



# Wastewater *Biosolids* MASTER PLAN

EXECUTIVE SUMMARY

November 2019



# BACKGROUND ON THE PROJECT

The City of Flagstaff (City) has two separate water reclamation plants: the Rio De Flag WRP (RDFWRP) located in the central portion, east of downtown and the Wildcat Hill WRP (WHWRP) located in the northeast portion of the City.

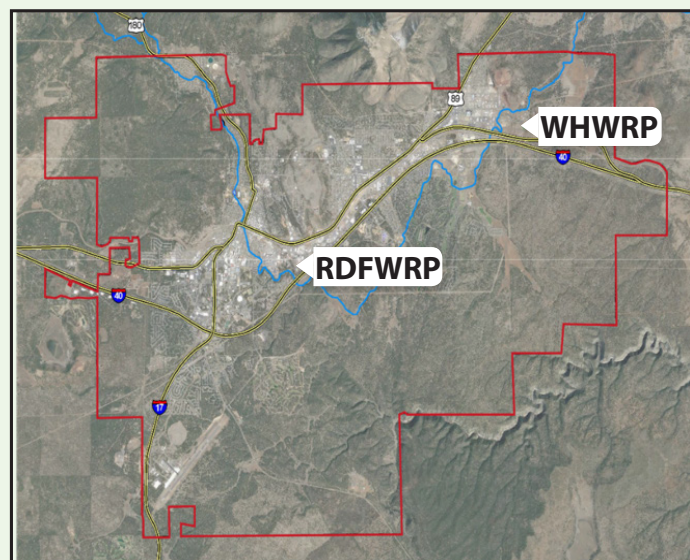
The RDFWRP is a satellite plant and is currently permitted as a 4 mgd MMADF facility producing Class A+ reclaimed water.

Receiving the remaining flow from the City's customers, the WHWRP is permitted as a 6 million gallons per day (mgd) maximum monthly average day flow (MMADF) facility. It produces Class A+ reclaimed water and serves as a regional solids handling facility designed to produce Class B biosolids, treating biosolids produced at the facility as well as primary sludge and waste activated sludge (WAS) from the RDFWRP.

The reclaimed water produced at both plants is beneficially reused in the City's reclaimed water distribution system or linear recharged into the Rio De Flag river. Current reclaimed water quality goals for the treatment processes and technologies to be employed at the two facilities are based on Class A+ Reclaimed Water Standards.

In 2018, the City of Flagstaff started the Wastewater Biosolids Master Plan (BMP) Project. The primary goal is to define long-term strategies for managing, treating, and disposing biosolids. Additionally, the City is seeking to determine current and future liquids and solids capacity needs, identify immediate, mid-term, and long-term improvements at the two facilities, and develop a prioritized list of projects for inclusion in the 10-Year Wastewater Capital Improvements Plan (CIP). The CIP will allow the City to effectively manage its wastewater assets and meet the growing needs of the community in a timely and economical manner.

RDFWRP and WHWRP Location Map



The Class B biosolids produced at the WHWRP is disposed of at the Dedicated Land Disposal (DLD) site that is located at the plant. The biosolids can currently be disposed of at the DLD site only, because of the relatively high water content in the biosolids (approximately 10 percent solids concentration). Landfill disposal is currently not an option.

Dedicated Land Disposal Site at WHWRP



This project recommends ways to transform the WHWRP solids into end products that may be beneficially reused and/or disposed of at the DLD or landfill, in a cost-effective and environmentally-friendly manner. The general approach to biosolids management for the WHWRP is to:

- Expand the portfolio of options for overall biosolids management flexibility and program robustness.
- Focus on alternatives that are technically and economically viable and reasonable.
- Develop a sustainable program consistent with City goals and policies.

## History of the Wastewater System in Flagstaff

As shown in the time line below, the City of Flagstaff has invested into both of its wastewater treatment plants, carrying out expansions, upgrades, and repairs. This investment has been crucial to the longevity of the City's assets. To continue on this path, the City will need to implement a robust asset management program and proactively plan for future investments.

Plant	ORIGIN		TECHNOLOGY CHANGE		TECHNOLOGY CHANGES		
	Year	Description	Year	Description	Year	Description	
Rio De Flag WRP	1971	Original construction of 4 mgd facility	2009	Upgraded sand filter No. 2 to cloth-media tertiary filters	2017	Replacement of blowers	
	1981	Designed to produce Class A+ reclaimed water	2011		2018	Replacement of the UV system	
Wildcat Hill WRP	1971	Original construction of 3 mgd facility	2006	Upgrades to cogen facility	2014-2015	Replacement of two bar screens	
	1981	Expanded to a 6 mgd facility	2009	Treatment process modifications were made to produce Class A+ reclaimed water (IFAS facility)	2016	Upgrades to air compressors and air dryers for plant air system	
		2017	Upgraded to cloth-media tertiary filters	2017	Replacement of grit washers	2018	Upgrades to pump motors and VFDs throughout the plant
		2017	Upgrades to produce Class B reclaimed water (trickling filter facility)	2018	Replacement of heating, ventilation and air conditioning equipment	2018	Upgrades to pump motors and VFDs throughout the plant
		2018	Addition of sand filters and chlorine contact basins	2018	Addition of geotube dewatering facility	2018	Addition of MicroC storage and feed system
		2018	Addition of dechlorination facility	2018		2018	Addition of MicroC storage and feed system
		2018		2018		2018	Addition of chemical metering pumps
		2018		2018		2018	Upgrades to pump motors and VFDs throughout the plant

## Glossary of Terms

- AADF (annual average day flow):** average of the daily flows for a calendar year. Relates to the plant capacity needed to meet the average wastewater production in the City.
- Anaerobic digestion:** treatment process for solids from wastewater treatment, that decomposes organic matter and reduces the amount of solids in the absence of air, producing methane gas and inert solids.
- Beneficial reuse of biosolids:** biosolids can be reused to improve and maintain productive soils and to stimulate plant growth.
- Biosolids:** safe and beneficial resource composed of essential plant nutrient and organic matter that is recovered from the treatment of domestic sewage in a wastewater treatment facility.
- BOD (biochemical oxygen demand):** parameter that indicates the amount of organic matter in wastewater, as measured by the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic compounds.
- CAS (conventional activated sludge):** secondary wastewater treatment process that uses suspended-growth biological reactors and sedimentation tanks.
- CIP (capital improvements plan):** plan developed by utilities to identify, prioritize, and execute projects that invest funds in new infrastructure or rehabilitation of existing infrastructure.
- Dewatering:** process that removes water from a solids stream to reduce the volume that needs to be handled, to a solids content between 10 - 30%.
- Firm capacity:** the capacity of a system with the largest unit out of service.
- GPCD (gallons per capita per day):** per capita wastewater production. This parameter is used to compare wastewater production among different communities, or quantify trends for a given community.
- IFAS (integrated fixed-film activated sludge):** secondary wastewater treatment process that employs a combination of suspended-growth and attached-growth in biological reactors, followed by sedimentation tanks.
- MBR (membrane bioreactor):** secondary wastewater treatment process that uses suspended-growth biological reactors and ultrafiltration membranes.
- mgd (million gallons per day):** parameter used to quantify wastewater flow in pipes and treatment facilities.
- MMADF (maximum month average day flow):** the maximum 30-day average flow in a calendar year. Relevant for the maximum capacity of biological treatment and solids treatment processes.
- PDF (peak day flow):** the highest average daily flow in a calendar year. Relevant for treatment processes such as primary treatment, secondary clarification, and tertiary filtration.
- PHF (peak hour flow):** the highest one-hour average flow in a calendar year. Relevant for treatment processes based on hydraulic capacity, such as pumping, screening and grit removal, and disinfection.
- Preliminary treatment:** processes designed to protect the operation of the wastewater treatment plant, by removing any constituents that can clog or damage pumps, or interfere with subsequent treatment processes.
- Primary treatment:** processes designed to remove settleable solids from wastewater and reduce loadings to the downstream treatment processes.
- R&R (rehabilitation and replacement):** the ongoing need for rehabilitation and replacement of structural, mechanical, or electrical/instrumentation components of treatment facilities, due to reaching normal lifespan.
- Reclaimed water:** highly treated wastewater that can be used to supplement existing water supplies.
- Secondary treatment:** biological treatment of the wastewater to remove organic matter and nutrients such as nitrogen and phosphorus, including biological reactors and solids-liquid separation units that produce a relatively clean effluent stream.
- Solar drying:** solar drying technology makes use of renewable solar energy to dry biosolids to solids contents between 70 - 90% solids.
- Stabilization:** treatment aimed at significantly reducing and decomposing organic matter and pathogenic organisms to produce biosolids that can be suitable for beneficial reuse.
- Tertiary treatment:** final stage of wastewater treatment where secondary treatment effluent undergoes filtration to remove turbidity, and disinfection to eliminate pathogens and make the reclaimed water suitable for reuse.
- Thickening:** process that removes water from a solids stream to reduce the volume that needs to be handled, to a solids content between 4 - 6%.
- TKN (total Kjeldahl nitrogen):** parameter that indicates the amount of nitrogen in wastewater, including ammonia and organic nitrogen.
- TSS (total suspended solids):** parameter that measures the dry weight of suspended particles in wastewater, only including solids that can be retained in a filter.
- WAS (waste activated sludge):** excess sludge (microorganisms) produced from the biological treatment of wastewater.

# PLANNING CRITERIA FOR THE PROJECT

Basic planning criteria were established for existing facilities to develop recommendations for future treatment processes and related improvements for the City's treatment plants. The criteria included influent wastewater flow and characteristics; population projections and buildout population; and future flow and load projections.

## Influent Wastewater Flow and Characteristics

After analyzing historical data, we established hydraulic flow peaking factors to determine peak flows for the plant, as well as wastewater characteristics and wastewater load peaking factors to determine peak loadings to the plant.

