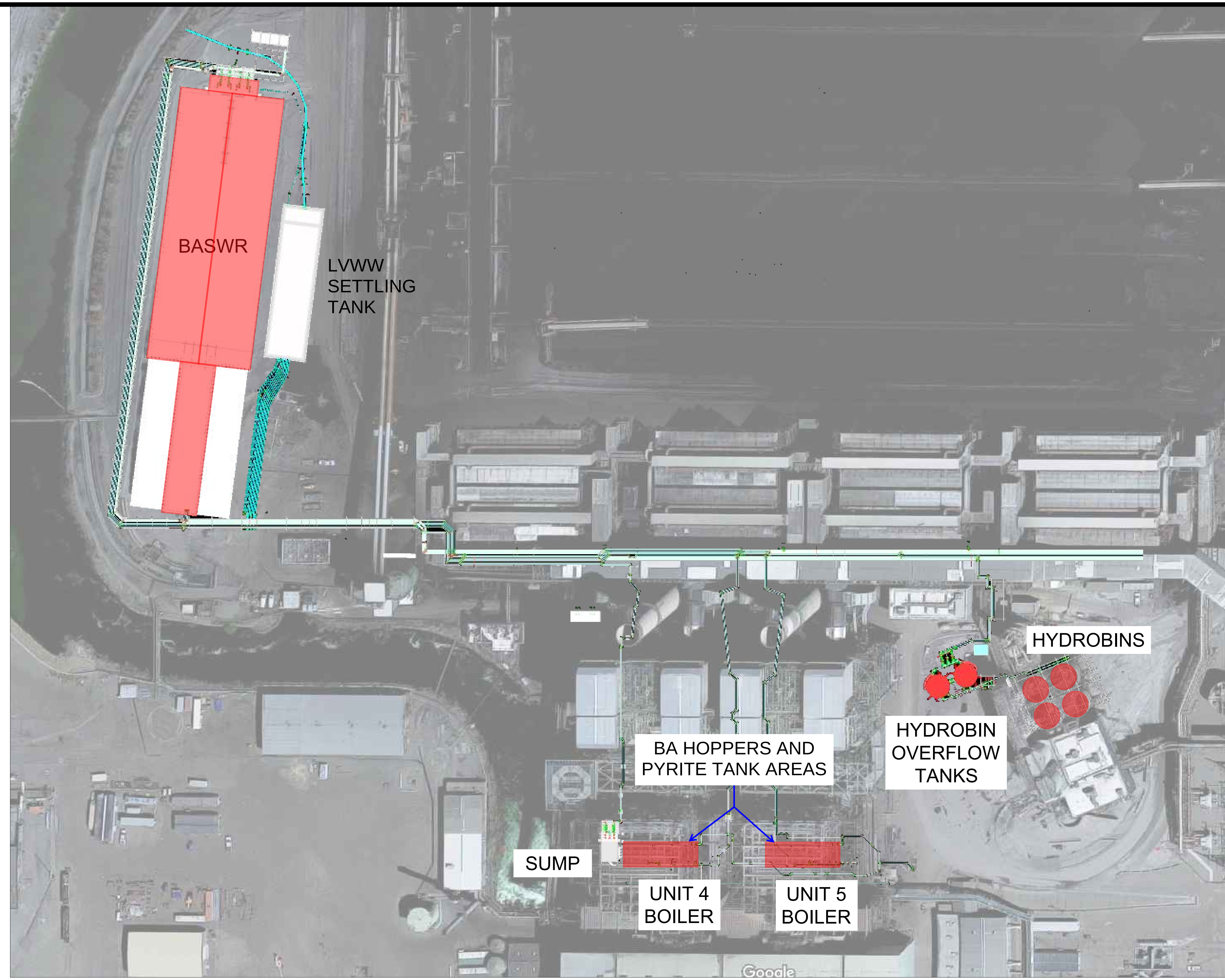
<- increase in system concentration from evaporation losses

10.00 dT

	MGD	**gpm**	
Evaporation	0.147	102.05	gpm
Dragout	0.050	35.00	gpm
Purge Rate	0.115	79.76	gpm
Makeup	0.312	216.81	gpm

APPENDIX E – GENERAL ARRANGEMENT





BURNS McDONNELL

date 08/12/21

designed K. MATTHEWS

FOUR CORNERS

OVERALL SITE
ELG PLANT MODIFICATIONS
GENERAL ARRANGEMENT

project 129532

W. A. FCC016494

SK **M003**

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