According to the data, **wastewater strength has increased in Flagstaff over time**, which is typical for communities in the Southwest. For both plants, recent influent wastewater BOD and TSS concentrations were higher than the design concentrations. **This increased strength detrimentally impacts the amount of wastewater that can be treated at the plants.**

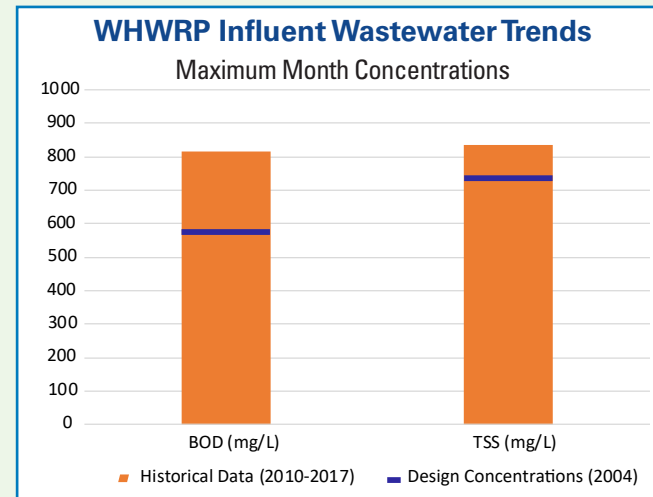
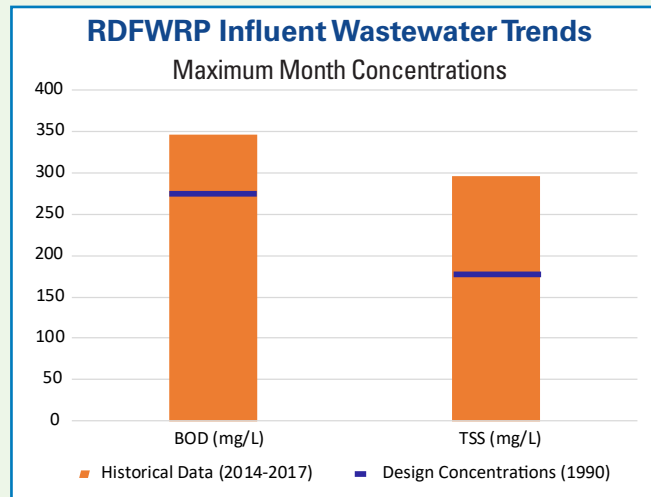
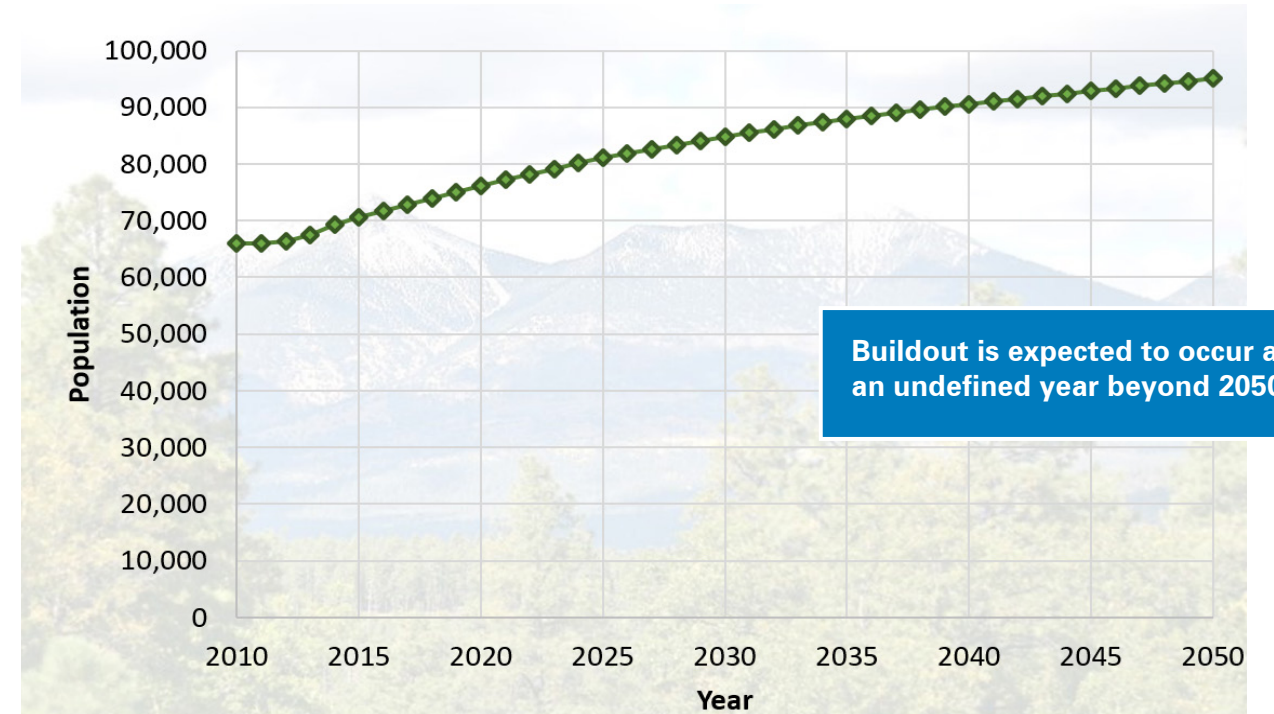
Parameter	Units	RDFWRP Criteria	WHWRP Criteria
<b>Influent Flow</b>			
Annual Average Day Flow (AADF)	mgd	3.3	4.3
Maximum Month Average Day Flow (MMADF)	mgd	4.0	6.0
Peak Day Flow (PDF)	mgd	4.3	7.9
Peak Hour Flow (PHF)	mgd	8.2	14.3
<b>Hydraulic Peaking Factors</b>			
Maximum Month Average Day	--	1.20	1.40
Peak Day	--	1.30	1.85
Peak Hour	--	2.50	3.33

PLANNING CRITERIA - INFLUENT FLOWS

## Population Projections

The graphic shows the adopted population projections for this study. These projections drive the flow and load projections used to define capacity needs at the City's WRPs.

City of Flagstaff (Planning Department)  
Population Projections



## Water Conservation and Water Efficiency has Increased Relative Concentration (or "Strength") of the Influent Wastewater

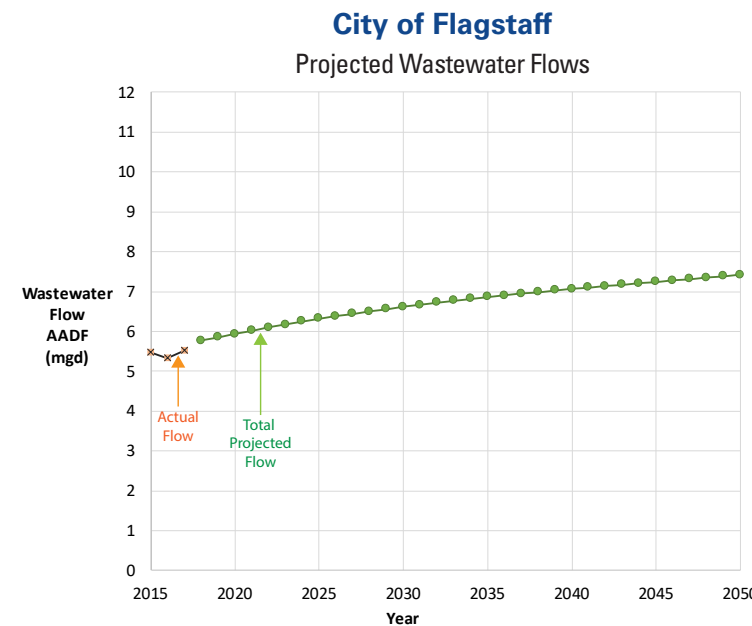
Compared to other cities and towns in Arizona, Flagstaff has a low wastewater generation of 78 gallons per capita per day (GPCD), indicating that the City's water conservation and efficiency efforts may be impacting the City's wastewater system.

Although water conservation is extremely important, it can reduce treatment plant capacity--**the higher the strength of the wastewater, the more treatment capacity needed to treat each gallon of wastewater.** Many think that plant capacity depends entirely on wastewater flows, which are associated with population. However, the real drivers for treatment capacity are wastewater loadings (i.e., a product of flow and concentrations such as BOD and TSS).

Arizona Towns/Cities	Wastewater Generated (GPCD)
Yuma	115
Tempe	114
Sedona	102
Prescott	98
Tucson	80
Goodyear	78
<b>Flagstaff</b>	<b>78</b>
Lake Havasu City	70
Avondale	69
Gilbert	61
Peoria	60

## Wastewater Flow Projections

Wastewater flows were projected based on the population projections and per capita production of 78 GPCD.



## Buildout Population, Flow and Load Projections

The City of Flagstaff's buildout population is 150,000.

The table below summarizes buildout wastewater flow and loads for the buildout population. These values include a 20% safety factor to account for potential changes in flows or loads, which is typical for this type of assessment.

Parameter	Units	Value at Buildout
Flow	mgd	14.0
BOD Load	lb/d	48,100
TSS Load	lb/d	37,000
TKN Load	lb/d	6,100

BUILDOUT WASTEWATER FLOW AND LOADS

**The Buildout Wastewater Flow for the City is Projected to be 14 mgd**

# RIO DE FLAG WATER RECLAMATION PLANT CONDITION ASSESSMENT AND CAPACITY EVALUATIONS

A visual condition assessment was conducted of all major assets, and a detailed capacity evaluation was performed for the treatment processes. The goal was to identify the assets' current condition to prioritize R&R efforts.

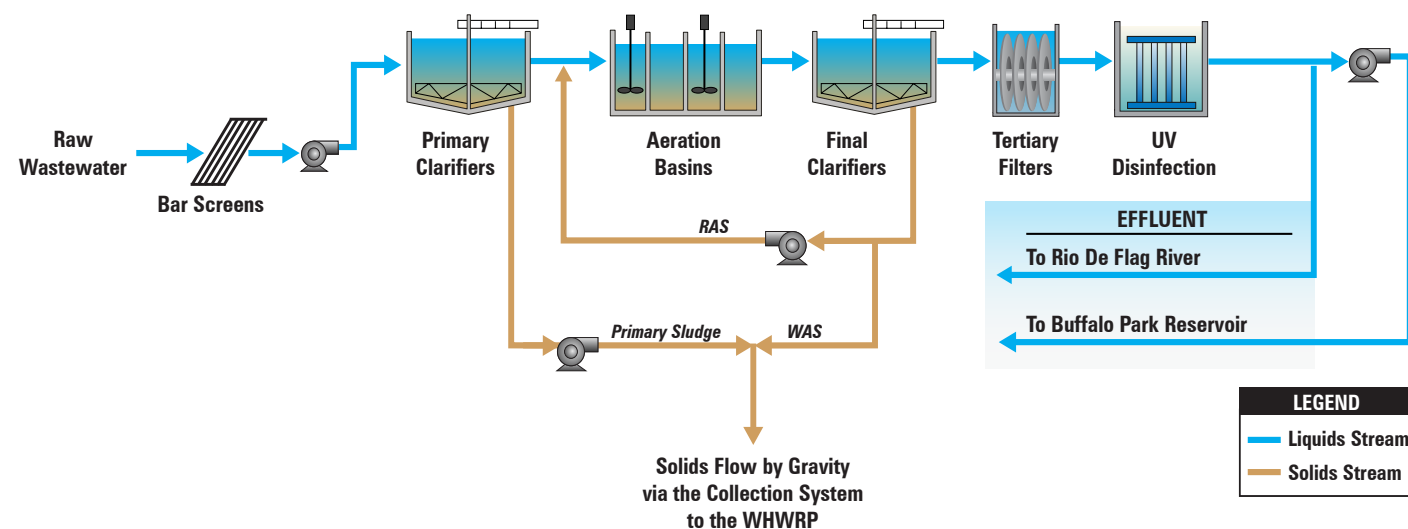


The RDFWRP currently treats about 2 mgd. Although all solids produced at the facility are sent to the WHWRP for treatment, the RDFWRP has full liquids treatment capability.

## Existing Facilities

The main processes at the RDFWRP include screening, influent pumping, primary clarification, activated sludge process using the four-stage Bardenpho™ configuration (aeration basins), secondary clarification, tertiary filtration (using sand and disk filters), ultraviolet (UV) disinfection, and reclaimed water pumping.

### RDFWRP Process Flow Schematic



## Condition Assessment of Existing RDFWRP Facilities

**A majority of the assets have been well maintained and are generally in good condition.**

The City should continue to plan for proactive maintenance and R&R funds to maintain the condition of the plant's assets. All assets should be placed on a reassessment cycle and be periodically reassessed to avoid costly failures.



## Existing Plant Process Capacity

The graphic shows the estimated capacities of the existing facilities at the RDFWRP. All capacities were normalized to an equivalent AADF based on the respective peaking factors, depending on which criteria govern each unit process. **Our results show that the plant can satisfactorily treat the permitted capacity under current loading conditions.**

### RDFWRP CAPACITY RESULTS

There are no process bottlenecks that would limit the actual capacity of the plant below its permitted capacity.

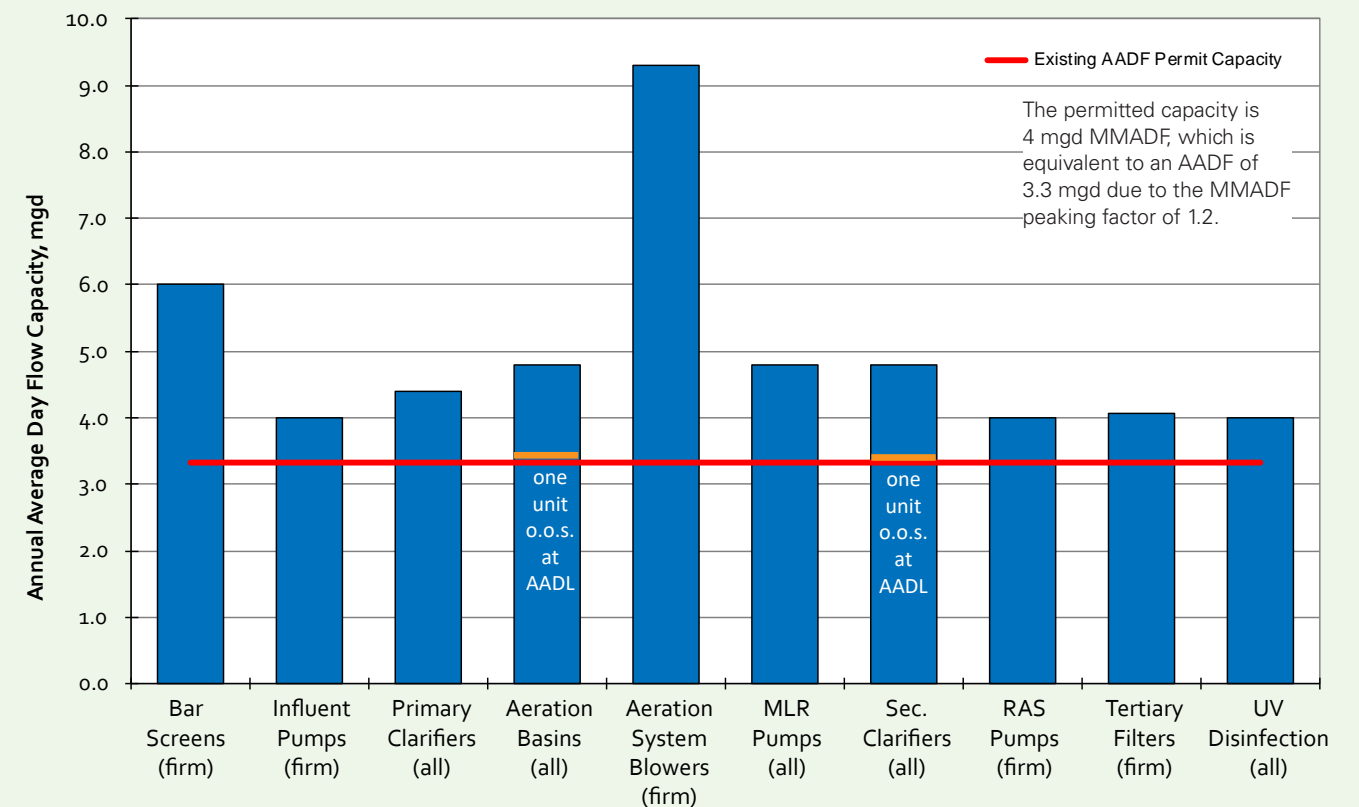
The plant is currently operated with an AADF of 2 mgd because of current limitations around sending more flow to the plant.

The plant has adequate capacity to continue operating at 2 mgd AADF.

**We identified a few process redundancy related limitations.**

- With a primary clarifier out of service, the remaining unit would need to operate at higher hydraulic loading rates, with decreased efficiency. This would require all aeration basins and secondary clarifiers to remain in operation to compensate for the loss in primary treatment efficiency.
- Similarly, the plant can treat an AADF between 3.4 and 3.5 mgd when either an aeration basin or a secondary clarifier is out of service. However, it can't handle that AADF when both are out of service, and it can handle it only at average loadings outside the maximum month loading conditions.
- Finally, the UV disinfection system would be required to operate at a reduced UV dose if an entire channel is taken out of service.

### Estimated Capacity of All Facilities at RDFWRP



Note: o.o.s = out of service

### RECOMMENDATIONS FOR NEAR-TERM PROJECTS AT RDFWRP

We recommend including the influent splitter structure's rehabilitation in the 10-Year CIP and prioritizing it for FY 2020/2021. The structure is showing signs of excessive corrosion, with possible exposed rebar due to exposure to hydrogen sulfide gas. The structure should be repaired before more deterioration occurs down to the rebar; otherwise, it would need to be completely replaced in the future.

**Overall, the capital improvement needs at the RDFWRP are minimal in the near-term.**

# WILDCAT HILL WATER RECLAMATION PLANT CONDITION ASSESSMENT AND LIQUIDS CAPACITY EVALUATIONS

## Existing Facilities

A condition assessment was performed on the WHWRP, starting with the headworks facility and then proceeding through the entire plant from “stem to stern.” A detailed capacity evaluation was also performed on the liquids and solids treatment processes. The main processes that make up the liquids treatment train are screening, grit removal, primary clarification, primary effluent pumping, activated sludge process (integrated fixed-film activated sludge/IFAS basins), secondary clarification, secondary effluent pumping, tertiary filtration, chlorine disinfection (in chlorine contact basins/CCBs), dechlorination (using sulfur dioxide), and reclaimed water pumping. The existing solids treatment processes include disc thickening, anaerobic digestion, dewatering (using geotube bags), and sludge stabilization basins (SSBs).

## Condition Assessment of Existing WHWRP Facilities

Although several assets have been modified, the original and expanded plant has aging infrastructure that requires major capital investments to minimize the overall risk as it relates to level of service.

### WE FOUND FOUR CRITICAL ISSUES WITH THE AGING ASSETS

- Code compliance issues
- Safety concerns
- Single points of failure
- Plant components nearing or at end of useful life

WRP Component	Typical Life (Years)	WHWRP Component Life (Years)
<b>STRUCTURAL CONCRETE</b>		
› Unlined	20-40	9, 28, 37-47
› Lined/Coated	40-60	
<b>MECHANICAL</b>		
› Process Mechanical	15-25	9, 28, 37-47
› Pumps	15-20	
› Chemical Equipment	10-20	
› HVAC	15-25	
› Coolers/ACs/Fans	10-15	
› Valves and Actuators	30-35	
<b>ELECTRICAL</b>		
› Generators	15-20	9, 28, 37-47
› VFDs	10-15	
› Control Panels	25-30	
<b>INSTRUMENTATION</b>		
› Field Instruments	10-15	9, 28, 37-47
› SCADA	10-15	
› PLCs	10-15	
<b>CIVIL</b>	50-60	9, 28, 37-47
<b>MATERIALS – PLASTIC</b>	7-10	9, 28, 37-47

**WHWRP COMPONENT LIFE** In the final column on the right, the number nine corresponds to the age, in years, of the most recent IFAS basins and supporting equipment. The number 28 corresponds to the age of the chlorination/dechlorination facilities constructed in 1991. The numbers 37-47 refers to the age of the majority of the facility’s assets, which were installed in 1971 or during the subsequent 1981 expansion.

## Existing LIQUIDS STREAM Process Capacity

The table and graphic below summarize the results of the estimated capacity analyses performed on the existing facilities at the WHWRP for the liquids treatment train. All capacities were normalized to an equivalent AADF based on the respective peaking factors, depending on the criteria governing each unit process. As shown, there are several process bottlenecks in the liquids train.

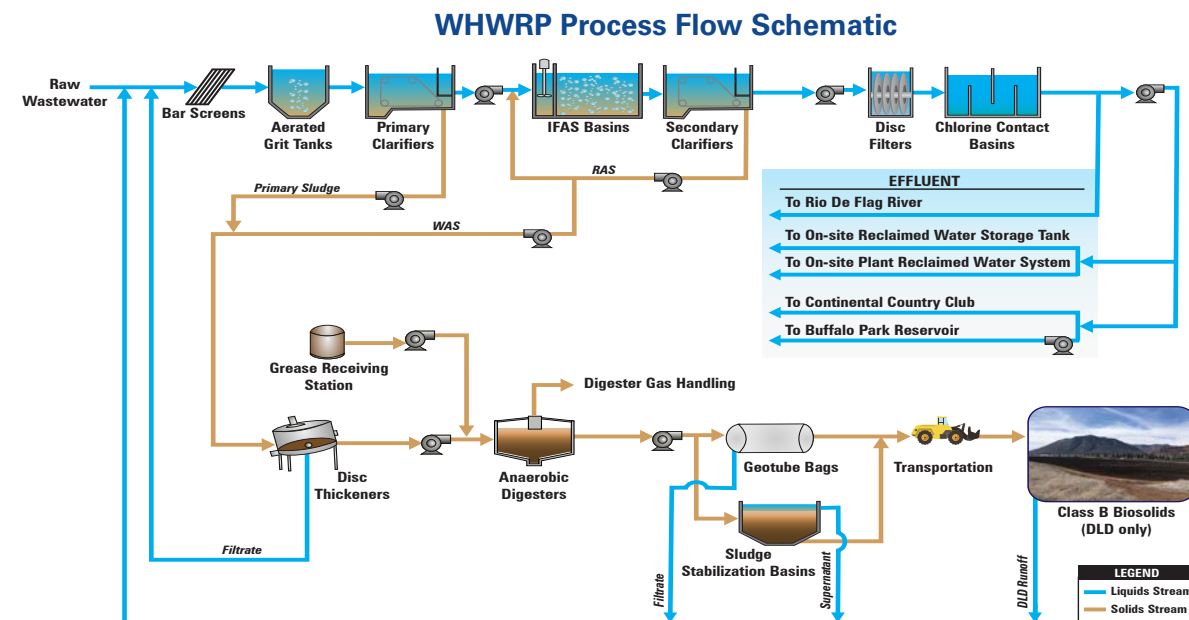
### MAJOR LIQUIDS PROCESSES REQUIRING IMPROVEMENTS

- › Influent Bar Screens
- › Primary Clarifiers and Primary Effluent Pump Station (PEPS)
- › Secondary Treatment System (IFAS Basins and Secondary Clarifiers)

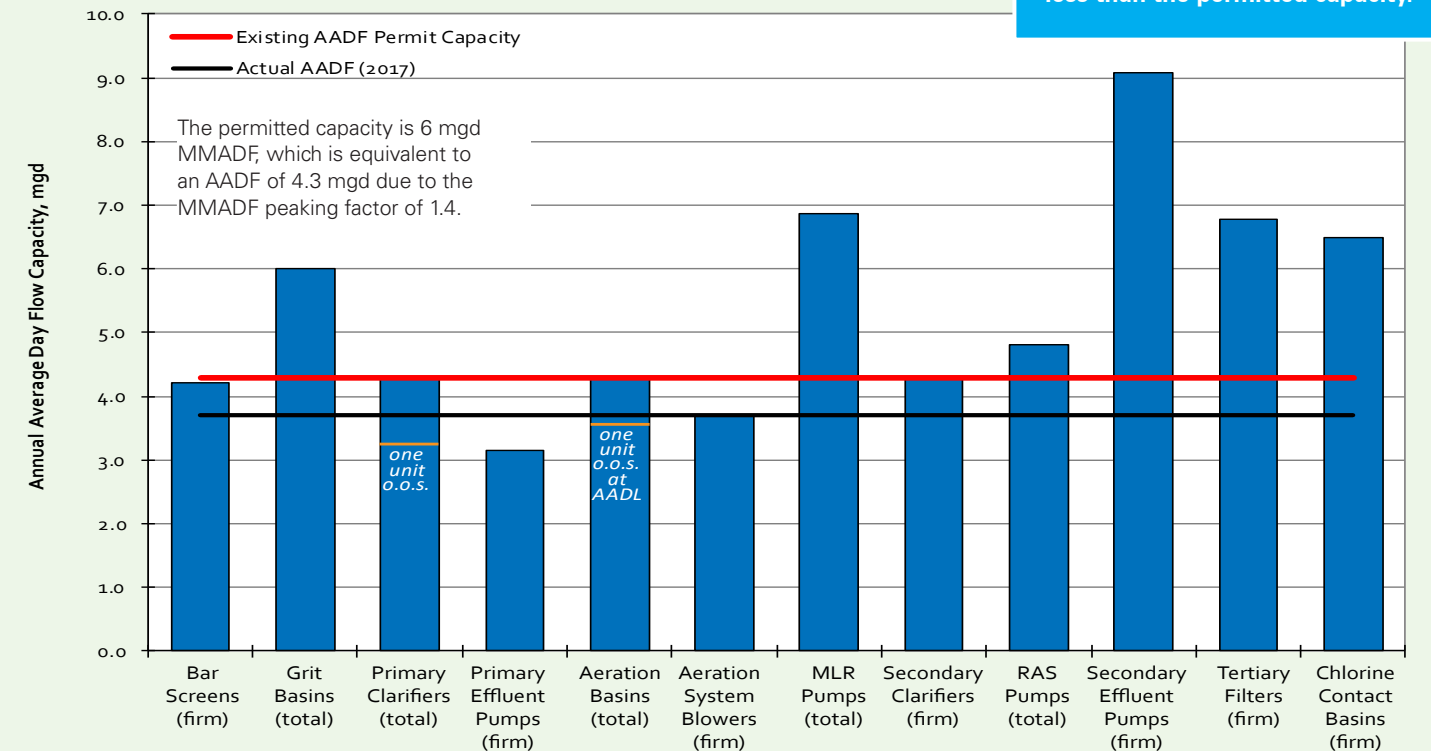
<b>Influent Bar Screens</b>	The firm capacity of 14 mgd peak hour flow with one mechanical screen out of service is slightly below the peak hour flow of 14.3 mgd associated with the plant AADF of 4.3 mgd.
<b>Grit Removal Basins</b>	There is sufficient capacity to treat the plant permitted flow of 6 mgd MMADF, equivalent to an AADF of 4.3 mgd.
<b>Primary Clarifiers</b>	The system lacks redundancy, and operating with one unit out of service limits the primary clarifier capacity to 3.2 mgd AADF. Even with all basins in service, the clarifiers are stressed under PDF and PHF conditions, with the hydraulic loading rates exceeding the recommended criteria by approximately 21 to 35 percent.
<b>Primary Effluent Pump Station (PEPS)</b>	The primary effluent pumps lack redundancy, and operating with one pump out of service limits the firm pumping capacity to 3.2 mgd AADF.
<b>Secondary Treatment</b>	The estimated capacity of the secondary treatment system (IFAS basins + secondary clarifiers) was 4.3 mgd AADF (MMADF of 6 mgd) for the loading scenario considering 2 mgd equivalent residual solids from the RDFWRP. Increasing the solids contribution from the RDFWRP to 4 mgd solids equivalent decreases the capacity of the secondary treatment system to 3.4 mgd AADF (4.8 mgd MMADF). The mixed liquor return (MLR) pumps have sufficient pumping capacity to treat the plant permitted flow.
<b>Secondary Clarifiers</b>	The existing physical configuration of the clarifiers limits the capacity of the IFAS basins to 4.3 mgd AADF.
<b>Return Activated Sludge (RAS) Pumps</b>	There is sufficient total capacity to maintain the recommended RAS flow ratio, but the pump arrangement of two dedicated pumps per clarifier and two hoppers per clarifier makes the secondary clarifiers more vulnerable. Shelf-spares RAS pumps are recommended to avoid having to take an entire secondary clarifier out of service due to failure of one of its RAS pumps.
<b>Secondary Effluent Pumps, Tertiary Filters, and Chlorine Contact Basins</b>	These systems have sufficient capacity to treat the plant’s permitted flow of 6 mgd MMADF, equivalent to an AADF of 4.3 mgd.

### SUMMARY OF LIQUIDS TREATMENT CAPACITIES

Note: Refer to Glossary on page 3 for acronyms.



### Estimated Capacity of Liquids Treatment Train Facilities at WHWRP



Note: o.o.s = out of service

# WILDCAT HILL WATER RECLAMATION PLANT SOLIDS CAPACITY

## EVALUATIONS

The WHWRP solids processes treat residual solids from both the RDFWRP and the WHWRP. Thus, the solids treatment train capacity evaluation accounts for the solids produced from the treatment of wastewater at both facilities.

### Existing SOLIDS STREAM Process Capacity

The bar graph below summarizes the estimated capacity analyses of the existing solids facilities at the WHWRP. All capacities were normalized to an equivalent AADF based on the respective peaking factors, depending on the criteria governing each unit process. The results of the analysis are as follows.

#### Primary Sludge Pumps, WAS Pumps, and Disc Thickeners

These systems have sufficient firm capacity to handle the equivalent AADF permit capacity of 7.1 mgd.

#### Anaerobic Digesters

The system lacks not only redundancy, but also capacity to treat the sludge equivalent to the permitted liquids treatment capacities of the RDFWRP and WHWRP. At current conditions, both digesters in service can treat sludge equivalent to an AADF of approximately 6.3 mgd. At the current AADF of approximately 5.5 mgd for both plants combined, both digesters need to be in service to meet the minimum HRT of 15 days established for Class B biosolids (required for disposal at the DLD).

Parameter	Units	Current Conditions
Combined Plant AADF (RDFWRP+WHWRP)	mgd	5.5
Digester Feed Solids	%TS	4.0 - 6.0
No. of Digesters Available	---	2
HRT with All in Service		
• At AADL	days	16.6 - 24.9
• At MMADL	days	11.9 - 17.8
HRT with One Out of Service		
• At AADL	days	8.3 - 12.4
• At MMADL	days	5.9 - 8.9

#### DIGESTER CAPACITY UNDER CURRENT LOADING CONDITIONS

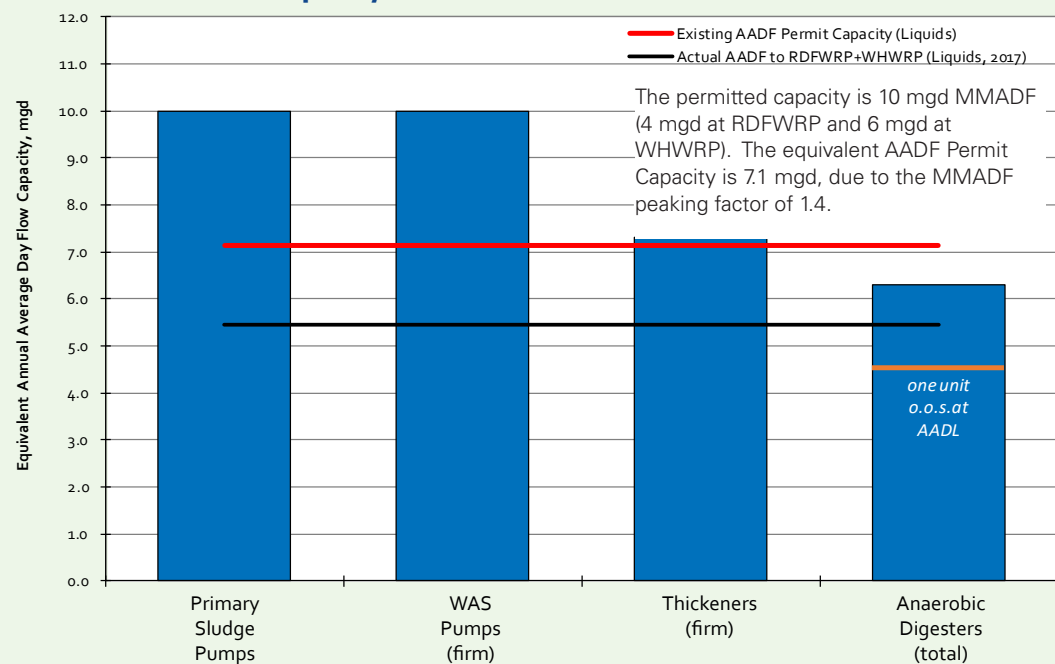
Numbers in red indicate HRT values below the minimum of 15 days required to achieve Class B biosolids. Note that a minimum HRT of 15 days is required to achieve the Class B biosolids quality needed for disposal at the DLD.

#### MAJOR SOLIDS PROCESSES REQUIRING IMPROVEMENTS

Additional digester capacity is an immediate capital improvement need.

Compared to the RDFWRP, this facility has more R&R needs.

Estimated Capacity of Solids Treatment Train Facilities at WHWRP



The WHWRP solids train has significant deficiencies relative to treating the solids produced from the combined permitted flow from both facilities of 10 mgd MMADF, equivalent to an AADF of 7.1 mgd.

Note: o.o.s = out of service

## RECOMMENDATIONS FOR NEAR-TERM PROJECTS AT WHWRP

- Digester capacity expansion**  
A digester capacity expansion project is required immediately at the WHWRP.
- Primary clarifiers rehabilitation**
- PEPS capacity expansion**  
Given its location in the plant's hydraulic profile, failure of the PEPS will cause flow to back up in the primary clarifiers, headworks, and ultimately in the collection system. It will also prevent flow from being conveyed to the downstream IFAS system for secondary treatment.
- Secondary clarifiers weir replacement and adjustment**  
The secondary clarifiers are the limiting factor for the secondary treatment system's capacity. Given their excessive length, the weirs' existing configuration makes them prone to solids carryover in the front portions of the clarifiers. Modifications to the weirs are thus necessary to reduce the potential for solids carryover. We recommend adjusting the effluent weir length to approximately one-third of its current length and conducting CFD modeling for baffling and inlet and outlet reconfiguration.



The capacity of the existing digesters relative to current loads is a critical issue.

# BIOSOLIDS REUSE AND DISPOSAL OPTIONS

## What are biosolids?

When properly treated and processed, the sewage sludge removed from the liquids process stream at a wastewater treatment plant becomes biosolids which are nutrient-rich organic materials.

Biosolids have beneficial end-use properties, and can be recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth.

## How are they regulated?

Biosolids disposal and use are federally regulated by the USEPA 40 CFR Part 503 Biosolids Rule (503 regulations).

Arizona Department of Environmental Quality enforces the federal regulations and is responsible for issuing AZPDES permits, administering compliance, and overseeing the activities of all biosolids disposal, use, and transportation within Arizona.

The 503 regulations classify biosolids as Exceptional Quality (EQ), Class A, or Class B according to the level of treatment provided to reduce metals concentrations and pathogens and vector attraction.

Class B biosolids can be achieved through specific pathogen and vector attraction reduction alternatives; pathogen reduction does not have to occur prior to or at the same time as vector attraction reduction.

Class A biosolids can be achieved through specific pathogen and vector attraction reduction alternatives, with pathogen reduction occurring prior to or at the same time as vector attraction reduction; additionally, fecal coliform or Salmonella bacteria levels must meet specific density requirements at the time of biosolids use/disposal.

For biosolids to qualify as EQ, they must be treated to Class A pathogen and vector attraction reduction levels and must also meet more stringent limits for heavy metals.

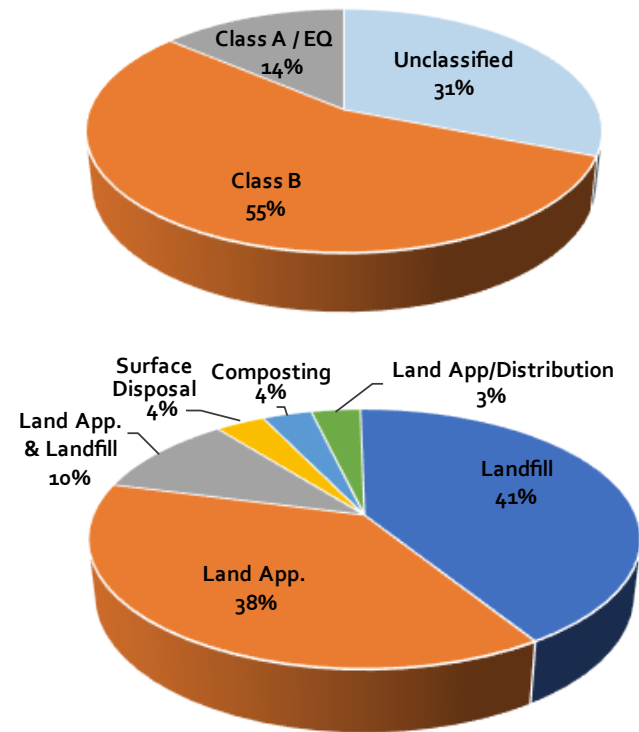
## Regional Biosolids Management Trends

**Biosolids management programs are driven by federal and regional regulations as well as land availability**

At the federal level, similar to regulations for liquid processes in wastewater treatment, the presence of Compounds of Emerging Concern (CECs, such as personal healthcare products and pharmaceuticals) in components of emerging concern biosolids is an issue on the horizon, but no impending regulatory programs are envisioned to address these compounds in the near future.

At the regional level, trends for biosolids quality and management in Arizona show the following:

- Most facilities produce either Class B or Unclassified biosolids.
- Landfill and land application account for 90 percent of the biosolids disposal options.



**Biosolids Quality and Management Trends in Arizona (29 Facilities)**

## Heavy Reliance on a Single Disposal Option Is Not Recommended for WHWRP

Biosolids regulations are continuously changing and becoming stricter, application sites are increasingly less available, hauling and tipping fees are increasing, competition for limited landfill capacity is increasing, and concerns over the continued long-term availability of landfills are growing.

## A Biosolids Management Strategy Has Two Main Components: Biosolids End Use/ Disposal Method(s) and Solids Treatment Processes

The preferred end use/disposal methods dictate the biosolids quality requirements, which in turn dictate the required solids treatment processes.

### Typical Biosolids Management Strategy Components



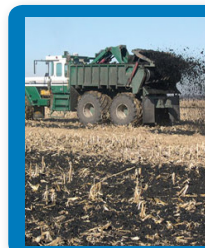
## Alternate Uses for Biosolids

Four economically feasible alternate uses for the biosolids are available to the City in the near- to mid-term and are described below. In the future, public distribution and the use of biosolids management firms may be viable options.



### Dedicated Land Disposal

The disposal of (minimum) Class B biosolids at the DLD site continues to be a viable option.



### Land Application

Land application is an economical way to BENEFICIALLY REUSE biosolids. Biosolids are applied at agronomic rates calculated based on the nutrients in the biosolids and the needs of the soil they are applied to. The biosolids provide nutrients to the soil and replenish the soil organic matter. However, opportunities in Northern Arizona are limited.



### Alternative Daily Cover at Cinder Lake Landfill

Biosolids can be BENEFICIALLY REUSED for alternative daily cover, meaning they are the final cover for a landfill. Using biosolids in this manner can reduce odors and vectors, which are organisms that spread diseases. Additional discussions with Public Works and stakeholders are required.



### Landfill Disposal

Biosolids can be disposed of at a landfill. For this option, the biosolids would have to pass a paint filter test to confirm they are non-hazardous, and they would have to be dewatered to create a product with greater than 18 percent solids content. Additional discussions with Public Works and stakeholders are required.

## Solids Treatment Processes for WHWRP

The solids treatment processes selected for the WHWRP are economically feasible, effective in achieving the desired biosolids quality, and have a proven track record with successful full-scale installations.

## OUR RECOMMENDATIONS

### THICKENING

The two existing thickeners have sufficient firm capacity to last until approximately 2050. We recommend continuing to use the mechanical thickening operations. In the near-term, we see no capacity- or technology-related need to expand or change the thickening process.

### STABILIZATION

Additional digesters are required in the near-term, and a digester expansion project is recommended for immediate implementation to provide system capacity and redundancy. Conventional mesophilic anaerobic digestion (CMAD), the current stabilization process used at the plant, is the preferred technology.

### DEWATERING

We recommend adding a new mechanical dewatering facility in the mid-term.

### PROCESS TO FURTHER STABILIZE SLUDGE

Solar drying offers a relatively economical and low-energy method to produce Class A biosolids and is recommended in the mid-term.

# BIOSOLIDS MANAGEMENT OPTIONS FOR THE WHWRP

## Biosolids Management Alternatives

Four biosolids management alternatives were developed for the WHWRP, including the baseline option (Alt 0), in which the current operating strategy is used. These alternatives are listed in the following table and summarized below.

Alternative	Description	Biosolids Quality Produced
Alt 0 (baseline)	Anaerobic Digestion plus Geotube Bags/SSBs	Class B Biosolids (dewatered to ~10%)
Alt 1	Anaerobic Digestion plus Dewatering	Class B Biosolids, dewatered
Alt 2	Anaerobic Digestion plus Dewatering plus Composting	Class B and Class A Biosolids, dewatered
Alt 3	Anaerobic Digestion plus Dewatering plus Solar Drying	Class B and Class A Biosolids, dewatered

### BIOSOLIDS MANAGEMENT ALTERNATIVES

**Alt 0:** As the baseline option, this alternative continues the current operating strategy, which uses anaerobic digestion, storage at the SSBs, and dewatering using geotube bags.

**Alt 1:** This alternative is a modification of Alt 0 where dewatering is achieved with mechanical dewatering equipment instead of the geotube bags.

**Alt 2:** With this alternative, anaerobic digestion and mechanical dewatering are used, similar to Alt 1, but they are followed by sidestream composting.

**Alt 3:** This alternative consists of anaerobic digestion and mechanical dewatering as well, followed by sidestream solar drying to produce Class B and Class A biosolids.

## Alternatives Analysis

All four alternatives were compared. Because a key difference among the alternatives was the extent of dewatering used, the volume of biosolids needing handling and disposal was a major factor in the comparison.

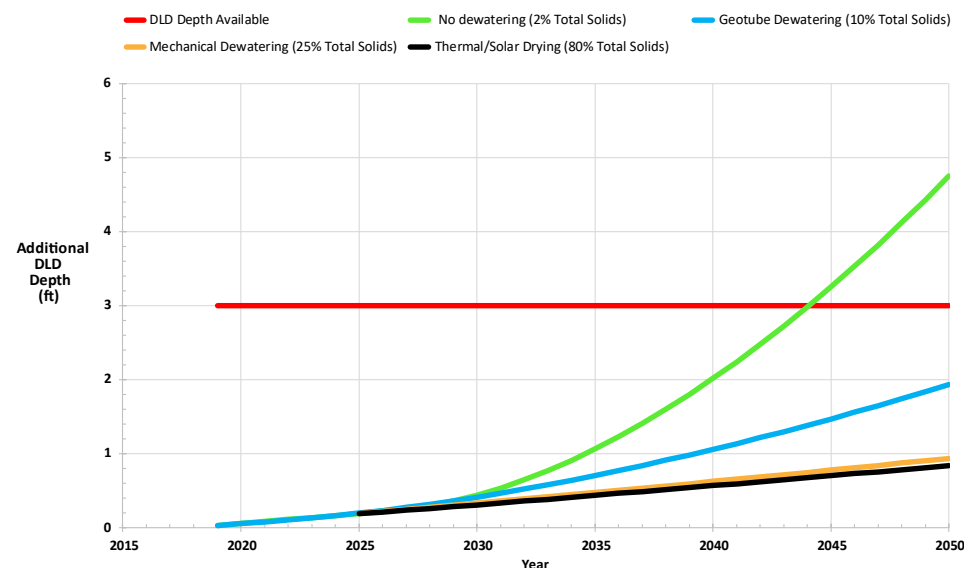
During the comparison, we found that mechanical dewatering dramatically reduced the volume of biosolids needing to be handled. Mechanical dewatering would open up possibilities for beneficial reuse and would benefit the dedicated land disposal. It would also reduce hauling costs and could allow for using the DLD year-round.

From a DLD operation standpoint, mechanical dewatering and solar drying are very similar, except for the additional volume reduction achieved with solar drying.



A dry product allows the City flexibility in biosolids disposal and reuse.

### Analysis of DLD Operations Under Different Biosolids Dewatering Alternatives

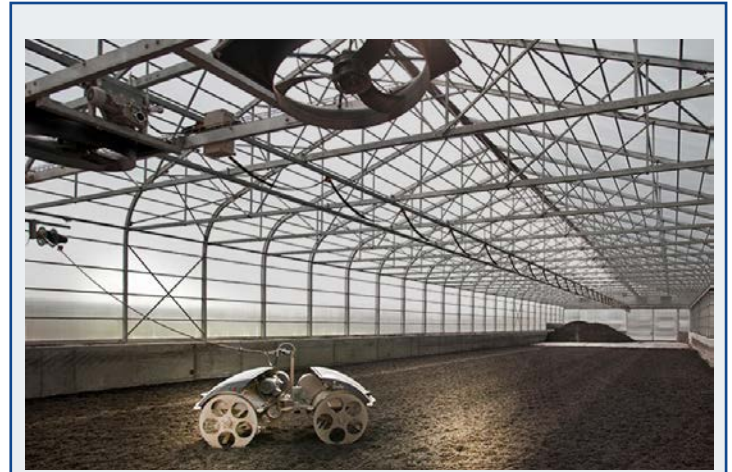


**The City should PLAN FOR MECHANICAL DEWATERING, since it provides benefits for DLD operation and allows beneficial reuse of the biosolids**

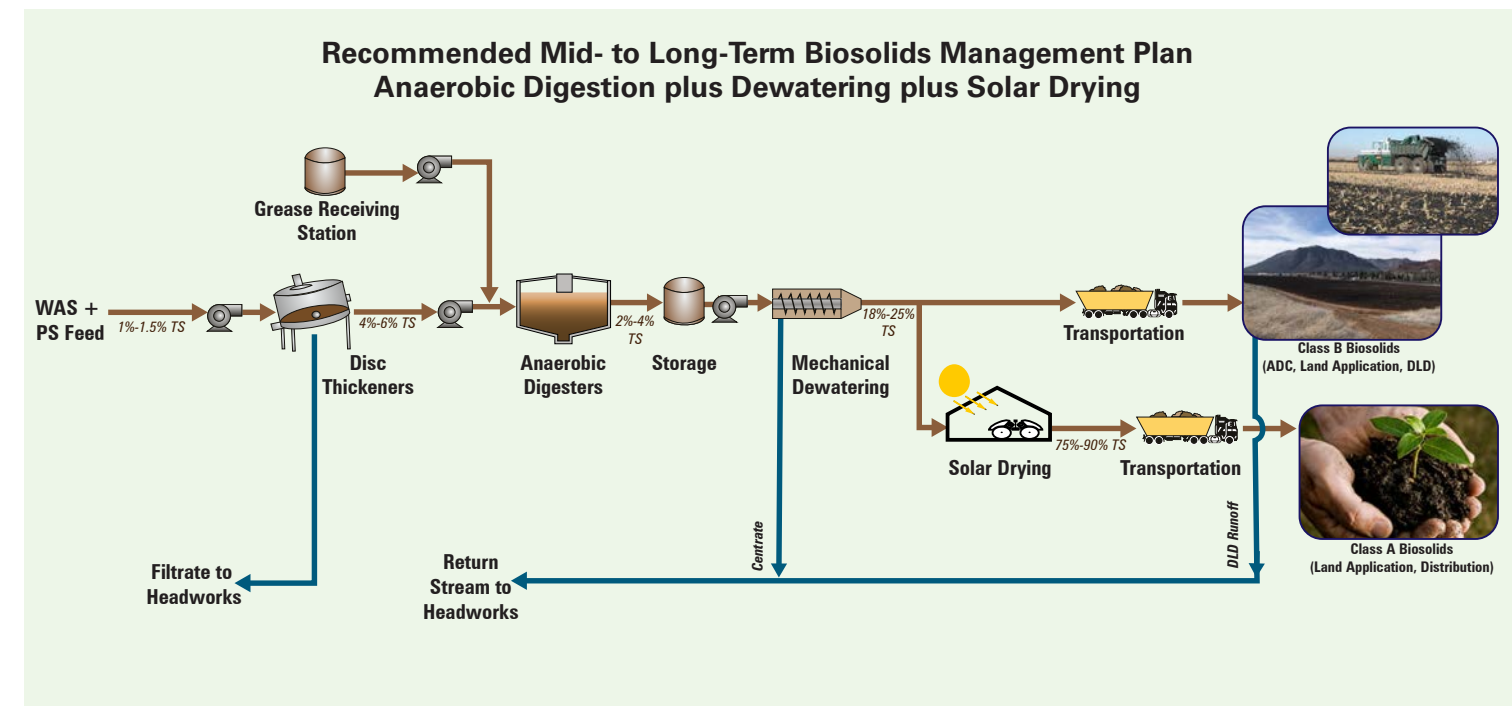
## Near- and Long-Term Biosolids Management Strategies

From our analysis, we recommend the following:

- Near-term (0-5 years): Continue the existing strategy of thickening, anaerobic digestion, dewatering with geotube bags, and disposal of Class B biosolids in the DLD.
- Mid- to long-term planning horizon (5-10 years): Prioritize adding a mechanical dewatering facility followed by sidestream treatment of biosolids using solar drying.
  - › Plan for a new mechanical dewatering building in the mid-term.
  - › Plan for solar drying operations along with the dewatering facility or after it is built.
  - › Consider composting operations in the long-term after a sustainable market for Class A biosolids is established.



**SOLAR DRYING IS A "GREEN" ALTERNATIVE THAT CAN ACHIEVE CLASS A BIOSOLIDS AND IS AMENABLE TO FLAGSTAFF'S ENVIRONMENT**



# TREATMENT CAPACITY NEEDS AT WHWRP AND RDFWRP

## Liquids Capacity Needs

As summarized in the table below, under current conditions, **the wastewater treatment capacity of 6.3 mgd AADF is expected to be reached by year 2024.** At that time, additional installed capacity will be needed at the WHWRP.

Parameter	Current Operation	Flow Diversion Option 1	Flow Diversion Option 2
WHWRP Capacity, AADF (mgd)	4.3	3.4	4.3
RDFWRP Capacity, AADF (mgd)	2.0	3.3	3.3
Total Operating Capacity, AADF (mgd)	6.3	6.7	7.6

Trigger for Additional Liquids Capacity at WHWRP	By year 2024	By year 2032	Beyond 2050

### SUMMARY OF CITY'S TREATMENT CAPACITY

To delay the need for additional capacity, there are two strategies.

#### Flow Diversion Option 1 - Divert Flow to RDFWRP by 2024

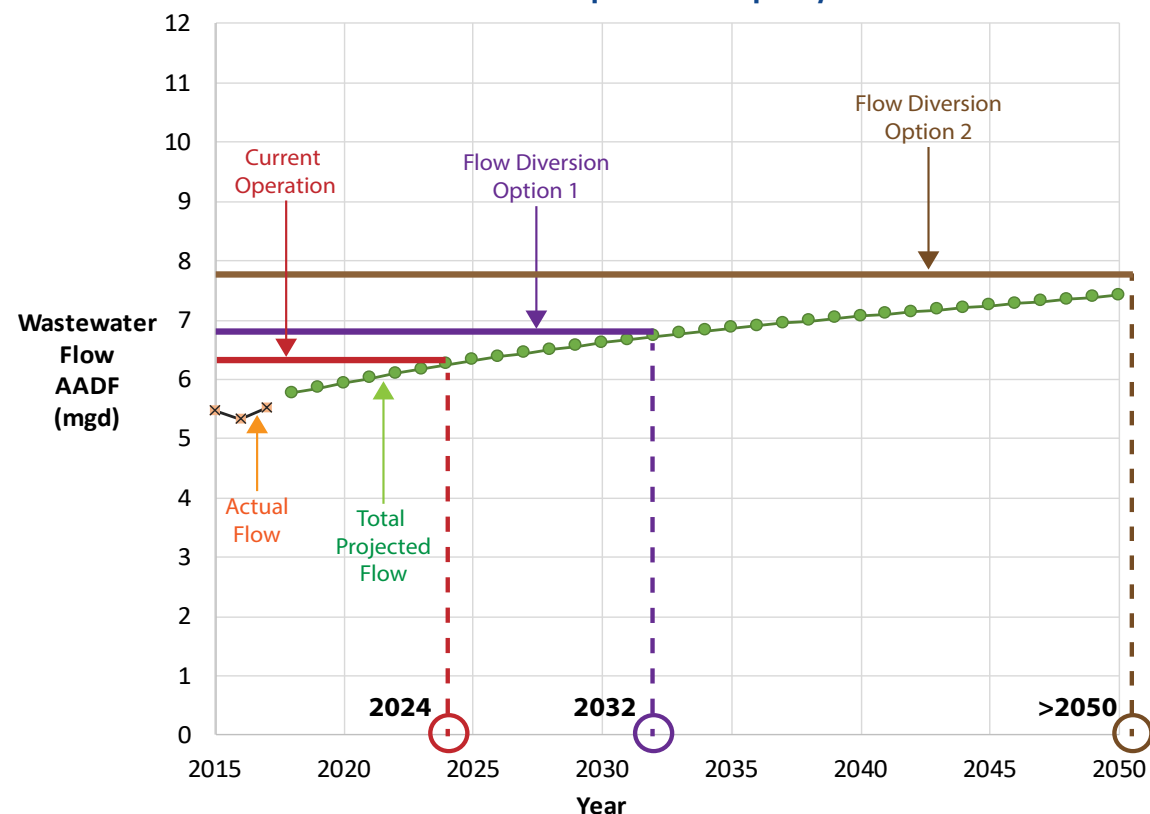
The current limitations to convey flow to the RDFWRP need to be further evaluated and resolved so that flow diversion can be operational by year 2024. The new combined capacity of 6.7 mgd AADF would be reached by year 2032. However, it is uncertain at this point if or when sufficient wastewater flows will be available on the west-side of Flagstaff so that RDFWRP can treat more flow.

#### Flow Diversion Option 2 - Thicken and Haul Residual Solids to WHWRP by 2032

In addition to diverting more flow to the RDFWRP, residual solids from the RDFWRP would be taken out of the collection system and sent directly to the solids treatment train at the WHWRP. This could potentially be pumped directly or hauled by truck (which is probably the more likely option). The new combined capacity of 7.6 mgd AADF will be reached beyond year 2050.

Alternatively, by year 2032, additional capacity could be constructed at the WHWRP if the City prefers to continue sending RDFWRP solids to WHWRP via the collection system.

Liquids Train Capacity

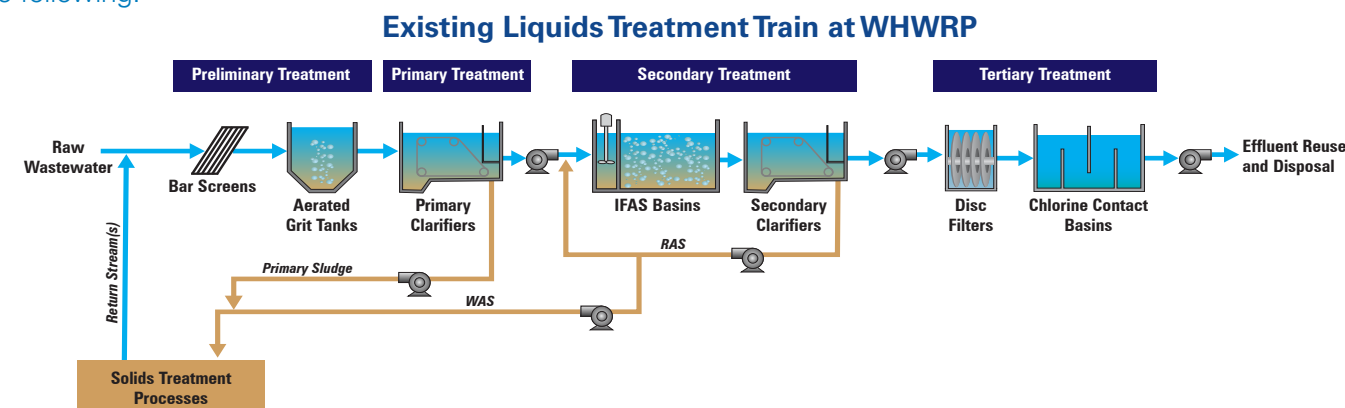


## WHWRP Expansion Overview

Capacity expansion at the WHWRP, when required, will be implemented in phases to maximize the use of available infrastructure. In the near-term, the existing IFAS system would continue to be utilized in parallel with the additional capacity, and the plant would essentially be operated using "dual" process treatment trains. In the future, the IFAS system will be phased out and retired and additional capacity built for ultimate operation using a single process treatment train.

Five secondary treatment process technology alternatives were evaluated for upgrading and expanding the WHWRP: conventional activated sludge (CAS), IFAS, membrane bioreactor (MBR), granular activated sludge (GAS), and ballasted activated sludge (BAS). These alternatives require different equipment, basin sizes, and maintenance attention, and are generally viable for the WHWRP. We recommend that all five technologies be carried forward as feasible options for further evaluation under a later project.

Of the total buildout wastewater flow of 14 mgd AADF, a liquids treatment capacity of 10 mgd AADF would be required at the WHWRP. While transitioning to accommodate buildout flows at the WHWRP, we recommend the following:



#### Preliminary Treatment

Regardless of the secondary treatment technology selected, we recommend a headworks replacement project in the mid-term.

Add a new headworks facility sized for 5 mgd AADF that would include influent pumping, screening, and grit removal (and possibly fine screening in the case of MBR).

#### Primary Treatment

Add new primary clarifiers to increase treatment capacity and replace aging infrastructure.

Four 85-ft circular primary clarifiers would be required for buildout. In the mid-term, we recommend two 85-ft clarifiers.

Consider alternative "intensified" technology such as primary filtration.

#### Secondary Treatment

Additional capacity requires new tankage for aeration basins and solids/liquids separation and aeration system expansion.

The new trains would operate in parallel with the IFAS system until the IFAS system can be retired.

CAS, IFAS, MBR, GAS, and BAS are viable technologies and generally fit on the available site.

#### Tertiary Treatment

Expand the tertiary filtration system as flows increase beyond 6.8 mgd AADF (for all treatment processes except MBR).

Expand the disinfection system as flows increase beyond 6.5 mgd AADF.

#### Anticipated Timing

2030 - 2035	2030 - 2035	By 2024 (if not diverting flow) or Beyond 2050 (if diverting flow and thickening/hauling RDFWRP solids)	Beyond 2050

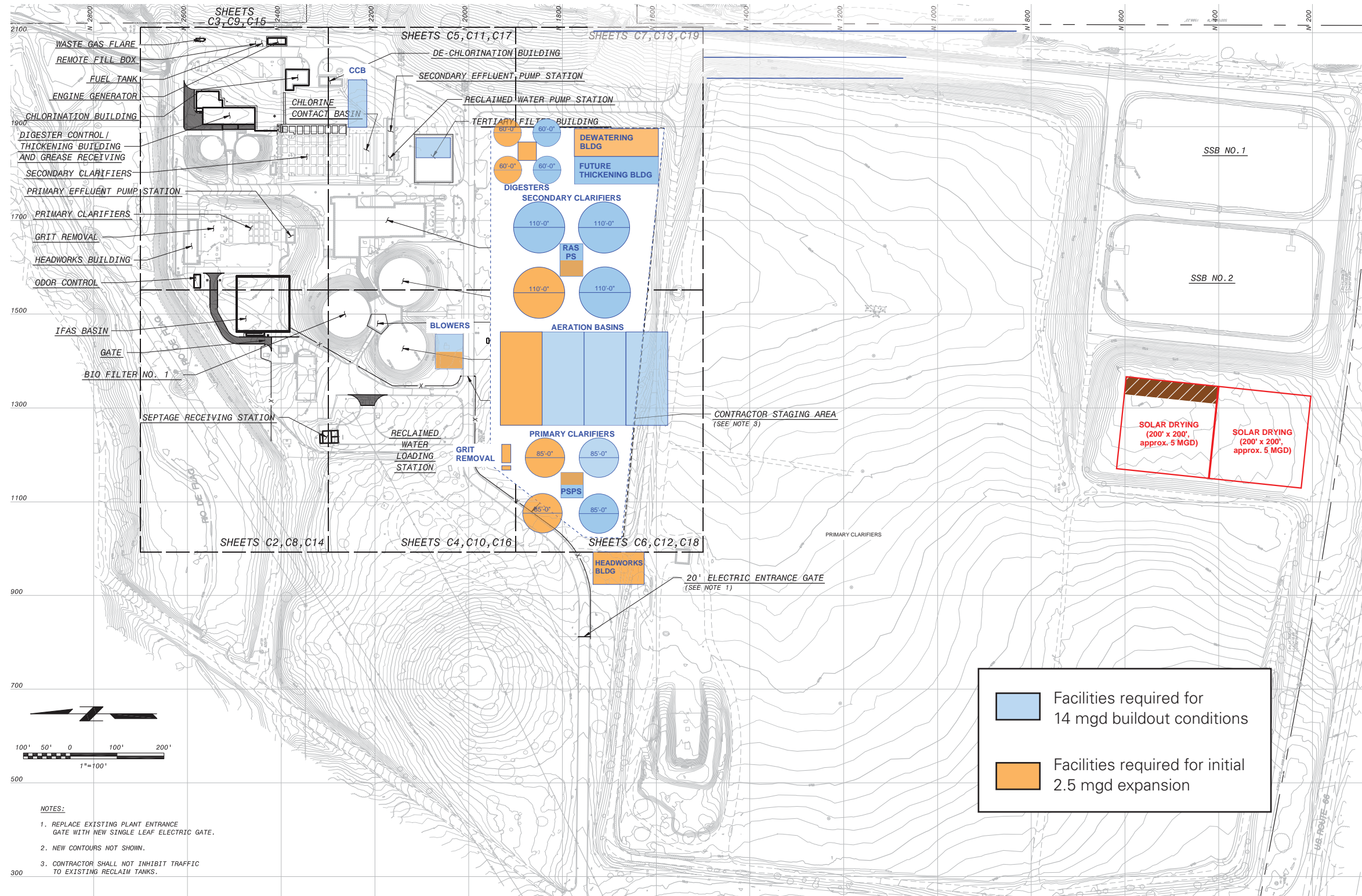
## RECOMMENDATIONS

We recommend a project to study and resolve the limitations around sending more flow to RDFWRP in the near-term, because of the uncertainties regarding if or when sufficient wastewater flows will be generated on the west-side of Flagstaff.

# WILDCAT HILL WATER RECLAMATION PLANT CONCEPTUAL SITE LAYOUT FOR BUILDOUT CONDITIONS USING CAS TECHNOLOGY

Below is the site layout with conventional activated sludge (CAS) technology. As such, CAS represents the most conservative approach for site planning purposes, relative to all the technologies evaluated.

## Conventional Treatment Train - 10 MGD AADF Liquids - 14 MGD AADF Solids



## MAIN SITE PLAN COMPONENTS

### Solids Treatment

- Future thickening building is assumed for additional thickening capacity beyond year 2050.
- Two 60-foot digesters and a digester complex will be required in the near-term, which will be expandable to the ultimate quad configuration.
- New mechanical dewatering and solar drying facilities are recommended in the mid-term.

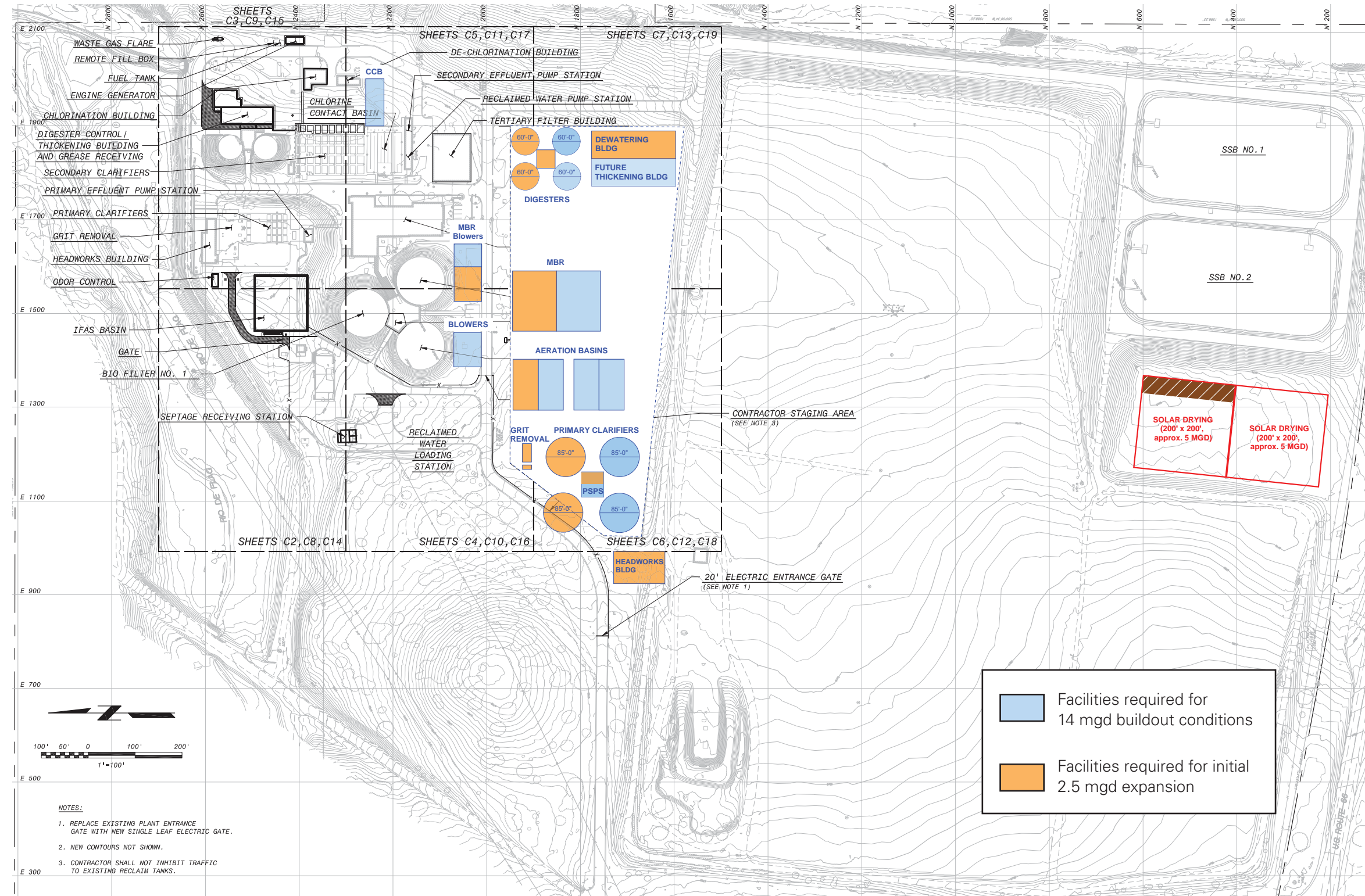
### Liquids Treatment

- New headworks building and primary clarification facilities are recommended in the mid-term.
- New aeration basin, secondary clarifier and pump station, and expanded blower capacity are recommended for the initial capacity expansion.

# WILDCAT HILL WATER RECLAMATION PLANT CONCEPTUAL SITE LAYOUT FOR BUILDOUT CONDITIONS USING MBR TECHNOLOGY

Below is the site layout with membrane bioreactor (MBR) technology, which uses a membrane process along with a biological process. MBR has a very compact footprint and is easily integrated with advanced treatment processes if the City pursues advanced treatment in the future, depending on future requirements and regulations.

## MBR Treatment Train - 10 MGD AADF Liquids - 14 MGD AADF Solids



## MAIN SITE PLAN COMPONENTS

### Solids Treatment

- Future thickening building is assumed for additional thickening capacity beyond year 2050.
- Two 60-foot digesters and a digester complex will be required in the near-term, which will be expandable to the ultimate quad configuration.
- New mechanical dewatering and solar drying facilities are recommended in the mid-term.

### Liquids Treatment

- New headworks building and primary clarification facilities are recommended in the mid-term.
- New aeration basin (smaller than CAS basins), membrane filtration facility, and expanded blower capacity are recommended for the initial capacity expansion.

# Recommended BMP-Related Capital Improvements for Flagstaff

## Prioritization of Major Capital Improvement Projects (CIP)

A prioritized list of the major CIP needs that have resulted from the different evaluations conducted in this Biosolids Master Plan (BMP) is shown below. These projects form the basis for the 10-Year BMP-related CIP.

Priority No.	Project Description	Timing
1	Digester capacity expansion at WHWRP	Immediate
2	R&R needs at WHWRP and RDFWRP ■ PEPS capacity expansion and Primary Clarifiers rehabilitation at WHWRP ■ Secondary Clarifiers weir replacement at WHWRP ■ Splitter Box rehabilitation at RDFWRP	Immediate
3	Additional flow diversion to RDFWRP	By 2024
4	Mechanical dewatering and solar drying at WHWRP	2025 to 2030
5	New preliminary and primary treatment at WHWRP	2030 to 2035
6	Liquids capacity expansion at WHWRP ■ Option A – Divert RDFWRP solids out of collection system ■ Option B – Additional capacity expansion at WHWRP	By 2032
7	Other R&R needs at WHWRP	Varies

## SUMMARY AND RECOMMENDATIONS

The result of this Biosolids Master Plan was the development of a fiscally responsible and implementable 10-Year CIP for wastewater improvements at the RDFWRP and WHWRP.

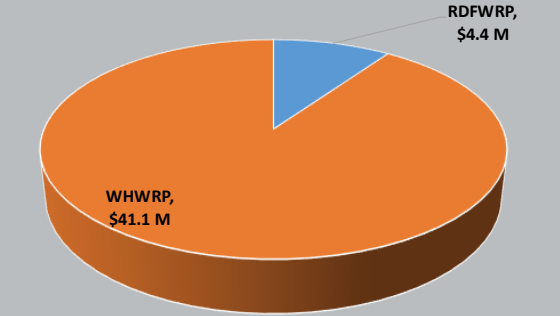
Biosolids Projects that we recommend include digester capacity expansion followed by new mechanical dewatering and solar drying facilities at the WHWRP.

We also recommend that the overall plan be continuously reviewed and adjusted by the City, and that the effort be guided by periodic analysis of flows, capacity needs, and R&R needs at the two facilities.

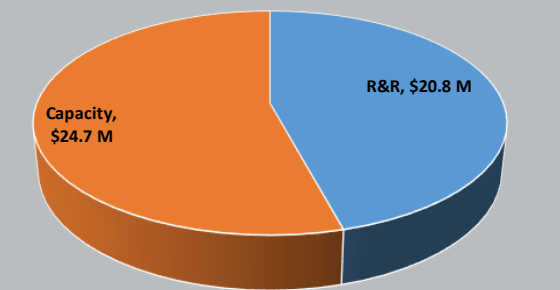
## How are the Funding Needs Allocated?

These pie-charts show a breakdown of the 10-Year BMP costs relative to the needs at the RDFWRP vs. WHWRP, as well as those that are categorized as Capacity-related vs. R&R needs.

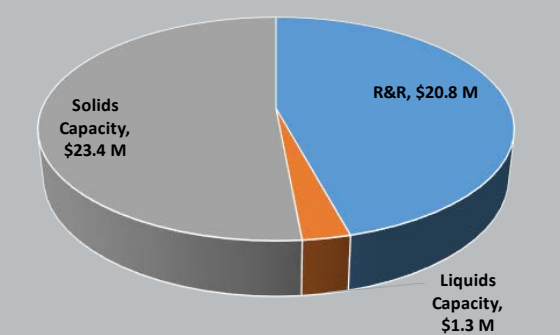
RDFWRP vs. WHWRP Program Costs



Capacity vs. R&R Program Costs



Solids/Liquids Capacity vs. R&R Program Costs



## 10-Year BMP-Related CIP Recommendations

The 10-Year CIP for the RDFWRP and WHWRP that have been identified as part of this BMP are presented in the graphic. Note that all cost estimates are approximate, for budgetary purposes only, and subject to change.

These 10-Year project costs total approximately \$45.5M.

### Near-Term Biosolids Projects



1 Digester Expansion at WHWRP

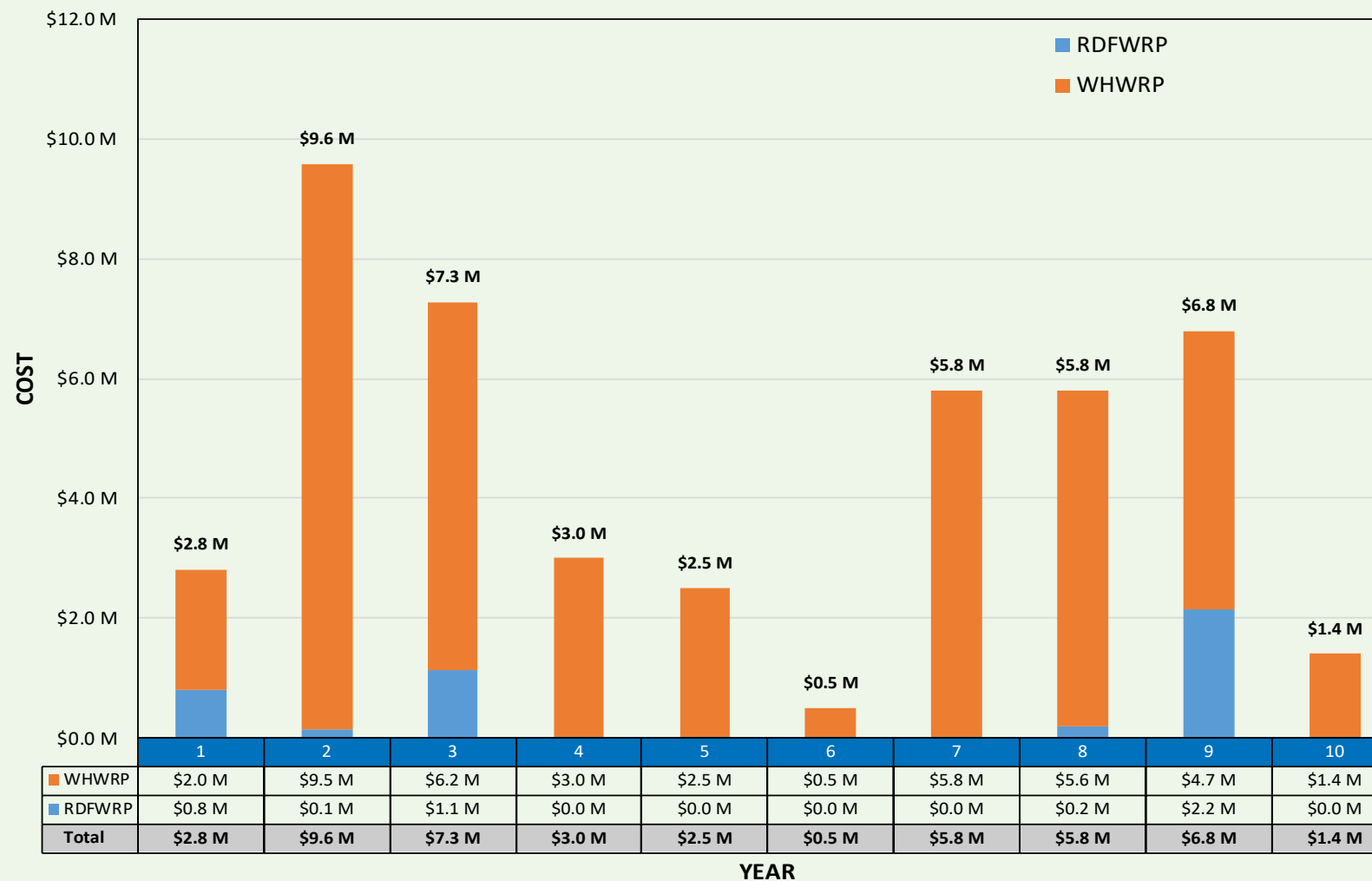


2 Mechanical Dewatering at WHWRP



3 Biosolids Solar Drying at WHWRP

BMP-Related 10-Year CIP for Flagstaff



## Cost Analysis Summary

- Majority of the CIP needs are at the WHWRP, which is the older plant
- Capacity-related and R&R needs represent nearly equal portions of the overall 10-Year program cost
- Majority of the Capacity-related needs are associated with additional solids capacity at WHWRP.

# Acknowledgments

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